



UL 2200

STANDARD FOR SAFETY

Stationary Engine Generator Assemblies

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UL Standard for Safety for Stationary Engine Generator Assemblies, UL 2200

Second Edition, Dated June 1, 2012

Summary of Topics

The revision pages dated July 29, 2015 were issued to incorporate the following new and revised requirements:

- ***Revision to Paragraph 41.1.3.3 to Add Higher Pressure Flexible Fuel Tubing and Hose Types for Gasoline or Diesel Fuel***

The new/revised requirements are substantially in accordance with Proposal(s) on this subject dated April 10, 2015 and June 12, 2015.

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1

UL 2200

Standard for Stationary Engine Generator Assemblies

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June 1, 2012

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through July 29, 2015.

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CONTENTS

INTRODUCTION

1 Scope	6A
2 Glossary	6A
3 Components	11
4 Units of Measurement	12
5 Undated References	12

CONSTRUCTION

6 Materials	12
7 Frame and Enclosure	12
7.1 General	12
7.2 Enclosures and guards	13
7.3 Access doors, covers, and panels	14
7.4 Cast metal enclosures	14A
7.5 Sheet metal enclosures	15
7.6 Nonmetallic enclosures	18
7.7 Glass covered openings	19
7.8 Openings for wiring	19
7.9 Openings in an enclosure	21
7.10 Enclosure bottom openings	21
7.11 Enclosure top openings	24
7.12 Sharp edges	24
8 Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts – and User Servicing	25
9 Electric Shock	30
9.1 Voltage	30
9.2 Stored energy	31
10 Corrosion Protection	33
11 Mechanical Assembly	34
12 Switches and Controls	35
13 Alternators and Generators	36
14 Disconnection Device	37
15 Disconnects Used in Service Equipment Applications	37
16 Output Connections	37
16.1 General	37
16.2 Openings for conduit or cable connection	41
16.3 Openings for class 2 circuit conductors	41
16.4 Receptacles	42
17 Wire Bending Space	42
18 Output Circuit Grounding	47
18.1 General	47
18.2 Ground fault circuit interrupter	50
19 Equipment Grounding	51
20 Bonding of Internal Parts	52
21 Internal Wiring	54
21.1 Wires	54
21.2 Protection of wiring	55
22 Current-Carrying Parts	56

22.1	General	56
22.2	Bus bars	56
22.3	Heat sinks	59
23	Electrical Connections	59
24	Spacings	60
24.1	General	60
24.2	Insulation barriers	65
25	Control Circuits	66
26	Accessible Signal Circuits	68
27	Transformers	68
28	Separation of Circuits	69
28.1	Factory wiring	69
28.2	Separation barriers	70
28.3	Field wiring	70
29	Overcurrent Protection	71
29.1	General	71
29.2	Control circuits	72
29.3	Output alternating current power circuits	74
30	Air Filters	74
31	Capacitors	74
32	Resistors	75
33	Printed-Wiring Boards	75
34	Insulating Materials	75
35	Adhesives	79
36	Battery Heaters and Miscellaneous Heaters	79
37	Engine Starting Equipment	80
38	Battery	80
38.1	Battery compartment	80
38.2	Isolation	80
39	Protection of Service Personnel	80
40	Inverters, Converters, Controllers and Interconnection System Equipment for Generators	81

MECHANICAL SYSTEMS

CONSTRUCTION

41	Fuel Systems	82
41.1	Gasoline or diesel	82
41.2	Liquefied petroleum gas	85
41.3	Natural gas	91
42	Exhaust Systems	94

PERFORMANCE

43	General	94
44	Temperature Test	95
45	Dielectric Voltage-Withstand Test – General	99
46	Harmonic Distortion Test	100
47	Output Voltage And Frequency Fluctuation Test	101
48	Blocked Inlet Test	101
49	Backfire-Deflector Test	101
50	Neutral to Ground Potential Measurement Test	102
51	10-Day Moist Ammonia-Air Stress Cracking Test	102

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52	Salt Spray Test	103
53	LP-Gas Container Load Tests	103
54	Abnormal Tests	103
54.1	General	103
54.2	Overspeed test	104
54.3	Output overload test	105
54.4	AC output short circuit test	105
54.5	Component short- and open-circuit test	105
54.6	DC output short circuit test	106
55	Overtemperature Protection – Overload and Endurance Operation Tests	106
56	Grounding Impedance Test	107
57	Overcurrent Protection Calibration Test	107
58	Strength of Terminal Insulating Base and Support Test	107
59	Mechanical Strength Tests for Metal Enclosures	108
60	Cycling Test	109
61	Evaluation of Reduced Spacings on Printed-Wiring Boards	109
61.1	General	109
61.2	Dielectric voltage-withstand test	109
61.3	Shorted trace test	109
62	Bonding Conductor Test	110
63	Impact Tests	111
63.1	Impact on glass covered openings	111
63.2	Impact – guards over moving parts	111
64	Heat Sink Temperature Cycling Test	112
65	Ignition Test Through Bottom-Panel Openings	112
66	Bus Bar Tests	112A
66A	Volume Change and Extraction Test	112B
66A.1	General	112B
66A.2	Pull test – as received	112B
66A.3	Aging test	112B
66A.4	Pull test - after the aging test	112B
66B	Vibration Test	113
66C	Aerostatic Leakage Test	113
66D	Hydrostatic Strength Test	113

RATING

67	Details	114
----	---------------	-----

MARKING

68	Details	114
68.1	General	114
68.2	Content	115
68.3	Cautionary markings	121
69	Instruction Manual	122A
69.1	General	122A
69.2	Vented batteries	128

MANUFACTURING AND PRODUCTION TESTS

70	Production-Line Dielectric Voltage-Withstand Test	129
----	---	-----

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OUTDOOR-USE UNITS

71 General	130
72 Construction	130A
73 Performance	132A
73.1 Rain test	132A
73.2 Accelerated aging tests	136
73.3 Metallic coating thickness test	137
74 Marking	138

MICROTURBINES

75 General	138
76 Construction	139
76.1 Fuel lines	139
76.2 Co-generation piping and heat exchangers	139
77 Performance	141
77.1 Battery packs	141
77.2 Lift lugs	144
77.3 Turbine blade failure	144

APPENDIX A

Standards for Components.....	A1
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INTRODUCTION

1 Scope

1.1 These requirements cover stationary engine generator assemblies rated 600 volts or less that are intended for installation and use in ordinary locations in accordance with the National Electrical Code NFPA 70; the Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, NFPA 37, the Standard for Health Care Facilities, NFPA 99, and the Standard for Emergency and Standby Power Systems, NFPA 110.

1.2 These requirements do not cover engine generator assemblies for use in hazardous (Classified) locations.

1.3 These requirements do not cover UPS equipment. That equipment is covered by the Standard for Uninterruptible Power Systems, UL 1778.

1.4 These requirements do not cover engine generator assemblies for marine use.

1.5 These requirements do not cover snow loading, wind loading, or seismic forces.

2 Glossary

2.1 In the text of this standard, the term "unit" refers to any product covered by this standard; for example, engine module, generator module, generator assembly, etc. For the purpose of this standard, the definitions in 2.2 - 2.46 apply.

2.2 AC CONVENIENCE RECEPTACLE – A receptacle that is intended for general use.

2.2.1 AUTOMATIC SAFETY SHUTOFF VALVE (ASSV) – A device consisting of a valve and operator that controls the gas supply to the engine. The operator may be actuated by the application of gas pressure on a flexible diaphragm, by electrical means, by mechanical means, or some other means. The valve serves as a safety device that closes upon command from the automatic engine shutdown sensor.

Adapted from ANSI Z21.21-2012 Part VI with permission of CSA Group.

2.2.2 AUTOMATIC VALVE – A valve which controls the flow of gas to the engine during normal operation, and will automatically shut off the flow of gas to the engine in case the engine stops for any cause. Automatic valves include zero governor type regulating valves and auxiliary valves.

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2.2.3 AUXILIARY VALVE – A control valve that will automatically close to stop the flow of gas to the engine in the event the engine stops.

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2.3 BARRIER – A means of isolating that reduces the risk of access to a part that involves a risk of fire, electric shock, injury to persons, or electrical energy – high current levels. See 2.34 – 2.36.

2.4 BATTERY CASE/COVER – The container that directly encloses and confines the electrolyte of a battery or cell.

2.5 BATTERY, VALVE-REGULATED – A battery in which the venting of the products of electrolysis is controlled by a reclosing pressure-sensitive valve.

2.6 BATTERY, VENTED – A battery in which the products of electrolysis and evaporation escape freely to the atmosphere. These batteries have commonly been referred to as “flooded” or “wet.”

2.7 BUS BAR – A conductor or an assembly of conductors for collecting electric currents and distributing them to outgoing feeders.

2.8 CELL – The main components are two electrodes of dissimilar material separated from one another by a common ionically conductive electrolyte, that are intended to convert chemical energy directly into electrical energy.

2.9 CLASS 1 POWER LIMITED CIRCUIT – A circuit which is supplied from a source having a rated output of not more than 30 volts and 1000 volt-amperes.

2.10 CLASS 2 CIRCUIT – A circuit which is supplied from a Class 2 transformer (see 2.11).

2.11 CLASS 2 TRANSFORMER – A step-down transformer complying with the applicable requirements in the Standard for Low Voltage Transformers - Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

2.12 CLASS 3 CIRCUIT – A circuit which is supplied from a Class 3 Transformer (see 2.11).

2.13 COMPONENT – Refers to subassemblies used in the construction of the generating assembly. See Section 3.

2.14 CONTROL CIRCUIT – A circuit that carries electric signals and not main power current.

2.15 CONTROLLED ENVIRONMENT – An environment that is a conditioned, indoor location such as a computer room, office, or a factory floor that is free of conductive contaminants such as carbon dust and similar material.

2.16 DEDICATED PURPOSE GENERATOR OUTLET / RECEPTACLE – A receptacle used to supply power to specific purpose generator components or accessories such as block heaters, oil heaters, battery chargers, etc.

2.17 ELECTROLYTE – A semisolid, liquid, or aqueous salt solution that permits ionic conduction between positive and negative electrodes of a cell.

2.18 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.

2.19 FIELD-WIRING LEAD – Any lead to which a supply, load, or other wire is intended to be connected by an installer.

2.20 FIELD-WIRING TERMINAL – A terminal to which a supply, load, or other wire is intended to be connected by an installer.

2.21 GENERATOR ASSEMBLY – Refers to the assembly, consisting of the internal combustion engine and generator/alternator.

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

2.23 HEAT SINK – A piece of thermally conductive metal attached to a semiconductor or other electronic device and designed to prevent it from overheating by conducting heat away from it and radiating it to the environment.

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2.24 LIMITED-ENERGY CIRCUIT – An ac or dc circuit having a voltage not exceeding 1000 volts and the energy limited to 100 volt-amperes by any of the following:

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- a) Secondary winding of a transformer,
- b) One or more resistors complying with 25.10, or
- c) A regulating network complying with 25.11.

2.25 LINEAR LOAD – A load that does not rectify the current or otherwise alter the current wave shape, resulting in a load current that is proportional to the instantaneous voltage.

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

2.27 LOW-VOLTAGE, LIMITED-ENERGY (LVLE) CIRCUIT – A circuit involving an alternating current voltage of not more than 30 volts rms (42.4 volts peak) or a direct current voltage of not more than 60 volts and supplied by:

- a) An inherently limited Class 2 transformer or a not inherently limited Class 2 transformer and an overcurrent protective device that is:
 - 1) Not of the automatic reclosing type,
 - 2) Trip-free from the reclosing mechanism, and
 - 3) Either not readily interchangeable with a device of a different rating, or provided with a marking in accordance with 68.3.7.
- b) A combination of an isolated transformer secondary winding and one or more resistors or a regulating network complying with 25.11 that complies with all the performance requirements for an inherently limited Class 2 transformer or power source, or
- c) A battery that is isolated from the primary circuit or a combination of a battery, including the battery charging circuit of a unit that is isolated from the primary circuit, and one or more resistors or a regulating network complying with 25.11.

2.28 MODULE – A packaged functional assembly component of the generator assembly, such as engine module or generator module.

2.29 MULTI-CELL BATTERY – A battery consisting, internally, of a series or parallel array of two or more cells.

2.30 PRESSURE TERMINAL CONNECTOR – A field wiring terminal that accomplishes the connection of one or more conductors by means of pressure without the use of solder. Examples of a pressure terminal connector are the:

- a) Barrel and setscrew type,
- b) Crimp-type barrel, or
- c) Clamping plate and screw type.

2.31 PRIMARY CIRCUIT – Wiring and components that are conductively connected to a branch circuit.

2.32 PROTECTED LOAD – Appliances and equipment connected to the alternating current output circuit of unit.

2.33 RESTRICTED ACCESS AREA – A location for equipment where the following apply:

- a) Access is only gained by service personnel who have been instructed of the reasons for the restrictions applied to the location and about any precautions that must be taken, and
- b) Access is through the use of a special tool, or lock and key, or other means of security and is controlled by the authority responsible for the location.

2.34 RISK OF ELECTRICAL ENERGY – HIGH CURRENT LEVELS – The risk for damage to property or injury to persons, other than by electric shock, from available electrical energy is determined to exist, when between a live part and an adjacent dead metal part or between live parts of different polarity, there exists a potential of 2 volts or more and either:

- a) An available continuous power level of 240 volt-amperes or more, or
- b) A reactive energy level of 20 joules or more.

For example, a tool, or other metal short-circuiting a component is capable of causing a burn or a fire when enough energy is available at the component to vaporize, melt, or more than warm the metal.

2.35 RISK OF ELECTRIC SHOCK – As defined in Electric Shock, Section 9.

2.36 RISK OF FIRE – A risk of fire exists at any component unless an investigation of the supply delivering power to that component complies with the criteria in 25.4 – 25.12.

2.37 SAFETY CIRCUIT – Any primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, injury to persons, or electrical energy – high current levels. For example, in some applications, an interlock circuit is a safety circuit.

2.38 SAFETY INTERLOCK – A means relied upon to reduce the accessibility to an area that results in risk of electric shock, electrical energy – high current levels, or injury to persons until the risk has been removed, or to automatically remove the risk when access is gained.

2.39 SECONDARY CIRCUIT – A circuit supplied from a secondary winding of an isolating transformer. See Section 27.

2.40 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.

2.41 STATIONARY UNIT – An engine generator that is intended to be hard wired and/or permanently installed.

2.42 SWITCH, LOCKOUT – An indicating type switch that provides a means to disconnect all ungrounded conductors and is also provided with a positive lockout in the off position.

2.43 SWITCH, TRANSFER - A device for transferring one or more load conductor connections from one power source to another.

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

2.45 USER – Any person other than service personnel.

2.46 USER ACCESS AREA – An area to which, under normal operating conditions, one of the following applies:

- a) Access is gained without the use of a tool;
- b) The means of access is deliberately provided to the operator; or
- c) The operator is instructed to enter regardless of whether or not tools are required to gain access. This includes control panels, behind locked doors, and inside of access covers.

2.47 ZERO GOVERNOR REGULATOR – A fuel regulating device in which pressure is reduced to zero at the fuel inlet to the engine; when a partial vacuum is created in the fuel line, suction will cause the regulator to open, thus allowing flow to the engine as long as the demand continues. This device is also known as a demand type regulator.

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3 Components

3.1 Except as indicated in 3.2, a component used as a part of a unit covered by this standard 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 standard.

3.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

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

3.4 Components that are incomplete in construction features or restricted in performance capabilities shall be used only under the specific conditions for which they have been evaluated.

4 Units of Measurement

4.1 Where a value for measurement is followed by a value in other units in parentheses, the first stated value is the requirement.

5 Undated References

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

CONSTRUCTION

6 Materials

6.1 The material of a part, such as an enclosure, a frame, a guard, or similar part, the breakage of which results in a risk of injury to persons, shall have such properties as to meet the demand of expected use conditions.

6.2 The requirement in 6.1 applies to those portions of a part adjacent to moving parts that involve a risk of injury to persons.

6.3 A part as specified in 6.1 shall withstand the impact test described in 63.2, without being affected to the extent that:

- a) The performance is adversely affected so as to result in a risk of injury, or
- b) Parts capable of causing injury to persons are exposed to unintentional contact.

Exception: A component such as a pilot lamp, lens, or control knob is not required to be subjected to the impact test.

7 Frame and Enclosure

7.1 General

7.1.1 A unit shall be provided with one or more enclosures that house all live parts. The enclosure shall protect the various parts of the unit against mechanical damage from forces external to the unit. The parts of the enclosure that are required to be in place to comply with the requirements for risk of fire, electric shock, injury to persons, and electrical energy – high current levels – shall comply with the applicable enclosure requirements specified in this standard. Terminals that do not present a risk of electric shock but do present a risk of electrical high energy levels such as battery terminals, starter relay/contactors terminals and terminals on engine-mounted battery-charging alternators within the engine compartment shall be insulated and secured in a manner where the terminal is not able to be removed except for servicing of the part and protected from contact by:

- a) An insulator that complies with the requirements in Insulating Materials, Section 34; or
- b) An insulating boot/barrier made from polyvinyl-chloride, neoprene or a rubber compound or material.

Exception: Live parts, including terminals, which do not present a risk of electric shock or a risk of electrical energy – high current levels, are not required to be enclosed.

7.1.2 The frame or chassis of a unit shall not be used to carry current during intended operation (see 19.11).

Exception: Engines used to carry current shall have voltages that are determined not to be a risk for electric shock, see Table 9.1.

7.1.3 A part, such as a dial, display face, or nameplate, that serves as a functional part of the enclosure shall comply with the enclosure requirements.

7.1.4 When an electrical instrument, such as a meter, forms part of the enclosure, the face or the back of the instrument housing, or both together, shall comply with the requirements for an enclosure.

Exception: A meter complying with the requirements in the Standard for Electrical Analog Instruments – Panel Board Types, UL 1437 is not required to comply.

7.2 Enclosures and guards

7.2.1 Whether a guard, a release, an interlock, or similar device is required and whether such a device is applicable shall be determined from an investigation of the complete unit, its operating characteristics, and the risk of injury to persons resulting from a cause other than gross negligence. The investigation shall include consideration of the results of breakdown or malfunction of any component; not more than one component at a time, unless one event contributes to another. When the investigation shows that breakdown or malfunction of a particular component results in a risk of injury to persons, that component shall be investigated for reliability.

7.2.2 The rotor of a motor, a pulley, a fan blade, a belt, a gear, or other moving part that is capable of causing injury to persons shall be enclosed or provided with other means to reduce the risk of unintentional contact therewith.

Exception: A part or portion of a part that is required to be exposed to perform the working function is not required to be enclosed and, when required, guarding shall be provided.

7.2.3 The degree of protection required by 7.2.2 depends upon the general construction and intended use of a unit. Protection for service personnel shall be provided such that the risk of unintentional contact with hazardous moving parts is greatly reduced during servicing operations involving other parts of the equipment.

7.2.4 A moving part that involves a risk of injury to persons shall comply with the requirements specified in Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts – and User Servicing, Section 8, taking into account:

- a) The degree of exposure required to perform its intended function,
- b) The sharpness of the moving part,
- c) The risk of unintentional contact with the moving part,
- d) The speed of the moving part, and

- e) The risk that a part of the body is endangered or the risk that clothing is capable of being entangled, resulting in a risk of injury to persons.

These factors are to be considered with respect to both intended operation and foreseeable misuse.

7.3 Access doors, covers, and panels

7.3.1 An access cover shall be hinged where it provides access to a fuse or other overload-protective device, the functioning of which requires renewal or resetting, or where it is required to open the cover in connection with intended operation of the unit. A means shall be provided to hold the cover closed.

Exception No. 1: A hinged cover is not required when the only overload-protective device enclosed is:

- a) Connected in a control circuit, provided the protective device and the circuit loads are within the same enclosure,*
- b) Rated 2 amperes or less for loads not exceeding 100 volt-amperes,*
- c) An extractor fuse having an integral enclosure, or*
- d) Connected in a low-voltage, limited-energy circuit.*

Exception No. 2: A hinged cover is not required for an enclosure that:

- a) Contains no user-serviceable or -operable parts, and*
- b) Is marked in accordance with 68.3.6.*

7.3.1.1 Hinged doors, covers, and panels that provide user or service access, including the function specified in 7.3.1, shall be constructed such that they open to no less than 90 degrees from the closed position.

Exception: A wind strap, chain, or similar attachment that may be detached without the use of tools to open the hinged door, cover, or panel to 90 degrees meets the intent of this requirement.

7.3.2 A door or cover that provides access to a fuse or other overload-protective device shall be tight-fitting or self-latching.

7.4 Cast metal enclosures

7.4.1 The thickness of cast metal for an enclosure shall be as specified in Table 7.1.

Exception: Cast metal of a lesser thickness is not prohibited when upon investigation (consideration being given to the shape, size, and function of the enclosure) it is found to be mechanically equivalent for the intended use.

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Table 7.1
Thickness of cast-metal enclosures

Use, or dimension of area involved	Minimum thickness, inch (mm)	
	Die-cast metal	Cast metal of other than the die-cast type
Area of 24 square inches (154.8 cm ²) or less and having no dimension greater than 6 inches (152 mm)	1/16 ^a (1.6)	1/8 (3.2)
Area greater than 24 square inches (154.8 cm ²) or having any dimension greater than 6 inches (152 mm)	3/32 (2.4)	1/8 (3.2)
At a threaded conduit hole	1/4 (6.4)	1/4 (6.4)
At an unthreaded conduit hole	1/8 (3.2)	1/8 (3.2)

^a The area limitation for metal 1/16 inch (1.6 mm) thick is obtained by the provision of reinforcing ribs subdividing a larger area.

7.5 Sheet metal enclosures

7.5.1 Sheet metal enclosures shall comply with 7.5.2 or the requirements in the Standard for Enclosures for Electrical Equipment, UL 50.

7.5.2 With reference to 7.5.1, the thickness of a sheet-metal enclosure shall not be less than that specified in Tables 7.2 and 7.3. Uncoated steel shall not be less than 0.032 inch (0.81 mm) thick, zinc-coated steel shall not be less than 0.034 inch (0.86 mm) thick, and nonferrous metal shall not be less than 0.045 inch (1.14 mm) thick for surfaces of an enclosure at which a wiring system is to be connected.

Exception No. 1: The thickness of a sheet metal enclosure is not prohibited from being less than specified in Tables 7.2 and 7.3 when investigated and determined to be mechanically equivalent.

Exception No. 2: The thickness of an enclosure may be two gauge sizes less than indicated in Tables 7.2 and 7.3, when uninsulated live parts are located at least 2-1/2 inches (64 mm) from the surface, and 4 gauge sizes less when the uninsulated live parts are located at least 5 in (128 mm) from the surface. The thickness shall be not less than No. 24 MSG or GSG (steel), or 18 AWG (aluminum, copper, or brass), unless a lesser thickness is acceptable in accordance with Tables 7.2 and 7.3. An example of 2 gauge sizes less is No. 18 MSG instead of No. 16 MSG; an example of 4 gauge sizes less is No. 20 MSG instead of No. 16 MSG.

Table 7.2
Thickness of carbon steel or stainless steel enclosures

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness inch (mm)	
Maximum width, ^b	Maximum length, ^c	Maximum width, ^b	Maximum length, ^c	Uncoated	Metal Coated
Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)		
4.0 (10.2)	Not limited	6.25 (15.9)	Not limited	0.020 ^d (0.51)	0.023 ^d (0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)		
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026 ^d (0.66)	0.029 ^d (0.74)
7.0 (17.8)	8.75 (22.2)	10.0 (25.4)	12.5 (31.8)		
8.0 (20.3)	Not limited	12.0 (30.5)	Not limited	0.032 (0.81)	0.034 (0.86)
9.0 (22.9)	11.5 (29.2)	13.0 (33.0)	16.0 (40.6)		
12.5 (31.8)	Not limited	19.5 (49.5)	Not limited	0.042 (1.07)	0.045 (1.14)
14.0 (35.6)	18.0 (45.7)	21.0 (53.3)	25.0 (63.5)		
18.0 (45.7)	Not limited	27.0 (68.6)	Not limited	0.053 (1.35)	0.056 (1.42)
20.0 (50.8)	25.0 (63.5)	29.0 (73.7)	36.0 (91.4)		

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Table 7.2 Continued on Next Page

Table 7.2 Continued

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness inch (mm)	
Maximum width, ^b	Maximum length, ^c	Maximum width, ^b	Maximum length, ^c	Uncoated	Metal Coated
Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)		
22.0 (55.9)	Not limited	33.0 (83.8)	Not limited	0.060 (1.52)	0.063 (1.60)
25.0 (63.5)	31.0 (78.7)	35.0 (88.9)	43.0 (109.2)		
25.0 (63.5)	Not limited	39.0 (99.1)	Not limited	0.067 (1.70)	0.070 (1.78)
29.0 (73.7)	36.0 (91.4)	41.0 (104.1)	51.0 (129.5)		
33.0 (83.8)	Not limited	51.0 (129.5)	Not limited	0.080 (2.03)	0.084 (2.13)
38.0 (103.4)	47.0 (119.4)	54.0 (137.2)	66.0 (167.6)		
42.0 (106.7)	Not limited	64.0 (162.6)	Not limited	0.093 (2.36)	0.097 (2.46)
47.0 (119.4)	59.0 (149.9)	68.0 (172.7)	84.0 (213.4)		
52.0 (132.1)	Not limited	80.0 (203.2)	Not limited	0.108 (2.74)	0.111 (2.82)
60.0 (152.4)	74.0 (188.0)	84.0 (213.4)	103.0 (261.6)		
63.0 (160.0)	Not limited	97.0 (246.4)	Not limited	0.123 (3.12)	0.126 (3.20)
73.0 (185.4)	90.0 (228.6)	103.0 (261.6)	127.0 (322.6)		

^a See 7.5.4 and 7.5.5.

^b The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure are not prohibited from having supports in common and being made of a single sheet.

^c "Not limited" applies only where the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

^d Sheet steel for an enclosure intended for outdoor use shall not be less than 0.034 inch (0.86 mm) thick when metal coated and not less than 0.032 inch (0.81 mm) thick when uncoated.

Table 7.3
Thickness of aluminum, copper, or brass enclosures

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness
Maximum width ^b	Maximum length ^c	Maximum width ^b	Maximum length	
inches (cm)	inches (cm)	inches (cm)	inches (cm)	inches (cm)
3.0 (7.6)	Not limited	7.0 (17.8)	Not limited	0.023 ^d (0.58)
3.5 (8.9)	4.0 (10.2)	8.5 (21.6)	9.5 (24.1)	
4.0 (10.2)	Not limited	10.0 (25.4)	Not limited	0.029 (0.74)
5.0 (12.7)	6.0 (15.2)	10.5 (26.7)	13.5 (34.3)	
6.0 (15.2)	Not limited	14.0 (35.6)	Not limited	0.036 (0.91)
6.5 (16.5)	8.0 (20.3)	15.0 (38.1)	18.0 (45.7)	
8.0 (20.3)	Not limited	19.0 (48.3)	Not limited	0.045 (1.14)
9.5 (24.1)	11.5 (29.2)	21.0 (53.3)	25.0 (63.5)	
12.0 (30.5)	Not limited	28.0 (71.1)	Not limited	0.058 (1.47)
14.0 (35.6)	16.0 (40.6)	30.0 (76.2)	37.0 (94.0)	
18.0 (45.7)	Not limited	42.0 (106.7)	Not limited	0.075 (1.91)
20.0 (50.8)	25.0 (63.4)	45.0 (114.3)	55.0 (139.7)	
25.0 (63.4)	Not limited	60.0 (152.4)	Not limited	0.095 (2.41)
29.0 (73.7)	36.0 (91.4)	64.0 (162.6)	78.0 (198.1)	
37.0 (94.0)	Not limited	87.0 (221.0)	Not limited	0.122 (3.10)
42.0 (106.7)	53.0 (134.6)	93.0 (236.2)	114.0 (289.6)	

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Table 7.3 Continued on Next Page

Table 7.3 Continued

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness inches (cm)
Maximum width ^b inches (cm)	Maximum length ^c inches (cm)	Maximum width ^b inches (cm)	Maximum length inches (cm)	
52.0 (132.1)	Not limited	123.0 (312.4)	Not limited	0.153 (3.89)
60.0 (152.4)	74.0 (188.0)	130.0 (330.2)	16.0 (406.4)	

^a See 7.5.4 and 7.5.5

^b The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure are not prohibited from having supports in common and being made of a single sheet.

^c "Not limited" applies only when the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

^d Sheet copper, brass, or aluminum for an enclosure intended for outdoor use shall not be less than 0.029 inch (0.74 mm) thick.

7.5.3 Tables 7.2 and 7.3 are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

7.5.4 With reference to Tables 7.2 and 7.3, a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has the same outside dimensions as the enclosure surface and that has the torsional rigidity to resist the bending moments that are applied via the enclosure surface. An example of a construction that has equivalent reinforcement is one that produces a structure that is as rigid as one built with a frame of angles or channels.

7.5.5 With reference to 7.5.4 and Tables 7.2 and 7.3, a construction does not have a supporting frame when it is:

- a) A single sheet with single formed flanges – formed edges,
- b) A single sheet that is corrugated or ribbed,
- c) An enclosure formed or fabricated from sheet metal, or
- d) An enclosure surface loosely attached to a frame – for example, by spring clips.

7.6 Nonmetallic enclosures

7.6.1 A polymeric enclosure or polymeric part of an enclosure shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

7.6.2 A nonmetallic part that forms part of the enclosure need not comply with the requirement in 7.6.1 under any one of the following conditions:

- a) The part covers an opening that has no dimension greater than 1 inch (25.4 mm) and the component is made of a material classed as V-0, V-1, V-2, or HB,
- b) The part is made of a material classed V-0, V-1, V-2, or HB and covers an opening which prohibits access to live parts involving a risk of fire, electric shock, or electric energy— high current levels – or moving parts to the user when the part is removed.
- c) The part covers an opening that has no dimension greater than 4 inches (101.6 mm) and the part is made of a material classed as V-0, V-1, V-2, or HB, and there is no source of a risk of fire (see 2.36) closer than 4 inches from the surface of the enclosure, or
- d) The part is made of a material classed V-0, V-1, V-2, or HB and there is a barrier or a device that forms a barrier made of a material classed V-0 between the part and a source of a risk of fire.

The flammability clarifications shall be in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: A part of a component need not be classed V-0, V-1, V-2, or HB when it complies with the flammability class applicable to the component.

7.6.3 A polymeric material enclosure having in any single unbroken section, a projected surface area greater than 10 square feet (0.93 m²), or a single linear dimension greater than 6 feet (1.83 m) shall have a flame-spread rating of 200 or less when tested in accordance with the:

- a) Standard for Test for Surface Burning Characteristics of Building Materials, UL 723, or
- b) Radiant-panel furnace method in the Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source, ASTM E162.

7.6.4 A material with a flame-spread rating higher than specified in 7.6.3 is not prohibited from being used as the exterior finish or covering on any portion of the enclosure when the flame-spread rating of the combination of the base material and finish or covering complies with 7.6.3.

7.6.5 A conductive coating applied to a nonmetallic surface (such as the inside surface of a cover or an enclosure) shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: When flaking or peeling of the coating does not result in a risk of fire or electric shock as a result of a reduction of spacings or the bridging of live parts, then the coating need not comply with UL 746C.

7.7 Glass covered openings

7.7.1 Glass covering an opening shall be secured in place so that it is not readily displaced in service, and provides mechanical protection for the enclosed parts. Glass for an opening shall comply with the following dimensions:

- a) Glass for an opening not more than 4 inches (102 mm) in any dimension shall not be less than 1/16 inch (1.6 mm) thick,
- b) Glass for an opening not more than 144 square inches (929 cm²) in area and having no dimension greater than 12 inches (305 mm) shall not be less than 1/8 inch (3.2 mm) thick, and
- c) Glass used to cover an area larger than noted in (b) shall not be less than 1/8 (3.2 mm) inch thick and shall:
 - 1) Be of a nonshattering or tempered type that, when broken, complies with the Glazing Materials Used in Buildings – Safety Performance Specifications and Methods of Test, ANSI Z97.1, or
 - 2) Be subjected to the test described in 63.1.1.

7.8 Openings for wiring

7.8.1 The requirements described in 7.8.2 – 7.8.9 apply to fixed units.

7.8.2 Where threads for the connection of conduit are tapped all the way through a hole in an enclosure wall or where an equivalent construction is employed, there shall not be less than three nor more than five threads in the metal, and the construction of the enclosure shall be such that a conduit bushing is capable of being properly attached. Where threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or similar device, there shall not be less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors equivalent to that provided by a standard conduit bushing with an internal diameter the same as that of the corresponding trade size of rigid conduit.

7.8.3 Clamps and fasteners for the attachment of conduit, electrical metallic tubing, armored cable, nonmetallic flexible tubing, nonmetallic-sheathed cable, service cable, and similar devices that are supplied as a part of an enclosure shall comply with the Standard for Metallic Outlet Boxes, UL 514A, and the Standard for Conduit, Tubing, and Cable Fittings, UL 514B.

7.8.4 A knockout in a sheet-metal enclosure shall be secured and shall be removable without undue deformation of the enclosure.

7.8.5 A knockout shall be provided with a flat surrounding surface intended for proper seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout to be used during installation does not result in spacing between an uninsulated live part and the bushing to be less than that specified in Spacings, Section 24.

7.8.6 In measuring a spacing between an uninsulated live part and a bushing installed in a knockout as specified in 7.8.5, it is to be assumed that a bushing having the dimensions specified in Table 7.4 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

Table 7.4
Knockout or hole sizes and dimensions of bushings

Trade size of conduit	Knockout or hole diameter		Bushing dimensions			
			Overall diameter		Height	
Inches	Inches	mm	Inches	mm	Inches	mm
1/2	7/8	22.2	1	25.4	3/8	9.5
3/4	1-3/32	27.8	1-15/64	31.4	27/64	10.7
1	1-23/64	34.5	1-19/32	40.5	33/64	13.1
1-1/4	1-23/32	43.7	1-15/16	49.2	9/16	14.3
1-1/2	1-31/32	50.0	2-13/64	56.0	19/32	15.1
2	2-15/32	62.7	2-45/64	68.7	5/8	15.9
2-1/2	3	6.2	3-7/32	81.8	3/4	19.1
3	3-5/8	92.1	3-7/8	98.4	13/16	20.6
3-1/2	4-1/8	104.8	4-7/16	112.7	15/16	13.8
4	4-5/8	117.5	4-31/32	126.2	1	25.4
4-1/2	5-1/8	130.2	5-35/64	140.9	1-1/16	27.0
5	5-5/8	42.9	6-7/32	158.0	1-3/16	30.2
6	6-3/4	171.5	7-7/32	183.4	1-1/4	31.8

7.8.7 For an enclosure not provided with conduit openings or knockouts, spacings not less than the minimum specified in Spacings, Section 24 shall be provided between uninsulated live parts and a conduit bushing installed at any location to be used during installation. Permanent marking on the enclosure, a template, or a drawing furnished with the unit is used to specify such a location. The specified location of the openings shall be such that damage to internal parts shall not result when openings are made.

7.8.8 With respect to the requirement in 7.8.7, means shall be provided so that an opening for conduit is capable of being made without subjecting internal parts to contamination resulting from the presence of metallic particles. Compliance with this requirement is accomplished by the use of a removable, bolted plate.

7.8.9 A polymeric- or metal-closure plug for an unused conduit opening shall comply with the requirements in the Standard for Metallic Outlet Boxes, UL 514A.

7.9 Openings in an enclosure

7.9.1 The enclosure of a unit shall be designed and constructed to reduce the risk of emission of flame, molten metal, flaming or glowing particles, or flaming drops.

7.10 Enclosure bottom openings

7.10.1 A complete noncombustible bottom or a construction employing individual noncombustible barriers under components, groups of components, or assemblies, as specified in Figure 7.1 is required in accordance with 7.9.1.

Exception No. 1: Ventilating openings in the bottom panel are not prohibited when noncombustible baffle plates are provided to reduce the risk of materials from falling directly from the interior of the unit onto the supporting surface or any other location under the unit. An example of such a baffle is illustrated in Figure 7.2.

Exception No. 2: Ventilation openings in the bottom of an enclosure are not prohibited when the openings incorporate a perforated metal plate as described in Table 7.5, or a galvanized or stainless steel screen having a 14- by 14-mesh per inch (25.4-mm) constructed of wire with a diameter of 0.018 inch (0.4 mm) minimum.

Exception No. 3: Other constructions complying with the hot, flaming oil test in Ignition Test Through Bottom Panel Openings, Section 65, need not comply with this requirement.

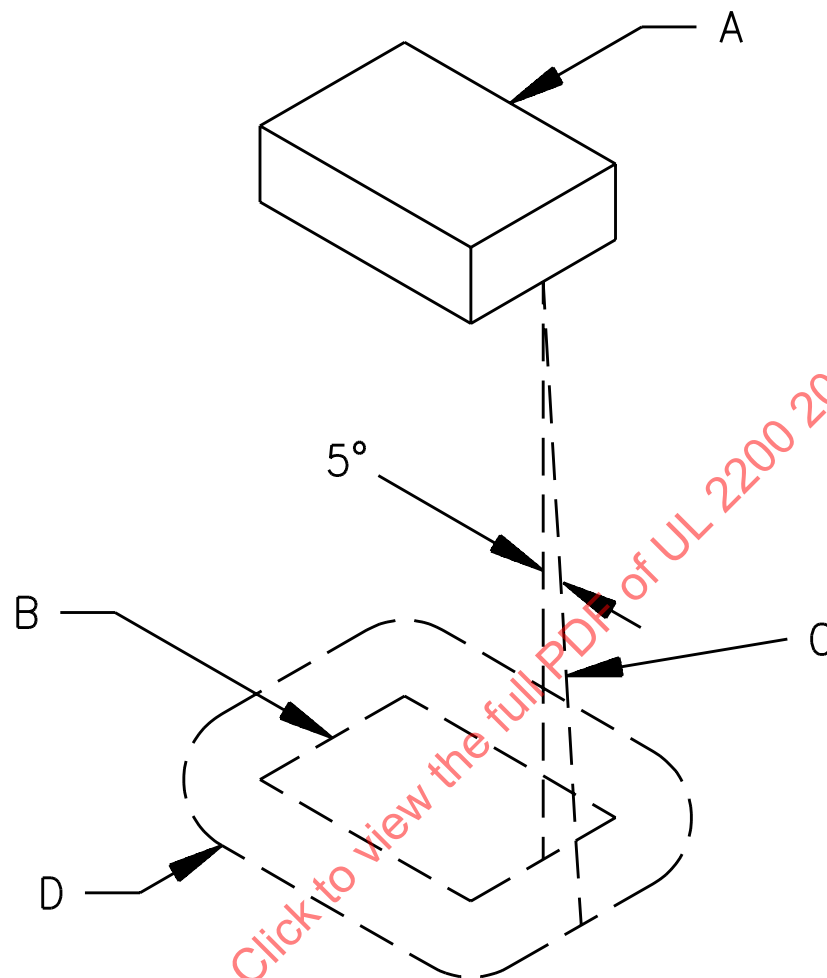
Exception No. 4: The bottom of the enclosure under areas containing only materials classed V-1 or better in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, shall have openings no larger than 1/4 inch (6.4 mm) square. Openings that are not square shall not have an area greater than 1/16 square inch (40 mm²).

Exception No. 5: Ventilating openings without limitation on their size and number and complying with 8.12 and provided in the bottom panel are not prohibited when in areas that contain only wires, cables, plugs, receptacles, transformers, and impedance protected or thermally protected motors.

Exception No. 6: Ventilating openings are not prohibited in the bottom panel when:

- a) The installation instructions state that the generator assembly shall be installed over non combustible materials, and*
- b) The generator assembly is located such that it prevents combustible materials from accumulating under the generator set.*

Figure 7.1
Enclosure bottom



EB120A

A – Region to be shielded by barrier. This consists of the entire component when it is not otherwise shielded, and of the unshielded portion of a component which is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line which traces out minimum area of barrier. When moving, the line is always:

- 1) Tangent to the component,
- 2) Five degrees from the vertical, and
- 3) So oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

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Figure 7.2
Example of a bottom-enclosure baffle

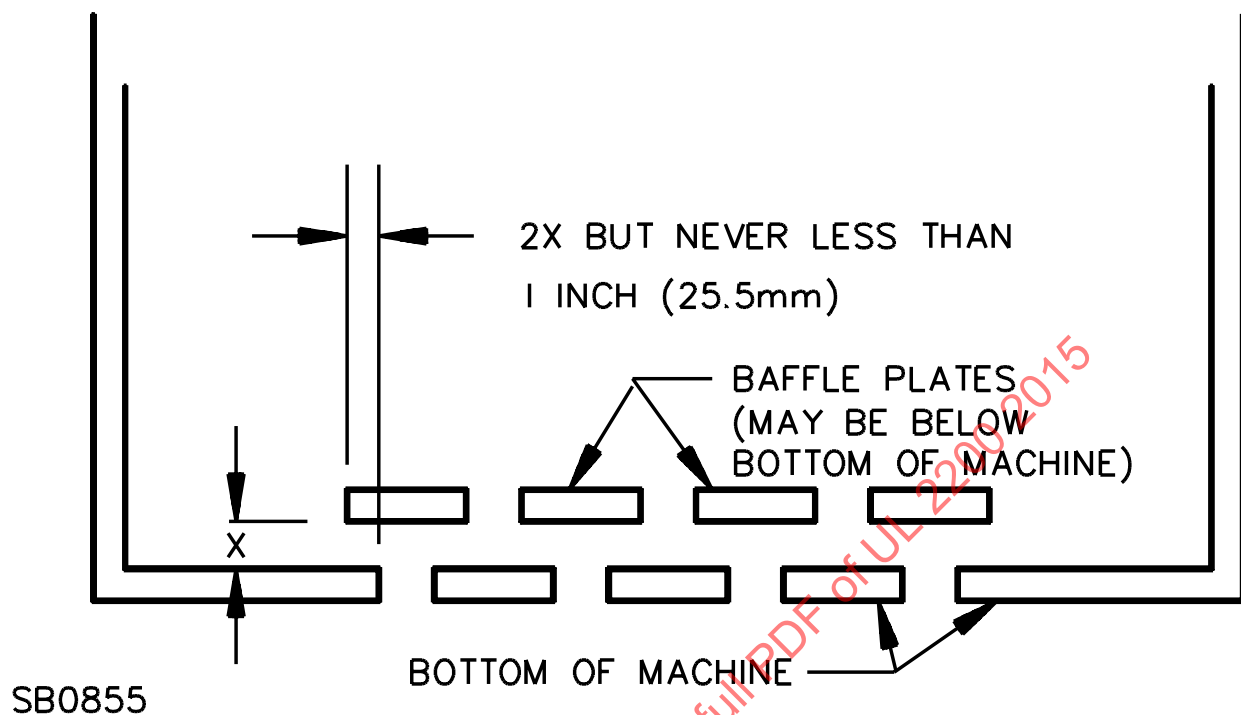


Table 7.5
Perforated metal plates for enclosure bottom

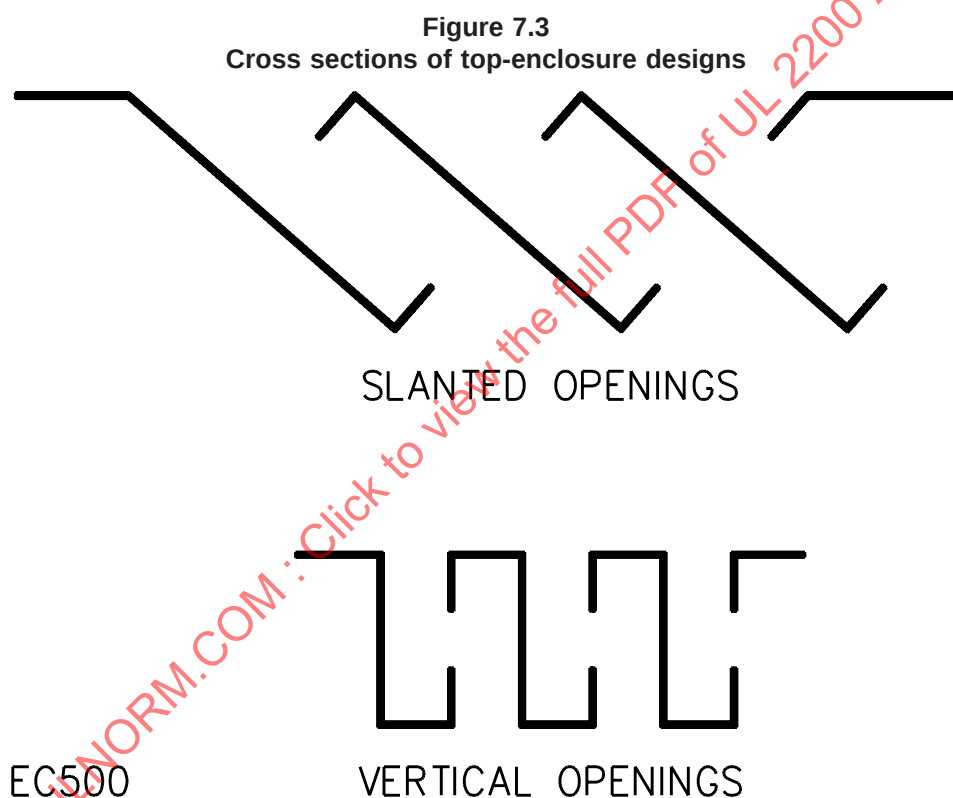
Minimum thickness		Maximum diameter of holes		Minimum spacings of holes center to center	
inch	(mm)	inch	(mm)	inch	(mm)
0.026	(0.66)	0.045	(1.14)	0.067	(1.70)
				233 holes per inch ² (645 mm ²)	
0.026	(0.66)	0.047	(1.19)	0.093	(2.36)
0.030	(0.76)	0.045	(1.14)	0.067	(1.70)
0.030	(0.76)	0.047	(1.19)	0.093	(2.36)
0.032	(0.81)	0.075	(1.91)	0.125	(3.18)
				72 holes per inch ² (645 mm ²)	
0.035	(0.89)	0.075	(1.90)	0.125	(3.18)
0.036	(0.91)	0.063	(1.60)	0.109	(2.77)
0.036	(0.91)	0.078	(1.98)	0.125	(3.18)
0.039	(0.99)	0.063	(1.60)	0.109	(2.77)
0.039	(0.99)	0.079	(2.00)	0.118	(3.00)

Note – In accordance with Exception No. 2 to 7.10.1.

7.11 Enclosure top openings

7.11.1 The minor dimension (see 8.8) of any opening in the top of an enclosure directly over an uninsulated live part involving a risk of electric shock or electrical energy – high current levels – shall not exceed 3/16 inch (4.8 mm) unless the configuration is such that direct vertical entry of a falling object is prevented from reaching such uninsulated live parts by means of a trap or restriction. See Figure 7.3 for examples of top surface openings that prevent direct entry.

Exception: Openings located 6 feet (1.8 meters) or higher from the floor, when the unit is installed in accordance with the manufacturer's instructions, are not prohibited from having a dimension greater than 3/16 inch (4.8 mm). Such openings shall comply with the accessibility requirements in Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts – and User Servicing, Section 8.



7.12 Sharp edges

7.12.1 An enclosure, a frame, a guard, a handle, or similar device shall have smooth well rounded edges that do not constitute a risk of injury to persons in normal maintenance and use.

Exception: This requirement does not apply to a part or portion of a part that is required to be sharp to perform a working function.

7.12.2 Wherever reference measurements are required to determine that a part as specified in 7.12.1 is not sharp enough to constitute a risk of injury to persons, the method described in the Standard for Tests for Sharpness of Edges on Equipment, UL 1439 shall be employed.

8 Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts – and User Servicing

8.1 The requirements in this section apply to parts that are accessible to the user. For protection of service personnel requirements, refer to Protection of Service Personnel, Section 39.

8.2 Uninsulated live parts at a potential involving a risk of electric shock, risk of electrical high energy levels, or risk of injury due to moving parts that are located in an area containing access to controls or disconnects by the user shall be insulated or enclosed to reduce the likelihood of contact with such parts, regardless of their location.

8.3 Engine generator assemblies intended to be located within a restricted access area are not considered user accessible when provided with the following:

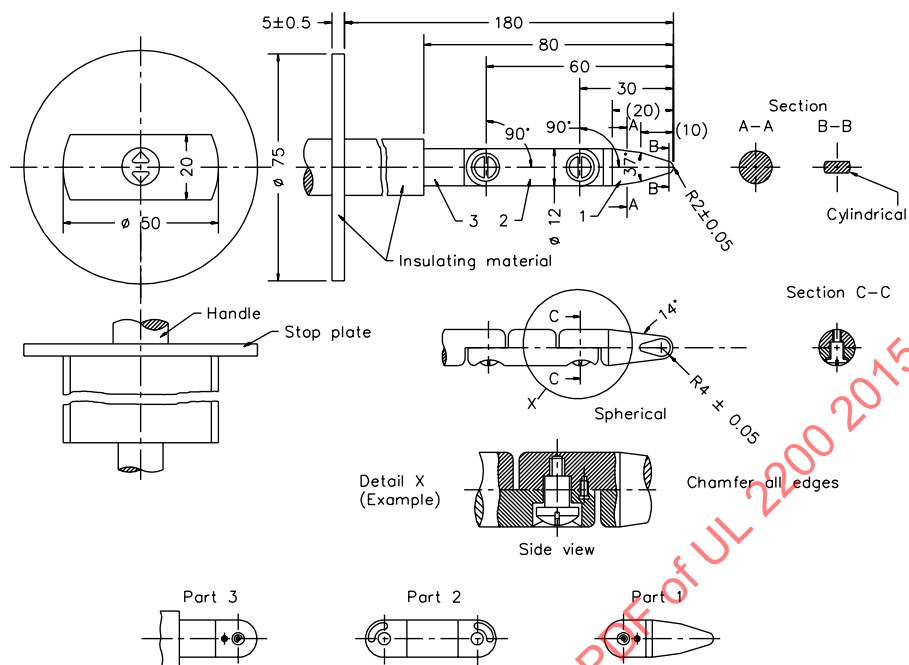
- a) Marked as required by 68.3.14; and
- b) Provided with instructions as specified in 69.1.4(s).

8.4 To reduce the risk of unintentional contact that involves a risk of electric shock from an uninsulated live part or film-coated wire, electrical energy – high current levels, or injury to persons from a moving part, an opening in an enclosure shall comply with either (a) or (b):

- a) For an opening that has a minor dimension (see 8.8) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 8.1.
- b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 8.1.

Exception: An opening in an integral enclosure of a motor is not required to comply with these requirements when it complies with the requirements in 8.5.

Figure 8.1
Articulate probe



SA1788A

Table 8.1

Minimum distance from an opening to a part that involves a risk of electric shock, electrical energy-high current level, or injury to persons

Minor dimension of opening ^{a,b}		Minimum distance from opening to part ^b	
Inches	(mm)	Inches	(mm)
3/4 ^c	(19.1)	4-1/2	(114.0)
1 ^c	(25.4)	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(190.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(444.0)
d		30	(762.0)

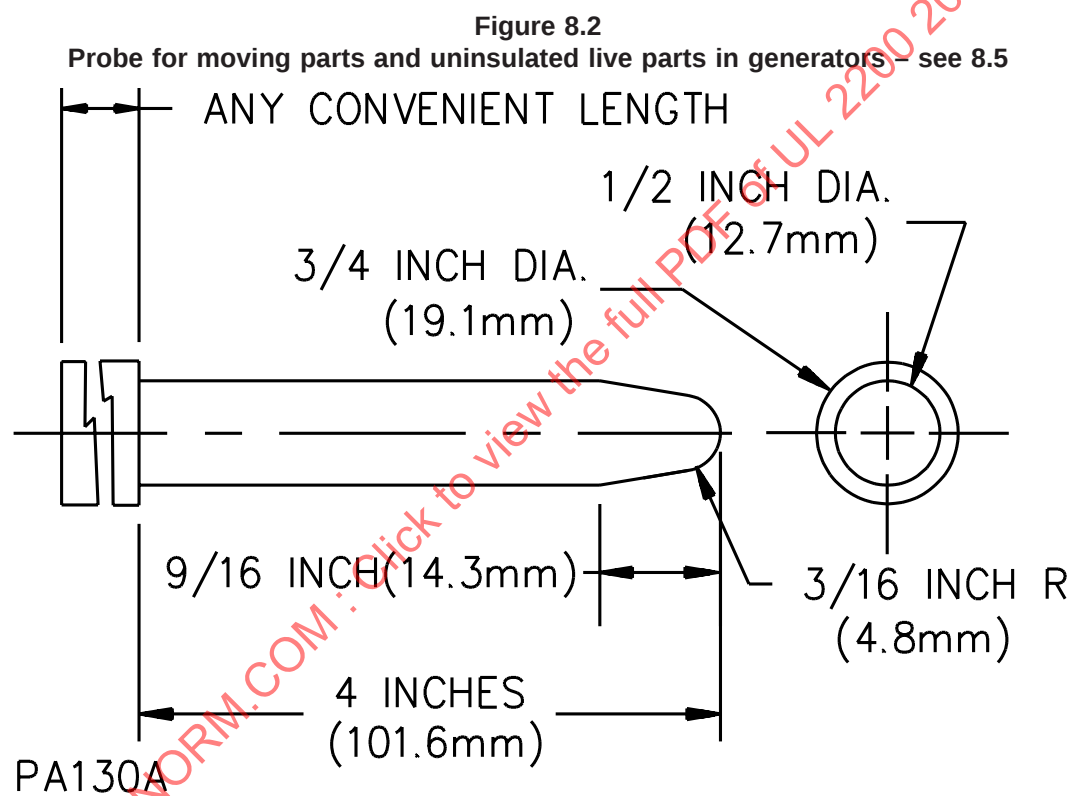
^a See 8.8.
^b Between 3/4 and 2-1/8 inches (19.1 and 54.0 mm), interpolation is to be used to determine a value between values specified in the table.
^c Any dimension less than 1 inch (25.4 mm) applies to a generator only.
^d More than 2-1/8 inches (54.0 mm) and not more than 6 inches (152.0 mm).

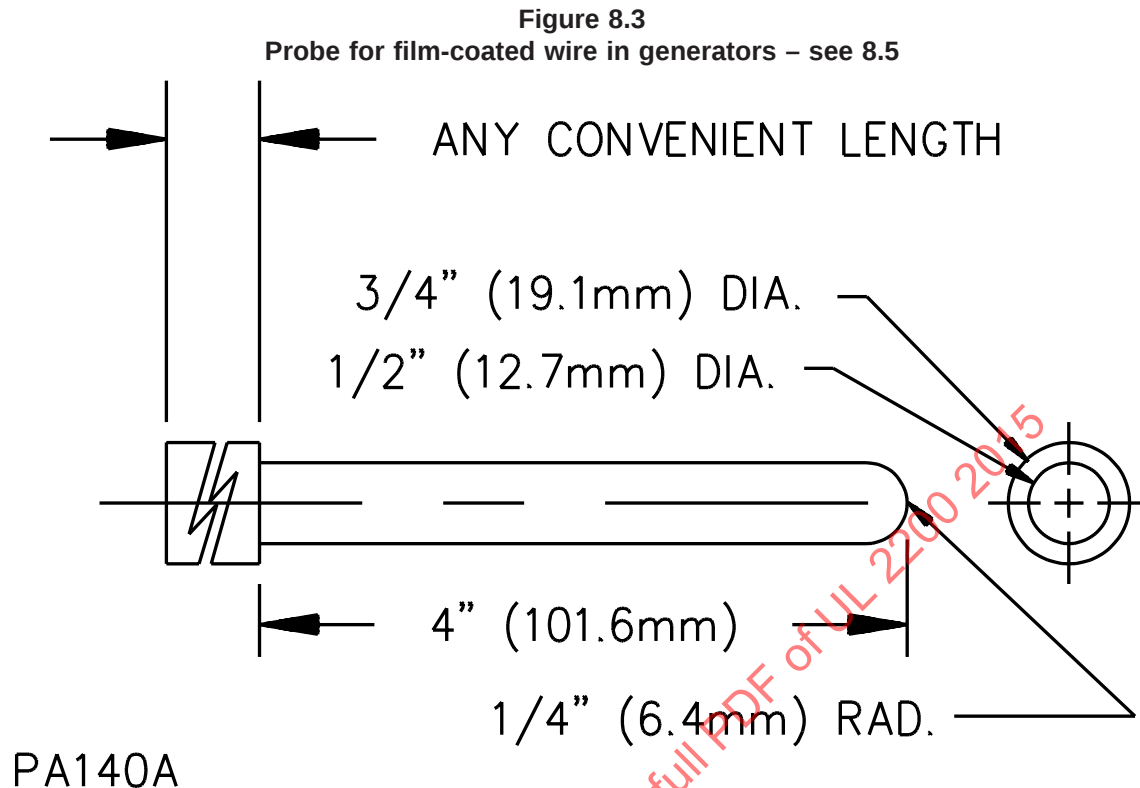
8.5 With respect to a part or wire as specified in 8.4, in an integral enclosure of a generator as specified in the Exception to 8.4:

a) An opening that has a minor dimension (see 8.8) less than 3/4 inch (19.1 mm) complies when:

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- 1) A moving part is not contacted by the probe illustrated in Figure 8.2,
 - 2) Film-coated wire is not contacted by the probe illustrated in Figure 8.3,
 - 3) In a directly accessible generator (see 8.10), an uninsulated live part is not contacted by the probe illustrated in Figure 8.1, and
 - 4) In an indirectly accessible generator (see 8.9), an uninsulated live part is not contacted by the probe illustrated in Figure 8.2.
- b) An opening that has a minor dimension of $\frac{3}{4}$ inch (19.1 mm) or more complies when a part or wire is spaced from the opening as specified in Table 8.1.





8.6 The probes specified in 8.4 and 8.5 and illustrated in Figures 8.1 – 8.3 shall be applied to the maximum possible depth of the opening; and shall be rotated or angled before, during, and after insertion through the opening to any position that is required to examine the enclosure. The probe illustrated in Figure 8.1 shall be applied in any possible configuration; and, where required, the configuration shall be changed after insertion through the opening.

8.7 The probes specified in 8.6 shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they shall be applied with a maximum force of 1 pound (4.4 N).

8.8 With reference to the requirements in 8.4 and 8.5, the minor dimension of an opening is the diameter of the largest cylindrical probe that is inserted through the opening.

8.9 With reference to the requirements in 8.5, an indirectly accessible generator is a generator:

- a) That is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that is opened or removed without using a tool (see 2.44),
- b) That is guarded or enclosed so that the risk of contact is small, or
- c) That is determined to have a low risk of contact (see 8.11) due to its location.

8.14 With reference to the requirements in 8.4 and 8.5, insulated brush caps are not required to be additionally enclosed.

8.15 The maximum voltage of a battery supply of a unit employing batteries intended for user replacement shall not exceed 60 volts.

8.16 Uninsulated live parts at a potential involving a risk of electric shock that are located in the area containing batteries intended for replacement by the user shall be insulated or enclosed to reduce the risk of contact with such parts, regardless of their location.

8.17 The instruction manual for a unit containing batteries intended for user installation or replacement shall include instructions for battery replacement as specified in 69.1.4.

9 Electric Shock

9.1 Voltage

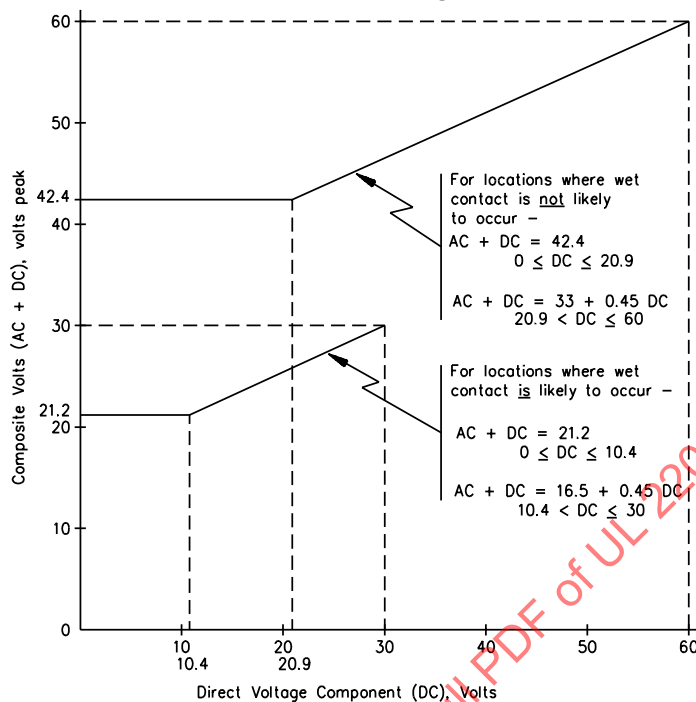
9.1.1 The requirements described in 9.1.2 – 9.2.2 are used to determine when the voltage of an accessible live part poses a risk for electric shock. Determination of whether a live part is accessible to users and service personnel is specified in Section 8, Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts – and User Servicing, and Section 39, Protection of Service Personnel.

9.1.2 A live part is determined not to be a risk for electric shock when the voltage of the part does not exceed the values specified in Table 9.1.

Table 9.1
Risk of electric shock – maximum voltage

Voltage type	Indoor-use units (wet contact not likely)	Outdoor-use units (wet contact likely – immersion not included)
1. Sinusoidal, ac	30 V, rms	15 V, rms
2. Nonsinusoidal, ac	42.4 V, peak	21.2 V, peak
3. Pure dc	60 V	30 V
4. DC interrupted at a rate of 10 to 200 Hertz	24.8 V, peak	12.4 V, peak
5. Combinations of dc and sinusoidal ac at frequencies not greater than 100 Hertz	See Figure 9.1	See Figure 9.1

Figure 9.1
Maximum voltage



S3253A

9.2 Stored energy

9.2.1 The capacitance between capacitor terminals that are accessible as determined by the requirements in Section 8, Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts – and User Servicing, and Section 39, Protection of Service Personnel, shall satisfy the following expressions:

$$V < 40,000$$

$$V < 729 C^{-0.7}$$

$$V < 367$$

$$V < 2314 C^{-0.7}$$

$$V < 60$$

$$V < 2314 C^{-0.7}$$

$$V < 30$$

where $C < 0.00328$

where $0.00328 \leq C < 2.67$

where $2.67 \leq C < 13.9$

where $13.9 \leq C < 184.5$ in a DRY environment

where $C \geq 184.5$ in a DRY environment

where $13.9 \leq C < 497$ in a WET environment

where $C \geq 497$ in a WET environment

In which:

C is the capacitance of the capacitor in microfarads; and

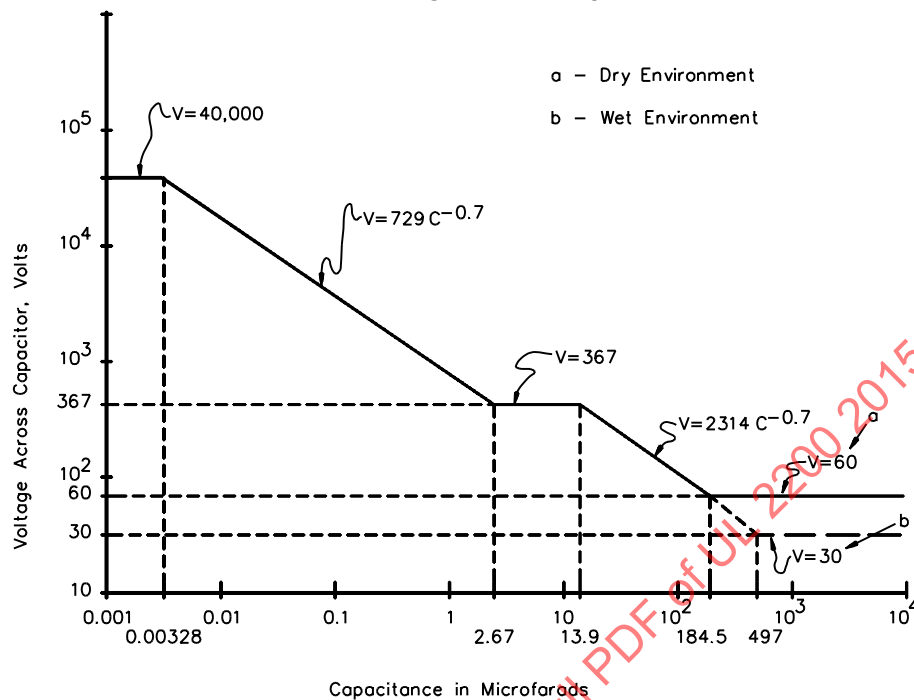
V is the voltage across the capacitor in volts. *V* is to be measured 5 seconds after the capacitor terminals are accessible by the removal or opening of an interlocked cover, or similar device. Typical calculated values appear in Table 9.2, and the equation is shown graphically in Figure 9.2.

Table 9.2
Risk of electric shock – stored energy current

Environment	Capacitance in microfarads ^a	Maximum voltage across the capacitor, in volts
Wet or Dry	0.00328 or less	40,000
	0.005	29,749
	0.01	18,313
	0.02	11,273
	0.05	5,936
	0.1	3,654
	0.2	2,249
	0.5	1,184
	1.0	729
	2.0	449
	2.0	449
	2.67 to 13.9	367
	20.0	284
	50.0	150
	100.0	92.1
Dry only	184.5	60.0
	184.5 or more	60.0
Wet	200	56.7
	497 or more	30.0

^a See 9.2.1 and Figure 9.2.

Figure 9.2
Limited for voltage across capacitance



S3260

9.2.2 With reference to 9.2.1, a part involving a potential of more than 40 kilovolts peak is to be investigated to determine whether or not it involves a risk of electric shock.

10 Corrosion Protection

10.1 Iron and steel parts shall be protected against corrosion by painting, galvanizing, sherardizing, plating, or other equivalent means. This requirement applies to all enclosure parts, whether of sheet steel or cast iron, and to all springs and other parts upon which intended mechanical operation depends. Bearing surfaces shall be of such materials and constructed so that binding due to corrosion is inhibited.

Exception: The parts specified in (a) – (d) are not required to be protected against corrosion:

- a) Bearings, or similar devices, where such protection is impracticable,
- b) A minor part, such as a washer, screw, bolt, or similar device where the failure of such unprotected parts does not result in a risk of fire, electric shock, electrical energy-high current levels, or injury to persons, or the operation of the unit being affected adversely,
- c) A decorative grille that is not required to form a part of the enclosure, and
- d) A part made of stainless steel (properly polished or treated, where required).

10.2 OUTDOOR-USE UNITS – See Section 71.

11 Mechanical Assembly

11.1 Loosening of parts in a unit as a result of vibration due to handling and operation of the unit shall not result in a risk of fire, electric shock, injury to persons, or electrical energy – high current levels.

11.2 Screws with properly applied lock washers, screws tightened by means of a power tool, rivets, and staked and upset screws are not subject to loosening. See 11.3.

11.3 The construction of staked and upset screws is to consist of an interference fit between the nut and bolt resulting in uneasy turning of the screw. This is accomplished by:

- a) The use of a center punch applied to the end of a bolt after assembly,
- b) Mismatching of the nut and bolt threads, or
- c) The equivalent.

11.4 A rotating part that, when loosened, results in a risk of fire, electric shock, electrical energy – high current levels, or injury to persons shall be assembled so that the direction of rotation tends to tighten the means that hold the rotating part in place.

Exception: A keyed part, a press fit, a part locked in place with a pin, or equivalent means used to hold a rotating part in place is not prohibited.

11.5 A switch, fuseholder, lampholder, AC convenience receptacle, motor-attachment plug, or other component that is handled by the operator shall:

- a) Be mounted securely,
- b) Not turn, and
- c) Comply with the requirements specified in 11.6.

Exception: The requirement that a switch shall not turn does not apply when all the following conditions are met:

- a) The switch is of a plunger, slide, or other type that does not tend to rotate during intended operation (a toggle switch is considered to be subjected to forces that tend to turn the switch),*
- b) The means of mounting the switch does not loosen the switch during operation,*
- c) Spacings are not reduced below the minimum required value when the switch rotates, and*
- d) Intended operation of the switch is by mechanical means rather than by direct contact by persons.*

11.6 The means of securing components specified in 11.5 shall include more than friction between surfaces. A lock washer is not prohibited from being used as a means to secure a device having a single-hole mounting means.

11.7 A blower or fan motor including the blower or fan blade itself shall be secured by any of the following or equivalent means in order to reduce the risk of the motor, blower, or fan blade from vibrating loose and falling from its mounting support:

- a) Bolts, screws and nuts complying with 11.3,
- b) Bolts, screws and nuts having holes or slots with properly applied cotter pins,
- c) Bolts and screws having a compression type lock nut,
- d) Rivets.

Exception: A blower or fan motor, including the blower or fan blade itself, secured by means described in 11.2 and oriented, positioned, or located above a barrier such that either the motor, blower, or fan blade does not contact other components resulting in a risk of fire, electric shock, or electrical energy – high current levels in the event that such parts vibrated loose from their support, is not required to comply with this requirement.

12 Switches and Controls

12.1 A switch or other control device shall have current and voltage ratings not less than those of the circuit that it controls when the unit is operated in its intended manner.

12.2 A primary-circuit switch that controls an inductive load having a power factor less than 75 percent, such as a transformer or some ballasts and that does not have an inductive rating, shall be either:

- a) Rated not less than twice the maximum load current under normal operating conditions, or
- b) Investigated for the application.

12.3 A switch used to connect a load to various sources or potentials shall be a type that has been investigated and rated for such use. This includes switches used for switching a voltmeter, frequency meter, and power factor meter between various phases.

12.4 A switch or other device controlling a relay, solenoid coil, or similar device shall have a pilot duty rating.

12.5 Each pole of a snap switch rated as a 2-circuit, 3-circuit, or multicircuit switch is not prohibited from controlling a separate load at the full voltage rating of the switch. Each pole of a snap switch rated as a 240-volt, 2-pole switch is not prohibited from controlling a separate 120-volt load. Both poles are not prohibited from being used to control both legs of a single 240-volt load. Each pole of a snap switch rated as a 240-volt, 3-pole switch is not prohibited from controlling a separate load not exceeding 139 volts. The three poles are not prohibited from being used to control the three legs of a 3-phase, 240-volt load.

12.6 A 240-volt or 250-volt snap switch used in a circuit involving more than 120 volts to ground shall be rated for such use as indicated by a double underlining under the voltage rating.

12.7 A switch shall not disconnect the grounded conductor of a circuit unless:

Exception No. 1: The grounded conductor is disconnected by a switch that simultaneously disconnects all conductors of the circuit.

Exception No. 2: The grounded conductor is disconnected by a switch that is so arranged that the grounded conductor is not disconnected until the ungrounded conductors of the circuit have been disconnected.

12.8 A transfer switch used to connect the load shall comply with requirements in the Standard for Transfer Switch Equipment, UL 1008.

12.9 Mechanical and electromechanical switches shall comply with the applicable requirements for switches such as in the Standard for General-Use Snap Switches, UL 20, the Standard for Industrial Control Equipment, UL 508, or other applicable standards.

12.10 When a unit switch or circuit breaker is mounted such that movement of the operating handle between the on position and off position results in one position being above the other position, the upper position shall be the on position. This requirement does not apply to:

- a) A switching device having more than one on position (such as a bypass switch),
- b) A double throw switch,
- c) A rotationally-operated switch, or
- d) A rocker switch.

13 Alternators and Generators

13.1 The alternator or generator relied upon to provide rated output power shall comply with the Standard for Electric Generators, UL 1004-4.

14 Disconnection Device

14.1 The generator assembly shall be provided with a disconnection device or a lockout switch that positively prevents the startup and operation of the generator assembly.

14.2 When a disconnection device is provided it shall:

- a) Open all ungrounded conductors,
- b) Consist of either a manually operated switch or circuit breaker,
- c) Employ an operating handle that is either accessible from outside of the enclosure or located under a hinged cover not requiring a tool for opening, and
- d) Be marked in accordance with 68.2.15.

14.3 A signal contact shall be available to indicate that the generator assembly is out of service when the disconnect device is open or the lockout switch is operated.

15 Disconnects Used in Service Equipment Applications

15.1 An engine generator assembly provided with a disconnect means intended to comply with service equipment rating requirements as defined in Article 225.36 of the National Electrical Code, NFPA 70, shall comply with the Reference Standard for Service Equipment, UL 869A.

16 Output Connections

16.1 General

16.1.1 A unit shall have provision for connection of a wiring system. This provision shall consist of:

- a) Either wiring terminals as specified in 16.1.4 – 16.1.14 or wiring leads as specified in 16.1.4 and 16.1.15 – 16.1.19, and
- b) A means for connection of cable or conduit as specified in 16.1.22 and 16.2.1.

Exception: The requirements described in 16.1.4 – 16.1.22 do not apply to the means for connection to accessible signal circuits complying with the requirements specified in Accessible Signal Circuits, Section 26.

16.1.2 When the generator is provided with AC convenience receptacles in addition to the output connections in 16.1.1, the AC convenience receptacle shall comply with 16.4.

16.1.3 The requirement in 16.1.1 applies to the wiring connection means for the output power circuits of a unit. These connections are intended to be made in the field when the unit is installed.

16.1.4 A field wiring terminal shall be sized for the connection of a conductor having an ampacity based on Table 310-16 of the National Electrical Code, NFPA 70, of no less than 115 percent of the maximum rated current to the first distribution device(s) containing overcurrent protection.

16.1.5 A field wiring terminal shall comply with the requirement in 16.1.4 for a wire of each metal for which it is marked. See 68.2.7.

16.1.6 A field wiring terminal shall be provided with a pressure terminal connector of other than the crimping type that is securely fastened in place – for example, firmly bolted or held by a screw.

Exception No. 1: A pressure terminal connector, including a crimping type, when used is field-installed in accordance with 16.1.8.

Exception No. 2: A wire-binding screw employed at a wiring terminal intended for connection of a 10 AWG (5.3 mm²) or smaller conductor is not prohibited when upturned lugs, a cupped washer, or the equivalent is provided to hold the wire in position.

16.1.7 A field wiring terminal shall be prevented from turning or shifting in position by a means other than friction between surfaces. This is to be accomplished by two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by an equivalent method.

Exception: A pressure terminal connector of the type that secures the wire by crimping and used in accordance with the requirements in 16.1.8 is not prohibited from turning when the least spacing between adjacent terminals and also between terminals and dead metal parts, complies with Spacings, Section 24 for when connectors are oriented in such a position that results in these spacings.

16.1.8 In accordance with Exception No. 1 to 16.1.6, a pressure terminal connector is not required to be provided when the conditions in (a) – (e) are met:

- a) One or more component terminal assemblies shall be available from the unit manufacturer or others, and they shall be specified in the instruction manual. See 69.1.4 (b) and (c).
- b) The fastening hardware such as a stud, nut, bolt, spring or flat washer, or similar device, as required for an effective installation, shall either be:
 - 1) Provided as part of the terminal assembly,
 - 2) Mounted on or separately packaged with the unit, or
 - 3) Specified in the instruction manual.
- c) The installation of the terminal assembly shall not involve the loosening or disassembly of parts other than a cover or other part giving access to the terminal location. The means for securing the terminal connector shall be readily accessible for tightening before and after installation of conductors.
- d) When the pressure terminal connector provided in a terminal assembly requires the use of other than a tool for securing the conductor, identification of the tool and any required instructions shall be included in the assembly package or with the unit. See 69.1.4(d).

e) Installation of the pressure terminal connector in the intended manner shall result in a unit complying with the requirements of this standard.

16.1.9 An insulating base for support of a pressure terminal connector shall be subjected to the test described in 58.1 and 58.2.

16.1.10 A wire-binding screw at a field-wiring terminal shall not be smaller than No. 10 (4.8 mm diameter).

Exception No. 1: A No. 8 (4.2 mm diameter) screw is used at a terminal intended only for the connection of a:

a) 14 AWG (2.1 mm²) conductor, or

b) A 16 or 18 AWG (1.3 or 0.82 mm²) control-circuit conductor.

Exception No. 2: A No. 6 (3.5 mm diameter) screw is used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm²) control-circuit conductor.

16.1.11 A wire-binding screw shall thread into metal.

16.1.12 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick.

Exception: A terminal plate less than 0.050 inch (1.27 mm) thick is not prohibited for use in a LVLE circuit or limited energy circuit (see 2.24 and 2.27) when the tapped threads have the mechanical strength to withstand the tightening torque specified in Table 16.1 without stripping.

Table 16.1
Tightening torque for wire-binding screws

Size of terminal screw, number	Wire sizes to be tested, AWG ^a	Tightening torque	
		Pound-inches	Newton meters
6	16 – 18 (ST)	12	1.4
8	14 (S) and 16 – 18 (ST)	16	1.8
10	10 – 14 (S) and 16 – 18 (ST)	20	2.3

^a ST – stranded wire; S – solid wire.

16.1.13 There shall be two or more full threads in the metal of a terminal plate. Extruding the metal at the tapped hole to provide at least two full threads is not prohibited.

Exception: Two full threads are not required for a terminal in a LVLE or limited-energy circuit (see 2.24 and 2.27) when a lesser number of threads results in a secure connection in which the threads do not strip when subjected to the tightening torque specified in Table 16.1.

16.1.14 A terminal for connection of a grounded conductor of an alternating current power circuit shall be identified as described in 68.2.10.

16.1.15 A field-wiring lead shall not be more than two wire sizes smaller than the copper conductor to which it is connected, and shall not be smaller than 18 AWG (0.82 mm²), for example, a 10 AWG (5.3 mm²) or larger field-wiring lead is required for connection to a 6 AWG (13.3 mm²) field-provided conductor. A field-wiring lead shall not be less than 6 inches (152.4 mm) long.

Exception No. 1: A 18 AWG size field-wiring lead is not prohibited for connection to a 12 AWG (3.3 mm²) size branch circuit conductor.

Exception No. 2: A lead, more than two wire sizes smaller than the field-provided copper conductor to which it is connected, and not smaller than 18 AWG (0.82 mm²), is not prohibited when more than one factory-provided copper lead is intended for connection to the same field-provided lead, and the construction complies with the conditions in (a) – (c):

- a) A wire connector for connection of the field-provided wire is provided as part of the unit or remote-control assembly, and the wire connector is intended for the combination of wires that are spliced,*
- b) The factory-provided leads are bunched or otherwise arranged so that stress does not result on an individual lead, and*
- c) Instructions are provided in accordance with 69.1.4(e).*

Exception No. 3: The requirements in 16.1.15 do not apply to control circuits (See Section 25).

16.1.16 A field-wiring lead shall consist of general building wire, or other wiring when it has an insulation of:

- a) At least 1/32-inch (0.8-mm) thick thermoplastic material,
- b) At least 1/64-inch (0.4-mm) thick rubber plus a braid cover for applications of 300 volts or less, and
- c) At least 1/32-inch (0.8 mm) thick rubber plus a braid cover for applications between 301 and 600 volts.

16.1.17 A field-wiring lead provided for connection to an external line-voltage circuit shall not be connected to a wire-binding screw or pressure terminal connector located in the same compartment as the free end of the wiring lead unless the screw or connector is rendered unusable for field-wiring connection or:

- a) The lead is insulated at the unconnected end, and
- b) A marking is provided on the unit in accordance with 68.2.16.

16.1.18 The free end of a field-wiring lead that is not used in every installation, such as a tap for a multivoltage transformer, shall be insulated. For a grounding lead, see 19.8.

16.1.19 A field-wiring lead for connection of a grounded conductor shall be identified as described in 68.2.10.

16.1.20 A wiring compartment shall be located so that wire connections therein are accessible for inspection, without disturbing either factory or field connected wiring, after the unit is installed in the intended manner.

16.1.21 Wiring compartments, raceways, and similar equipment, for routing and stowage of conductors connected in the field shall not contain rough, sharp, or moving parts that are capable of damaging conductor insulation.

16.1.22 For a unit intended for installation on a raised floor and having provision for entrance of field wiring through the bottom of the enclosure, the following requirements apply:

- a) The bottom enclosure openings shall comply with 7.10.1, and
- b) Conduit or knockout openings in accordance with 7.8.1 – 7.8.9 shall be provided.

16.2 Openings for conduit or cable connection

16.2.1 An opening or knockout complying with the requirements specified in 7.8.1 – 7.8.9 shall be provided for connection of conduit or cable wiring system.

Exception: A unit complying with 7.8.7 and 7.8.8 is not required to be provided with an opening or a knockout.

16.3 Openings for class 2 circuit conductors

16.3.1 An opening for the entry of a conductor or conductors of a Class 2 circuit shall be provided with an insulating bushing. The bushing is not prohibited from being mounted in place in the opening or from being within the enclosure so that it is properly mounted when the unit is installed.

Exception: The bushing is not prohibited from being omitted when:

- a) *The opening is capable of accommodating armored cable or conduit, and*
- b) *The installation instructions indicate that Class 1 wiring methods are to be used as indicated in 69.1.4(o).*

16.3.2 A bushing of rubber or rubber-like material provided in accordance with 16.3.1 shall be at least 1/8 inch (3.2 mm) thick, except that it shall be not less than 3/64 inch (1.2 mm) thick when the metal around the hole is eyeletted or similarly treated to provide smooth edges. A bushing shall be located so that it is not exposed to oil, grease, oily vapors, or other substances having a deleterious effect on the material of the bushing. A hole in which such a bushing is mounted shall be free from sharp edges, burrs, projections, or similar material, that is capable of damaging the bushing.

16.4 Receptacles

16.4.1 AC convenience receptacle mounted in wet locations shall be provided with either:

- a) A raintight, while-in-use, cover in accordance with the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C; or
- b) A self closing enclosure, door or hinged cover that prevents wetting of live parts with the attachment plug inserted or removed. The construction shall comply with the requirements in Section 7, Frame and Enclosure, and Section 60, Cycling Test, as preconditioning for the tests and requirements in Section 71 for Outdoor-Use Units.

17 Wire Bending Space

17.1 A permanently connected unit employing pressure terminal connectors for field connection of circuits described in 16.1.3 shall be provided with space within the enclosure as specified in 17.3 – 17.7. Identification of conductors, including grounding conductors, shall be based on the manufacturer's installation instructions.

17.2 The conductor size used in judging the wiring space is to be based on the use of a conductor sized in accordance with 16.1.4.

17.3 Wire bending space for field installed conductors shall be provided opposite any:

- a) Pressure wire connector as specified in 17.4 or 17.5, and
- b) Opening or knockout for a conduit or wireway in a gutter as specified in 17.9.

17.4 The wire bending space shall be as specified in Table 17.1 for conductors that enter or leave the enclosure surface opposite its wire connector. A wire is capable of entering or leaving a top, back, bottom, or side surface when there is an opening or knockout for a wireway or conduit.

Table 17.1
Minimum wire-bending space for conductors through a wall opposite terminals in inches (mm)

Wire size		Wires per terminal (pole) ^a			
AWG or kcmil	(mm ²)	1	2	3	4 or more
14 – 10 AWG	(2.1 – 5.3)	Not Specified	—	—	—
8	(8.4)	1-1/2 (38.1)	—	—	—
6	(13.3)	2 (50.8)	—	—	—
4	(21.1)	3 (76.2)	—	—	—
3	(26.7)	3 (76.2)	—	—	—
2	(33.6)	3-1/2 (88.9)	—	—	—
1	(42.4)	4-1/2 (114)	—	—	—
0	(53.5)	5-1/2 (140)	5-1/2	7 (179)	—
2/0	(67.4)	6 (152)	6	7-1/2 (191)	—
3/0	(85.0)	6-1/2 [1/2] ^a (165)	6-1/2 [1/2] ^a (165)	8 (203)	—
4/0	(107)	7 [1] ^a (179)	7-1/2 [1-1/2] ^a (191)	8-1/2 [1/2] ^a (216)	—
250 kcmil	(127)	8-1/2 [2] ^a (216)	8-1/2 [2] ^a (216)	9 [1] ^a (229)	10 (254)
300	(152)	10 [3] ^a (254)	10 [2] ^a (254)	11 [1] ^a (279)	12 (305)
350	(177)	12 [3] ^a (305)	12 [3] ^a (305)	13 [3] ^a (330)	14 [2] ^a (355)

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Table 17.1 Continued on Next Page

Table 17.1 Continued

Wire size		Wires per terminal (pole) ^a							
AWG or kcmil	(mm ²)	1		2		3		4 or more	
400	(203)	13	[3] ^a (330)	13	[3] ^a (330)	14	[3] ^a (355)	15	[3] ^a (381)
500	(253)	14	[3] ^a (355)	14	[3] ^a (355)	15	[3] ^a (381)	16	[3] ^a (406)
600	(304)	15	[3] ^a (381)	16	[3] ^a (406)	18	[3] ^a (457)	19	[3] ^a (483)
700	(355)	16	[3] ^a (406)	18	[3] ^a (457)	20	[3] ^a (508)	22	[3] ^a (559)
750	(380)	17	(432)	19	[3] ^a (483)	22	[3] ^a (559)	24	[3] ^a (610)
800	(405)	18	(457)	20	(508)	22	(559)	24	(610)
900	(456)	19	(483)	22	(559)	24	(610)	24	(610)
1000	(507)	20	(508)		—		—		—
1250	(633)	22	(559)		—		—		—
1500	(760)	24	(610)		—		—		—
1750	(886)	24	(610)		—		—		—
2000	(1013)	24	(610)		—		—		—

Note – The table includes only those multiple-conductor combinations that are intended to be used. Combinations not specified are not prohibited from being given further consideration.

^a Wire bending space are capable of being reduced by the number of inches shown in brackets under the following conditions:

- 1) Only removable or lay-in wire connectors receiving one wire each are used (there are sometimes more than one removable wire connector per terminal), and
- 2) The removable wire connectors are capable of being removed from their intended location without disturbing structural or electrical parts other than a cover, and are capable of being installed with the conductor in place.

17.5 Where a conductor is not likely to enter or leave the enclosure surface opposite its wire connector, the wire bending space shall be as specified in Table 17.2. The wire bending space is in accordance with Table 17.2 where:

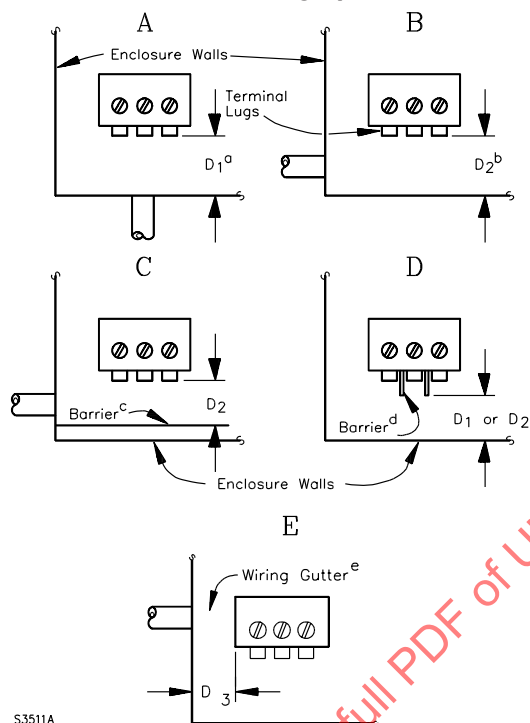
- a) A barrier is provided between the connector and the opening, or
- b) Drawings are provided specifying that the conductors are not to enter or leave the enclosure directly opposite the wire connector. See illustrations A, B, and C of Figure 17.1.

Table 17.2
Minimum width of gutter and wire-bending space for conductors through a wall not opposite terminals in inches (mm)

Size of wire		Wires per terminal (pole)				
AWG or kcmil	(mm ²)	1	2	3	4	5
14 – 10AWG	(2.1 – 5.3)	Not specified	–	–	–	–
8 – 6	(8.4 – 13.3)	1-1/2 (38.1)	–	–	–	–
4 – 3	(21.1 – 26.7)	2 (50.8)	–	–	–	–
2	(33.6)	2-1/2 (63.5)	–	–	–	–
1	(42.4)	3 (76.2)	–	–	–	–
1/0 – 2/0	(53.5 – 74)	3-1/2 (88.9)	5 (127)	7 (178)	–	–
3/0 – 4/0	(85.0 – 107)	4 (102)	6 (152)	8 (203)	–	–
250 kcmil	(127)	4-1/2 (114)	6 (152)	8 (203)	10 (254)	–
300 – 350	(152 – 177)	5 (127)	8 (203)	10 (254)	12 (305)	–
400 – 500	(203 – 253)	6 (152)	8 (203)	10 (254)	12 (305)	14 (356)
600 – 700	(304 – 355)	8 (203)	10 (254)	12 (305)	14 (356)	16 (406)
750 – 900	(380 – 456)	8 (203)	12 (305)	14 (356)	16 (406)	18 (457)
1000 – 1250	(507 – 633)	10 (254)	–	–	–	–
1500 – 2000	(760 – 1010)	12 (305)	–	–	–	–

Note – The table includes only those multiple-conductor combinations that are likely to be used. Combinations not mentioned are not prohibited from being given further consideration.

Figure 17.1
Wire bending space



D_1 is the distance between a wire connector or an adjacent barrier and the opposite wall that conductors are intended to pass through.

D_2 is the distance between a wire connector or an adjacent barrier and the opposite wall or barrier that conductors are not intended to pass through.

D_3 is the width of a wiring gutter having a side through which conductors are intended to pass through.

^a A conduit opening or knockout is provided in the wall opposite the terminal lugs. D_1 shall not be less than the minimum wire bending space specified in Table 17.1.

^b A conduit opening or knockout is provided in the wall at a right angle to the wall opposite the terminal lugs. The wall opposite the terminal lugs either is not provided with a knockout or conduit opening or a marking is provided indicating that the conduit opening or knockout is not to be used. D_2 shall not be less than the minimum wire bending space specified in Table 17.2.

^c A conduit opening or knockout is provided in the wall at a right angle to the wall opposite the terminal lugs. In addition, a conduit opening or knockout is provided in the wall opposite the terminal lugs, however, a barrier preventing the use of the opening is provided. D_2 shall not be less than the minimum wire bending space specified in Table 17.2.

^d When a barrier or other means is provided restricting bending of the conductor, the distance D_1 or D_2 , as applicable (see notes for D_1 and D_2 above) is to be measured from the end of the barrier.

^e A conduit opening or knockout is provided in a wiring gutter. The width of the gutter, D_3 , shall not be less than the minimum wire bending space specified in Table 17.2.

17.6 Where a conductor is restricted by a barrier or other means from being bent where it leaves the connector, the distance is to be measured from the end of the barrier. See illustration D of Figure 17.1.

17.7 For a unit not provided with a conduit opening or knockout (see 7.8.7) the minimum wiring bending space specified in 17.4 – 17.6 shall be based on:

- a) Any enclosure wall that is used for installation of the conduit, or
- b) Only specific walls that are to be used as determined by a marking, drawing, or template furnished with the unit.

17.8 The distance specified in 17.3 – 17.5 is to be measured in a straight line from the edge of the wire terminal closest to the wall in a direction perpendicular to the box wall or barrier. See illustrations A – C of Figure 17.1. The wire terminal is to be turned so that the axis of the wire opening in the connector is as close to perpendicular to the wall of the enclosure as possible without defeating any means provided to prevent turning, such as a boss, shoulder, walls of a recess, multiple bolts securing the connector, or similar device. A barrier, shoulder, or similar device is to be disregarded when the measurement is being made when it does not reduce the radius to which the wire must be bent. When a terminal is provided with one or more connectors for the connection of conductors in multiple, the distance is to be measured from the wire opening closest to the wall of the enclosure.

17.9 The width of a wiring gutter in which one or more knockouts are provided shall be large enough to accommodate (with respect to bending) conductors of the maximum size to be used at that knockout. The values of the minimum intended width of a wiring gutter, with respect to conductors entering a knockout, are the same as the values of minimum intended bending space given in Table 17.2. See illustration E of Figure 17.1.

Exception: The wiring space is not prohibited from being of less width when:

- a) Knockouts are provided elsewhere that are in compliance with these requirements,*
- b) The wiring space at such other point or points is of a width that accommodates the conductors in question, and*
- c) The knockout or knockouts at such other points are used in the intended wiring of the unit.*

18 Output Circuit Grounding

18.1 General

18.1.1 The generator assembly shall be provided with a means for grounding the output circuits in accordance with the National Electric Code, NFPA 70, Article 250.

18.1.2 An output alternating current power circuit shall be grounded when:

- a) The circuit has no electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another wiring system,
- b) The circuit is rated 50 – 600 volts, and
- c) The circuit is as described, and not limited to those in (1) – (3) [see Article 250.20(b) of the National Electrical Code, NFPA 70, for other circuits]:
 - 1) A circuit that is grounded so the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts. This requires that one conductor of each of the following circuits be grounded:
 - i) 120 volts, 2-wire;
 - ii) 240/120 volts, single-phase, 3-wire;
 - iii) 208/120 volts, two-phase, 3-wire;
 - iv) 208/120 volts, three-phase, 4-wire.
 - 2) A circuit nominally rated 480 wye/277 volts, 3-phase, 4-wire in which the neutral is used as a circuit conductor.
 - 3) A circuit-nominally rated 240/120 volts, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor.

For other units, an output alternating current power circuit complying with (a) is not prohibited from being grounded when the construction complies with the requirements described in 18.1.3 and 18.1.6.

18.1.3 With reference to 18.1.2, the conductor to be grounded shall be as follows:

- a) Single-phase alternating current system, 2-wire – one conductor.
- b) Single-phase alternating current system, 3-wire – the neutral conductor.
- c) Multiphase alternating current system having one wire common to all phases – the common conductor.
- d) Multiphase alternating current system where one phase is used as in (b) above – the neutral conductor.

18.1.4 Grounding of the circuits specified in 18.1.2 – 18.1.3 shall be made by a bonding jumper (see 18.1.5) connected between the grounded conductor referenced in 18.1.3 and to:

- a) The enclosure of a metal-enclosed unit, or
- b) The metal chassis that is bonded to the equipment grounding conductor or terminal of a nonmetallic enclosed unit.

Exception: The following provisions are to be provided in order for the circuit to be grounded in the field:

- a) A field-wiring terminal intended for use with a conductor size specified in Column 4 of Table 18.1 and identified in accordance with 68.2.10, shall be connected to the circuit by a bonding jumper of a size not less than specified in Column 4 of Table 18.1, and
- b) A marking identifying the circuit as a separately derived source and referencing the instruction manual in accordance with 68.2.19.

Table 18.1
Size of circuit bonding, equipment-grounding, and grounding electrode conductors

Column 1	Column 2		Column 3		Column 4	
	Minimum size of equipment grounding or bonding conductor AWG or kcmil (mm ²) ^b		Minimum size of grounding electrode conductor AWG or kcmil (mm ²)		Minimum size of output circuit bonding jumper AWG or kcmil (mm ²) ^e	
Maximum current rating ^a (Amperes)	Copper	Aluminum or copper-clad aluminum	Copper	Aluminum or copper-clad aluminum	Copper	Aluminum or copper-clad aluminum
20	12 (3.3)	10 (5.3)	8 (8.4)	6 (13.3)	8 (8.4)	6 (13.3)
60	10 (5.3)	8 (8.4)	8 (8.4)	6 (13.3)	8 (8.4)	6 (13.3)
90	8 (8.4)	6 (13.3)	8 (8.4)	6 (13.3)	8 (8.4)	6 (13.3)
100	8 (8.4)	6 (13.3)	6 (13.3)	6 (13.3)	6 (13.3)	4 (21.2)
150	6 (13.3)	4 (21.2)	6 (13.3)	4 (21.2)	6 (13.3)	4 (21.2)
200	6 (13.3)	4 (21.2)	4 (21.2)	2 (33.6)	4 (21.2)	2 (33.6)
300	4 (21.2)	2 (33.6)	2 (33.6)	1/0 (53.5)	2 (33.6)	1/0 (53.5)
400	3 (26.7)	1 (42.4)	1/0 ^c (53.5)	3/0 ^c (85.0)	1/0 ^c (53.5)	3/0 ^c (85.0)
500	1 (33.6)	1/0 (53.5)	2/0 (67.4)	4/0 (107.2)	1/0 (53.5)	3/0 (85.0)
600	1 (42.4)	2/0 (67.4)	2/0 (67.4)	4/0 (107.2)	2/0 (67.4)	4/0 (107.2)
800	1/0 (53.5)	3/0 (85.0)	3/0 (85.0)	250 (127)	2/0 (67.4)	4/0 (107.2)
1000	2/0 (67.4)	4/0 (107.2)	3/0 (85.0)	250 (127)	3/0 (85.0)	250 (127)
1200	3/0 (85.0)	250 (127)	3/0 (85.0)	250 (127)	250 ^d (127)	250 (127)
1600	4/0 (107.2)	350 (127)	3/0 (85.0)	250 (127)	300 ^d (152)	400 ^d (203)
2000	250 (127)	400 (203)	3/0 (85.0)	250 (127)	400 ^d (203)	500 ^d (253)
2500	350 (177)	600 (304)	3/0 (85.0)	250 (127)	500 ^d (253)	700 ^d (355)
3000	400 (203)	600 (304)	3/0 (85.0)	250 (127)	600 ^d (304)	750 ^d (380)
4000	500 (253)	800 (405)	3/0 (85.0)	250 (127)	700 ^d (380)	1000 ^d (508)
5000	700 (355)	1200 (608)	3/0 (85.0)	250 (127)	900 (456)	1250 (635)
6000	800 (405)	1200 (608)	3/0 (85.0)	250 (127)	1200 (608)	1500 (759)

Note – See Table 18.2 for equivalent area of bus.

^a Maximum ampere rating of the output circuit overcurrent protective device described in 29.3.1 – 29.3.3.

^b The equipment grounding conductor in the cord for a portable or stationary unit are not prohibited from being the same size as the current-carrying conductors.

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Table 18.1 Continued on Next Page

Table 18.1 Continued

Column 1	Column 2		Column 3		Column 4	
	Minimum size of equipment grounding or bonding conductor AWG or kcmil (mm ²) ^b		Minimum size of grounding electrode conductor AWG or kcmil (mm ²)		Minimum size of output circuit bonding jumper AWG or kcmil (mm ²) ^e	
Maximum current rating ^a (Amperes)	Copper	Aluminum or copper-clad aluminum	Copper	Aluminum or copper-clad aluminum	Copper	Aluminum or copper-clad aluminum
^c When the wire terminal connectors for the input or output circuit conductors, as applicable, are rated for two 3/0 AWG copper or two No. 250 kcmil aluminum conductors and do not accept a No. 600 kcmil conductor, these values are not prohibited from being reduced to 2 AWG copper or 1/0 AWG aluminum. ^d The cross section is not prohibited from being reduced to 12.5 percent of the total cross section of the largest input or output circuit conductor, as applicable, of the same material (copper or aluminum) for any phase on units rated 1200 amperes and above. This applies when the cross section of the circuit conductors is limited by the wire terminal connectors provided. ^e The bonding jumper for a stationary unit is not prohibited from being the same size as the current-carrying conductors of the output circuit.						

Table 18.2
Equivalent cross-sectional areas of wires and buses

Wire size (AWG or kcmil)	Minimum cross section of bus	
	Inch ²	mm ²
8	0.013	8.39
6	0.021	13.55
4	0.033	21.29
3	0.041	26.45
2	0.052	33.55
1	0.066	42.58
0	0.083	53.55
2/0	0.105	67.74
3/0	0.132	85.16
4/0	0.166	107.10
250	0.196	236.45
300	0.236	152.26
350	0.275	177.42
400	0.314	202.58
500	0.393	253.55
600	0.471	303.87
700	0.550	364.84
750	0.589	380.00
800	0.628	405.16
1000	0.785	506.45
1200	0.942	607.73
1250	0.981	632.90
1500	1.178	760.00

18.1.5 The size of the bonding jumper specified in 18.1.4 shall be, based on the current rating of the circuit, not less than the value specified in Column 4 of Table 18.1.

18.1.6 A fixed unit shall be provided with a terminal that complies with 16.1.5 – 16.1.14 for connection of the grounding electrode conductor to the metal enclosure or equipment grounding conductor described in 18.1.4 (a) and (b). The terminal shall be:

- a) Capable of securing a conductor size, based on the maximum current rating of the circuit, as specified in Column 3 of Table 18.1, and
- b) Marked as described in 68.2.11.

18.1.7 For an alternating current output circuit of a unit having a polarized AC convenience receptacle, lead, or terminal identified as a grounded circuit (see 68.2.10) that is not grounded at the unit itself because of an electrical connection to supply conductors originating in another wiring system – see 18.1.2(a), a potential involving a risk of electric shock shall not exist between ground and the grounded circuit contact, terminal, or lead. Compliance with this requirement is to be determined by the test specified in 50.1.

Exception: The test described in 50.1 is not required when the ac input neutral and ac output neutral conductors are solidly connected together, that is, no electronic components connected between the neutral conductors.

18.2 Ground fault circuit interrupter

18.2.1 All output circuits for supplying 120 volts, 60 Hz, 2-wire with ground and 120/240 volts, 60 Hz, 3-wire with ground to convenience outlets shall be protected by ground fault circuit interrupters designed for the current involved.

18.2.2 When installed on the generator, the ground fault circuit interrupter shall have a current rating not less than 115 percent of the circuit rating, and shall be installed in accordance with its installation instructions.

Exception: Dedicated purpose generator component outlets shall comply with the following:

- 1) *The dedicated purpose generator receptacle shall be grounded;*
- 2) *The dedicated generator outlets shall be provided with protection rated for the marked branch circuit for the outlet and for the specific dedicated load(s) connected to them;*
- 3) *A single outlet may be provided per dedicated purpose generator component, and*
- 4) *Dedicated purpose generator outlets shall be marked in accordance with 68.3.15.*

19 Equipment Grounding

19.1 There shall be provisions for grounding all dead metal parts of a unit that are exposed or that are capable of being contacted by a person during intended operation or adjustment and that are capable of becoming energized as a result of electrical malfunction.

19.2 The provisions for equipment grounding specified in 19.1 shall be provided for each wiring system to be connected to the alternating current output circuit.

Exception: Accessible signal circuits described in Accessible Signal Circuits, Section 26, are not required to have provisions for equipment grounding.

19.3 To determine whether a part is capable of becoming energized, factors such as construction, the proximity of wiring, and the results of a dielectric voltage-withstand test (conducted after the applicable overload, endurance, and abnormal tests) are to be evaluated.

19.4 The grounding means shall consist of an equipment-grounding terminal or lead.

19.5 An equipment-grounding terminal or lead-grounding point shall be connected to the frame or enclosure by a positive means, such as by a bolted or screwed connection. To reduce the risk of being inadvertently disconnected, the removal or opening of covers shall not require the ground lead to be disconnected. The bolt head of a grounding stud shall not be accessible from the outside of the unit.

19.6 An equipment-grounding connection shall penetrate a nonconductive coating, such as paint or vitreous enamel.

19.7 An equipment-grounding point shall be located so that the risk the grounding means is inadvertently removed during servicing is reduced.

19.8 A free end of an equipment-grounding lead shall be insulated (for example, the end is to be folded back and taped to the lead) unless the lead is located so that it does not contact live parts in the event that the lead is not used in the field.

19.9 An equipment-grounding lead shall be a size specified in Column 2 of Table 18.1. The lead shall have a free length of at least 6 inches (152 mm) and the surface of the insulation shall be green with or without one or more yellow stripes. No other lead in a field-wiring compartment or visible to the installer shall be so identified.

Exception: The color coding requirement does not apply to low-voltage Class 2 circuits provided the low-voltage leads are:

- a) Located remote from the line-voltage connections and the segregation complies with the requirements in Separation of Circuits, Section 28, or*
- b) Marked in accordance with 68.2.17.*

19.10 An equipment-grounding conductor shall not be spliced.

19.11 An equipment-grounding connection, equipment-grounding conductor, enclosure, frame, component mounting panel, or any other part connected to earth ground shall not carry current except during an electrical malfunction. See 25.1.

Exception: A line bypass capacitive impedance circuit for a radio frequency signal circuit or a transient voltage surge suppressor is not required to comply.

19.12 A grounded circuit conductor shall not be connected to any equipment-grounding or bonding circuit in a unit.

Exception: The output circuit of a unit as described in 18.1.1 and 18.1.2 is not prohibited from being connected to an equipment-grounding or bonding circuit.

19.13 A soldering lug, a connection means that depends on solder, a screwless (push-in) connector, a quick-connect, or other friction-fit connector shall not be used for equipment-grounding.

19.14 The equipment-grounding terminal shall be capable of securing a conductor of a size intended for the application in accordance with Column 2 of Table 18.1 and shall be constructed in accordance with the requirements specified in 16.1.5 – 16.1.13.

19.15 A wire-binding screw employed for the connection of a field-installed equipment grounding conductor shall have a green colored head that is either hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be marked as described in 68.2.8.

19.16 When two or more units are interconnected electrically and one of them is grounded, they shall be bonded together, such as by means of a conductor included in an interconnecting cable or by a conductive mechanical means, including the use of starwashers or the equivalent (see 20.6 – 20.10).

20 Bonding of Internal Parts

20.1 On a generator having provisions for grounding (see 19.1) all exposed dead metal parts that are capable of becoming energized through electrical fault that involves a risk of electric shock or electrical energy – high current levels, shall be conductively connected to the equipment grounding means.

20.2 All uninsulated metal parts of the enclosure, motor frames and mounting brackets, component mounting brackets, capacitors, and other electrical components that involve a risk of electric shock or electrical energy – high current levels shall be bonded for grounding when they are capable of being contacted by the user or inadvertently contacted by the serviceman.

Exception: A metal part as described in (a) – (g) is not required to be bonded for grounding:

a) An adhesive-attached metal foil marking, a screw, a handle, or similar device, that is located on the outside of an enclosure or cabinet and isolated from electrical components or wiring by grounded metal parts so that they do not become energized,

b) An isolated metal part, such as a magnet frame and an armature, a small assembly screw, or similar part, that is positively separated from wiring and uninsulated live parts,

c) A panel or cover that does not enclose uninsulated live parts when wiring is positively separated from the panel or cover so that it does not become energized,

d) A panel or cover that is insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick and secured in place,

e) An isolated metal part that is mounted on a printed wiring board – such as transformer and choke cores and heat sinks,

f) An isolated metal part that is marked in accordance with 68.3.10, and

g) A capacitor sleeved with insulating tubing complying with 24.2.2.

20.3 An internal metal-to-metal connection for bonding internal parts to an enclosure for grounding, and not for a field-installed grounding conductor or for the grounding wire in a supply cord, is not prohibited from employing a quick-connect terminal when:

- a) The connector is not displaced;
- b) The terminal has the dimensions specified in Table 20.1; and
- c) The component is limited to use on a circuit having a branch-circuit protective device rated 20 amperes or less.

Table 20.1
Quick-connect terminals for bonding internal parts

Nominal size of terminal, inches (mm)					
Width		Length		Thickness	
0.187	(4.7)	1/4	(6.4)	0.020	(0.5)
0.187	(4.7)	1/4	(6.4)	0.032	(0.8)
0.205	(5.2)	1/4	(6.4)	0.032	(0.8)
0.250	(6.4)	5/16	(8.0)	0.032	(0.8)

20.4 Where the continuity of the grounding system relies on the dimensional integrity of a nonmetallic material, the material meets the intent for the purpose when investigated for creep in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. See also 20.8.

20.5 A separate component bonding conductor shall be of copper, a copper alloy, or other material intended for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by painting, galvanizing, plating, or equivalent means. A separate bonding conductor or strap shall:

- a) Be protected from mechanical damage or be located within the outer enclosure or frame,
- b) Not be secured by a removable fastener used for any purpose other than bonding for grounding, unless the bonding conductor remains after removal and replacement of the fastener, and
- c) Not be spliced.

20.6 The bonding shall be by a positive means, such as by rivets, bolted or screwed connections, or by welding, soldering, or brazing with materials having a softening or melting point greater than 455°C (850°F). The bonding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel and provide metal-to-metal contact. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material, other than as indicated in 20.8.

20.7 With reference to 20.6 where, penetration of a nonconductive coating is not determined by examination, a Grounding Impedance Test, Section 56, shall be conducted.

20.8 A connection that depends upon the clamping action exerted by rubber or similar material is not prohibited when it complies with the requirements in the Bonding Conductor Test, Section 62, for bonding conductors under any normal degree of compression exerted by a variable clamping device and when the results are unchanged after exposure to the effects of oil, grease, moisture, and thermal degradation that occur in service. Also, the effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be taken into account with particular emphasis on it being reassembled in its intended position.

20.9 A separate component-bonding conductor shall:

- a) Not be smaller than the size specified in Column 2 of Table 18.1, (see 20.10),
- b) Not be smaller than the conductor supplying the component, or
- c) Comply with the marking requirements in Details, Section 68.

20.10 With reference to Column 2 of Table 18.1, where more than one size branch-circuit overcurrent device is involved, the size of the bonding conductor is to be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor.

21 Internal Wiring

21.1 Wires

21.1.1 The internal wiring of a generator shall be rated for the particular application with respect to the temperature and voltage, exposure to oil or grease, and other conditions of service to which the wiring is subjected.

21.1.2 With respect to 21.1.1, the effects of vibration, impact, and exposure are to be taken into account for wires smaller than 24 AWG (0.21 mm²).

21.1.3 All wiring shall be polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE), fluorinated ethylene propylene (FEP), or neoprene insulated, or shall comply with the vertical wire flame test requirements in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

Exception: The requirements in 21.1.1 – 21.1.3 do not apply to wiring for Class 2 circuits.

21.2 Protection of wiring

21.2.1 Internal wiring shall not be accessible when judged in accordance with Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts – and User Servicing, Section 8.

Exception: Internal wiring is capable of being accessed when it is located and secured within the enclosure so that it is not subjected to stress or mechanical damage.

21.2.2 Wires within an enclosure, compartment, raceway, or similar part shall be located or protected to reduce the risk of unintentional contact with any sharp edge, burr, fin, moving part, or similar part that is capable of damaging the conductor insulation.

21.2.3 Internal wiring shall be so routed and secured that neither it nor related electrical connections are subjected to stress or mechanical damage in such a manner that a broken termination does not present a risk of fire or electric shock by contacting parts of different circuits or other parts that may introduce a risk of fire or electric shock to the user.

21.2.4 A hole in a sheet-metal wall through which insulated wires pass and on which they bear shall be provided with a smoothly rounded bushing or shall have smooth, rounded surfaces upon which the wires bear, to avoid abrasion of insulation.

21.2.5 A bushing used on other than smooth, rounded surfaces of a hole through which wires pass shall be of material that has mechanical and heat-resistant properties intended for the application— such as porcelain, phenolic fiber at least 3/64 inch (1.2 mm) thick, a material complying with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C or smooth, rounded metal. A soft-rubber bushing or similar device is not to be used for other than low-voltage wiring (see 16.3.2) unless the material has been evaluated and found to comply for the purpose.

21.2.6 Metal clamps and guides used for routing stationary internal wiring shall be provided with smooth well-rounded edges.

21.2.7 Auxiliary mechanical protection that is not electrically conductive shall be provided:

- a) Under a metal clamp at which pressure is exerted on a conductor having thermoplastic insulation less than 0.030 inch (0.76 mm) thick and no overall braid, and

Exception: Auxiliary mechanical protection is not required for conductors having cross-linked synthetic insulation.

- b) On any wire or wires that are subject to motion.

22 Current-Carrying Parts

22.1 General

22.1.1 A current-carrying part shall be of silver, copper, a copper-base alloy, stainless steel, aluminum, or other materials intended for the application.

Exception No. 1: Plated steel may be used for secondary-circuit parts and for some primary-circuit parts (such as for capacitor terminals where a glass-to-metal seal is required and for leads or threaded studs of semiconductor devices).

Exception No. 2: Blued steel or steel with equivalent corrosion resistance may only be used for the current-carrying arms of mechanically or magnetically operated leaf switches, within a motor and its governor, motor terminals included, or where the temperature is in excess of 100°C (212°F).

22.1.2 An uninsulated live part and a component that has uninsulated live parts shall be so secured to the base or mounting surface that they do not turn or shift in position where such displacement results in a reduction of spacings below the minimum required values in Spacings, Section 24.

22.2 Bus bars

22.2.1 Each bus bar shall be plated at each joint with tin, silver, nickel, or cadmium.

Exception No. 1: A welded or brazed joint is not required to be plated.

Exception No. 2: A copper bus bar is not required to be plated when the current at the joint is 600 amperes or less.

Exception No. 3: Other coatings are not prohibited from being used for aluminum bus bars when they are investigated for the application in accordance with the requirements for current-carrying parts described in Bus Bar Tests, Section 66.

Exception No. 4: A bus bar provided with an oxide inhibiting compound over the joint surfaces is not required to be plated. See 22.3.1.

22.2.2 The bending of a bus bar shall not result in visible cracks. Roughening or slight surface crazing meets the intent of the requirement.

22.2.3 Each riveted joint connection shall have a spring washer at one end and either a spring washer or a flat washer at the other end. See 22.2.5 and 22.2.6.

Exception No. 1: A connection rated 225 amperes or less employing copper bus bars only is not required to comply.

Exception No. 2: Other constructions employing a rivet are not prohibited when they are investigated in accordance with the applicable requirements in Bus Bar Tests, Section 66.

22.2.4 Each joint connection shall employ a spring washer at one end of a bolt. See 22.2.6.

Exception No. 1: A spring washer is not prohibited from being replaced with a split ring lock washer and flat washer when each bus in the joint is copper or when each aluminum bus in the joint has a tensile yield strength of at least 20,000 psi (138 MPa).

Exception No. 2: A flat washer, a split-ring lock washer, or a bolthead that complies with 22.2.5 is not prohibited from being used in place of a spring washer when the joint does not include any aluminum or when aluminum bolts are used with aluminum bus bars.

Exception No. 3: Other constructions comply when they are investigated in accordance with the applicable requirements in Bus Bar Tests, Section 66.

22.2.5 The flat washer specified in 22.2.3 shall have a thickness of at least one-sixth that of the diameter of the rivet shank or bolt and shall have an outer diameter at least 150 percent of the rivet shank or bolt and not less than the outer diameter of any adjacent spring washer.

22.2.6 A spring washer as specified in 22.2.3 and 22.2.4 is a dished washer of stainless, or hardened and tempered steel, having an outer diameter not less than 150 percent of the bolt diameter, a thickness not less than one-eighth of the bolt diameter, and dished not less than 3-1/2 percent of the bolt diameter.

22.2.7 Unless investigated for such use, a bolted connection between two bus bars or between a bus bar and another current-carrying part shall not depend on the dimensional integrity of a thermoplastic material.

22.2.8 Where insulating or tubing, as described in 24.2.2 and 24.2.4, is applied over busbars, it shall be so that it is possible to tighten a bolted joint without removing any insulating material.

22.2.9 The current density of a bus bar shall not be more than that indicated in Table 22.1 or 22.2.

Exception No. 1: A bus bar having characteristics that do not result in maximum bus bar temperatures exceeding the values specified in Table 44.2 is not prohibited from having a current density exceeding that of Tables 22.1 and 22.2.

Exception No. 2: A bus bar contained in a unit having forced air ventilation that does not result in maximum bus bar temperatures exceeding the values specified in Table 44.2 is not prohibited from having a current density exceeding that of Tables 22.1 and 22.2.

Table 22.1
Ampacity of single or multiple bus bars and clamped joints

Bus bar material ^a	Current	Current density in amperes per square inch (6.45 cm ²)	
		Bus bar cross section	Contact area at clamped joints
Copper	0 – 600 amperes	1000 ^c	200
Copper	Over 600	1000 ^c	200 ^{d,e}
Aluminum ^b	Any	750 ^c	200 ^{d,e}

^a Multiple bus bars in parallel shall be of the same material.
^b Minimum conductivity of 55 percent of International Annealed-Copper Standard.
^c See also Table 22.2 for 800 ampere maximum single bus bars.
^d See 22.1.1, 22.2.10 – 22.2.12.
^e Joints bolted and plated with silver, tin, nickel, or cadmium.

Table 22.2
Rating and sizes of single bus bars – 800 amperes maximum

Current rating in amperes	Copper bus				Aluminum bus ^b			
	Bus size ^a		Cross section		Bus size ^a		Cross section	
	Inches	mm	in ²	mm ²	Inches	mm	in ²	mm ²
225	0.125 by 0.875	3.2 by 22.2	0.109	70.3	0.250 by 0.875	6.4 by 22.2	0.219	141.3
400	0.250 by 1.500	6.4 by 38.1	0.375	242.0	0.250 by 2.000	6.4 by 50.8	0.500	322.6
600	0.250 by 2.000	6.4 by 50.8	0.500	322.6	See Table 22.1	See Table 22.1	0.800	518.1
800	0.250 by 3.000	6.4 by 76.2	0.750	483.9	See Table 22.1	See Table 22.1	1.067	688.4

NOTES
1 See 22.2.10 – 22.2.12; for multiple buses in parallel, refer to Table 22.1. The minimum contact area at a clamped joint shall provide not less than 1 square inch (6.5 cm²) per 200 amperes.
2 Bolted joints and bus bars plated with silver, tin, nickel, or cadmium.
^a A bus bar having other dimensions is not prohibited when it has not less than the cross-sectional area specified in the table and when it has equivalent rigidity.
^b Minimum conductivity of 55 percent of International Annealed-Copper Standard.

22.2.10 The cross section of a bus as covered in Table 22.1 or 22.2 shall not be reduced by more than 5 percent due to rounding, shaping, or dimensional tolerances.

22.2.11 Removal of part of the bus material for slots or holes (whether used or not) is not prohibited when:

- The remaining material at any cross section along the length of the bus bar has at least 70 percent of the required ampacity in accordance with Table 22.1 or 22.2 and 22.2.12, and
- The remaining metal in any 6-inch (152-mm) length of bus is at least 93 percent of the metal of a bus having the required ampacity in accordance with Table 22.1 or 22.2 and 22.2.12. For example, a 1-inch (25.4-mm) wide bus is not prohibited from having 9/32 inch (7.1 mm) holes on 1-inch centers or a 4-inch (102-mm) wide bus is not prohibited from having 13/32-inch (10.3-mm) wide slots 3.2 inches (81.3 mm) long every 6 inches (152 mm).

Exception: The above limitations do not apply to a bus bar having characteristics that do not result in maximum bus bar temperatures exceeding the values specified in Table 44.1 under the test conditions indicated in Temperature Test, Section 44.

22.2.12 The limitations on current density specified in Tables 22.1 and 22.2 do not apply to:

- a) A connecting strap, bus, or similar device comprising a part of a circuit breaker, switch, or fuseholder employed in the unit, and
- b) A portion of a strap, bus, jumper, or similar device adjacent and connected to a terminal of a switch, circuit breaker, or fuseholder, and not more than 1 inch (25.4 mm) from the terminal, when a reduced cross section in that portion is required because of the recessing of the terminal or because of barriers adjacent to it.

22.3 Heat sinks

22.3.1 A current-carrying, aluminum heat sink shall be plated, conductive anodized, irradiated or the equivalent at surfaces contacting the solid state component.

Exception No. 1: A heat sink provided with an oxide inhibiting compound over the heat sink surfaces contacting the solid state component.

Exception No. 2: A heat sink subjected to the heat cycling tests described in Heat Sink Temperature Cycling Test, Section 64.

23 Electrical Connections

23.1 The requirements described in 23.2 – 23.7 apply to connections of internal wiring that are factory installed.

23.2 A splice or connection shall be mechanically secure and shall make electrical contact.

23.3 A soldered connection is mechanically secure where the lead is one of the following or equivalent:

- a) Wrapped one full turn around a terminal,
- b) Bent at a right angle after being passed through an eyelet or opening, except on printed-wiring boards where components are properly inserted or secured (as in a surface mounted component) and wave- or lap-soldered, or
- c) Twisted with other conductors.

23.4 When stranded internal wiring is connected to a wire-binding screw, the construction shall be such that loose strands of wire do not contact other uninsulated conductive parts. This is accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering of all strands together, or by any other equivalent means.

23.5 A nominal 0.110-inch (2.8-mm), 0.125-inch (3.2-mm), 0.187-inch (4.7-mm), 0.205-inch (5.2-mm), or 0.250-inch (6.4-mm) wide quick-connect terminal shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with respect to crimp pull-out, engagement-disengagement forces of the connector and tab, and temperature rises; all tests shall be conducted in accordance with UL 310.

23.6 An open-end spade lug does not comply unless an additional means, such as upturned ends on the lug or bosses or shoulders on the terminal, is provided to hold the lug in place when the binding screw or nut loosens.

23.7 A splice shall be provided with insulation equivalent to that of the wires involved unless permanent spacings are maintained between the splice and other metal parts. Insulation of the splice shall be one of the following or equivalent:

- a) A splicing device such as a pressure wire connector is not prohibited when insulated for the voltage and temperature the device is to be subjected or,
- b) Insulating tubing or sleeving used to cover a splice shall be used in accordance with 24.2.2, or,
- c) Two layers of thermoplastic tape, or two layers of friction tape, or one layer of friction tape and one layer of rubber tape, when the voltage involved is less than 250 volts. Thermoplastic tape wrapped over a sharp edge does not comply.

Exception: A splicing device, insulating tubing, sleeving, or tape is not required for use on splices within coil windings.

24 Spacings

24.1 General

24.1.1 The spacings for a generator intended for use in a general environment shall not be less than the applicable values specified in Table 24.1. Spacings for a unit intended for use in a controlled environment – see 2.15 and 24.1.3 – shall not be less than the applicable values specified in Table 24.2. For the purpose of this requirement, a general environment is an environment other than a controlled environment.

Exception No. 1: The spacing requirements of 24.1.1 shall not apply when the generator complies with 24.2.1 and where liners and barriers are used.

Exception No. 2: The spacing requirements of 24.1.1 shall not apply to the area between adjacent foils on printed wiring boards provided with a conformal coating complying with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. See 24.1.2.

Exception No. 3: On printed-wiring boards having a flammability classification of V-0 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts and Devices and Appliances, UL 94, and constructed from a base material having a minimum Comparative Tracking Index (CTI) rating of 100 and 175 volts (as determined by the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C) for controlled and general environments respectively, spacings (other than spacings to ground, between primary and secondary circuits, between the battery supply circuit and other circuits, and at field wiring terminals) are not specified between traces of different potential connected in the same circuit when:

a) The spacings comply with the requirements in *Evaluation of Reduced Spacings on Printed-Wiring Boards, Section 61, or*

b) An analysis of the circuit indicates that no more than 12.5 milliamperes of current flow between short-circuited traces having reduced spacings.

Exception No. 4: For multilayer-printed wiring boards, the minimum spacing between adjacent internal foils of opposite polarity and between an internal foil and a plated-through hole is 1/32 inch (0.79 mm). When these foils are in circuits described in 24.1.12 or 24.1.13, no spacing is specified.

Exception No. 5: The spacing requirements in Tables 24.1 and 24.2 do not apply to inherent spacings of a component such as a switch, lampholder, power switching semiconductor, or a motor. See 24.1.7.

Exception No. 6: Spacing requirements do not apply between adjacent terminals of a power switching semiconductor device including the connection points of the terminals of the device.

Table 24.1
Spacings for units intended for use in a general environment

Potential involved, volts rms (peak)	Minimum spacings, inch (mm)		
	Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part ^a		Between any uninsulated live part and the walls of a metal enclosure including a fitting for conduit or armored cable ^b
	Through air	Over surface	Shortest distance
0 – 50 (0 – 70.7)	1/16 (1.6) ^{c,d}	1/16 (1.6) ^{c,d}	1/16 (1.6) ^c
Greater than 50 to 150 (70.7 to 212.1)	1/8 (3.2) ^{c,d}	1/4 (6.4) ^d	1/4 (6.4)
Greater than 150 to 300 (212.1 to 424.2)	1/4 (6.4)	3/8 (9.5)	1/2 (12.7)
Greater than 300 to 600 (424.2 to 848.4)	3/8 (9.5)	1/2 (12.7)	1/2 (12.7)
Greater than 600 to 3000 (848.4 to 4242.0)	3/4 (19.1) ^e	3/4 (19.1) ^e	3/4 (19.1)
^a For printed wiring boards, see Exception Nos. 2 – 4 in 24.1.1. ^b For the purpose of this requirement, a metal piece attached to the enclosure is a part of the enclosure when deformation of the enclosure reduces spacings between the metal piece and uninsulated live parts. ^c The spacing between field-wiring terminals of opposite polarity and the spacing between a field-wiring terminal and a grounded dead metal part shall not be less than 1/4 inch (6.4 mm). ^d At closed-in points only, such as a screw and washer construction of an insulated stud mounted in metal, a spacing of 3/64 inch (1.2 mm) is not prohibited.			

Table 24.1 Continued

Potential involved, volts rms (peak)	Minimum spacings, inch (mm)		
	Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part ^a		Between any uninsulated live part and the walls of a metal enclosure including a fitting for conduit or armored cable ^b
	Through air	Over surface	Shortest distance
^e Between uninsulated high-voltage parts and the following: 1) Uninsulated high-voltage parts of opposite polarity or different potentials, 2) Earth-grounded metal parts, 3) Uninsulated primary-circuit parts, 4) Insulated primary-circuit parts, 5) Insulated high-voltage parts of opposite polarity, or of different potentials.			

Table 24.2
Spacings for units intended for use in a controlled environment

	Minimum spacings, inch (mm)		
	Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part ^{a,d}		Between any uninsulated live part and the walls of a metal enclosure including a fitting for conduit or armored cable ^d
	Through air	Over surface	Shortest distance
0 – 50 (0 – 70.7)	3/64 (1.2) ^c	3/64 (1.2) ^c	1/16 (1.6) ^c
Greater than 50 to 150 (70.7 to 212.1)	1/16 (1.6) ^{c,e}	1/16 (1.6) ^{c,e}	1/4 (6.4)
Greater than 150 to 300 (212.1 to 424.2)	3/32 (2.4) ^{c,e}	3/32 (2.4) ^{d,f}	1/2 (12.7)
Greater than 300 to 600 (424.2 to 848.4)	3/8 (9.5)	1/2 (12.7)	1/2 (12.7)
Greater than 600 to 3000 (848.4 to 4242.0)	3/4 (19.1) ^f	3/4 (19.1) ^f	3/4 (19.1)
^a For printed wiring boards, see Exception Nos. 2 – 4 in 24.1.1. ^b For the purpose of this requirement, a metal piece attached to the enclosure is a part of the enclosure when deformation of the enclosure reduces spacings between the metal piece and uninsulated live parts. ^c The spacing between field-wiring terminals of opposite polarity and the spacing between a field-wiring terminal and a grounded dead metal part shall not be less than 1/4 inch (6.4 mm).			

Table 24.2 Continued

	Minimum spacings, inch (mm)		
	Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part ^{a,d}		Between any uninsulated live part and the walls of a metal enclosure including a fitting for conduit or armored cable ^d
	Through air	Over surface	Shortest distance
^d On printed wiring boards, their connectors and board-mounted electrical components, wired on the load side of line filters or similar-voltage-peak-reduction networks or components or both, a minimum spacing of 0.023 inch (0.58 mm) plus 0.0002 inch (0.005 mm) per volt peak shall be maintained over surface and through air between uninsulated live parts and any other uninsulated conductive part (live or dead) not of the same polarity. ^e At closed-in points only, such as a screw and washer construction of an insulated stud mounted in metal, a spacing of 3/64 inch (1.2 mm) is not prohibited. ^f Between uninsulated high-voltage parts and the following: 1) Uninsulated high-voltage parts of opposite polarity or different potentials, 2) Earth-grounded metal parts, 3) Uninsulated primary-circuit parts, 4) Insulated primary-circuit parts, 5) Insulated high-voltage parts of opposite polarity, or of different potentials.			

24.1.2 With reference to Exception No. 2 to 24.1.1 concerning conformal coatings, minimum spacings between adjacent foils are based on voltage transient and dielectric voltage-withstand tests in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C. A conformal coating on printed-wiring boards is not insulation in lieu of spacings between a foil on a printed-wiring board and uninsulated live metal parts of opposite polarity or to dead metal parts.

24.1.3 Units investigated for use in a controlled environment indicated in 24.1.1 shall be marked as described in 68.2.19.

Exception: A unit employing a hermetically sealed enclosure, encapsulation, or conformal coating is not required to comply with this requirement.

24.1.4 For a unit intended for use in a controlled environment, a spacing between an uninsulated live part and a metal enclosure or other accessible dead metal part is not prohibited from being less than the value specified in the fourth column of Table 24.2 and not less than the values specified in the second and third columns of Table 24.2, when the unit enclosure complies with the Mechanical Strength Tests for Metal Enclosures, Section 59.

24.1.5 Where an uninsulated live part is not rigidly secured in position by means other than friction between surfaces or where a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that, for any position resulting from turning or other movement of the parts in question, at least the minimum required spacings are maintained.

24.1.6 With reference to 24.1.5, a properly applied lock washer is a method of rigidly securing a part.

24.1.7 Inherent spacings of the components specified in Exception No. 5 of 24.1.1 shall comply with the requirements for the component in question where the spacings are less than the values specified in this standard. Spacings from such components to another component and to the enclosure shall comply with the applicable spacings specified in this standard.

24.1.8 With respect to judging spacings, an uninsulated live part is at opposite polarity to uninsulated live parts in another circuit. Spacings are to be based on the highest of the circuit voltages.

24.1.9 Film-coated wire is an uninsulated live part in judging spacings.

24.1.10 Spacings at field-wiring terminals are to be measured with conductors installed in the terminals. The gage of these conductors is to be based on the rating of the circuit containing the terminals, see 16.1.4.

24.1.11 Spacings between uninsulated live parts of different potential and between such parts and dead metal that are capable of being grounded in service are not specified for parts of LVLE circuits in accordance with 2.27 nor in accessible signal circuits described in Accessible Signal Circuits, Section 26.

24.1.12 Spacings between uninsulated live parts of different potential and between such parts and dead metal that are capable of being grounded in service are not specified for parts of limited-energy circuits in accordance with 2.24. Spacings in these circuits exceeding 30 volts rms (42.4 volts peak) or 60 volts dc are judged by the Dielectric Voltage-Withstand Test, Section 45.

24.1.13 Spacings within the following circuits that are not safety circuits are not specified:

- a) Secondary circuits supplied by a transformer winding of less than 200 volt-amperes or at a potential of 60 volts or less; and
- b) Battery circuits at a potential of 60 volts or less.

The spacings in these circuits shall be judged on the basis of the Dielectric Voltage-Withstand Test, Section 45.

24.1.14 The compliance of spacings between live and dead metal parts connected to the enclosure within an instrument shall be determined by conducting the dielectric voltage-withstand test described in the Dielectric Voltage-Withstand Test, Section 45.

Exception: A meter complying with the requirements in the Standard for Electrical Analog Instruments – Panel Board Types, UL 1437 is not required to be subjected to a dielectric voltage-withstand test.

24.2 Insulation barriers

24.2.1 An insulating liner or barrier of material such as vulcanized fiber is not prohibited from being employed in lieu of required spacings specified in Exception No. 1 to 24.1.1 and shall not be the sole support of uninsulated live parts involving a risk of fire, electric shock, or electrical-energy/high current. When so used, it shall be not less than 0.028 inch (0.71 mm) thick and be so located that it is not adversely affected by arcing. Other insulating materials used as a barrier or as either direct or indirect support of uninsulated live parts involving a risk of fire, electric shock, or electrical-energy/high current shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: Vulcanized fiber not less than 0.013 inch (0.33 mm) thick is not prohibited when used:

- a) In conjunction with an air spacing of not less than 50 percent of the minimum through air spacing, and*
- b) Between a heat sink and a metal mounting surface, including the enclosure, of an isolated secondary circuit rated 50 volts rms or less.*

Exception No. 2: Mica not less than 0.006 inch (0.165 mm) is not prohibited from being used as insulation between a heat sink and a live case of a semiconductor device.

24.2.2 Other than as indicated in 24.2.3, insulating tubing complying with the requirements in the Standard for Extruded Insulating Tubing, UL 224 are not prohibited from being used as insulation of a:

- a) Conductor including bus bars in lieu of the minimum spacings, and
- b) Capacitor case in lieu of bonding the case for grounding, when the following conditions are met:
 - 1) The conductor is not subjected to compression, repeated flexure, or sharp bends,
 - 2) The conductor or case covered with the tubing is well rounded and free from sharp edges,
 - 3) The tubing is used in accordance with the manufacturer's instructions, and
 - 4) The conductor or case is not subjected to a temperature or voltage higher than that for which the tubing is rated.

24.2.3 Insulating tubing complying with UL 224 shall not be used as insulation over a bolted joint of a bus bar as provided in 22.2.8.

24.2.4 A wrap of thermoplastic tape, complying with the requirements in the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510 is not prohibited from being used when all of the following conditions are met:

- a) The wrap is no less than 0.013 inch (0.33 mm) thick, is applied in two or more layers, and is used in conjunction with no less than one-half the required through air spacing,
- b) The wrap is no less than 0.028 inch (0.72 mm) thick when used in conjunction with less than one-half the required through air spacing,

- c) Its temperature rating is no less than the maximum temperature observed during the Temperature Test, Section 44,
- d) The tape is not subject to compression,
- e) The tape is not wrapped over a sharp edge, and
- f) The tape is not wrapped over a bolted bus bar joint (see 22.2.8).

25 Control Circuits

25.1 A LVLE circuit as described in 2.27 or a limited-energy circuit as described in 2.24 is not prohibited from being connected to a single-point reference ground.

25.2 Except as indicated in 25.3, a LVLE circuit is not required to be investigated. Printed-wiring boards and insulated wire used in such circuits shall be types that are required for the application. See 21.1.1, and 33.1.

25.3 Safety circuits shall be judged by the requirements for primary circuits.

25.4 A control circuit, including associated electronic components on printed-wiring boards, that does not extend out of the unit is not required to be investigated when the maximum voltage and current are limited as specified in (a) and (b):

- a) A control circuit is not required to comply when the maximum voltage is as specified in the voltage limits of Table 9.1, and
- b) A control circuit is not required to comply when the maximum voltage and current is:
 - 1) 8 amperes for 0 – 42.4 volts peak ac, or 0 – 30 volts dc, or
 - 2) Amperes equal to 150 divided by the maximum voltage for 30 – 60 volts dc.

Printed-wiring boards, insulated wires, and motors used in such circuits shall be types that are required for the application. See 21.1, 21.1.3, and 33.1.

Exception: The value of current specified in (b) is not prohibited from being exceeded when the circuit includes an overcurrent protection device as described in 25.7 and 25.8.

25.5 With reference to the current specified in 25.4(b), the maximum current is to be measured under any condition of loading including short circuit using a resistor that is to be continuously readjusted during the 1-minute period to maintain maximum load current. The current shall not exceed the value indicated in 25.4(b).

25.6 With reference to the voltage limit specified in 25.4(a), measurement is to be made with the unit connected to the voltage specified in 43.2 and with all loading circuits disconnected. When a tapped transformer winding is used to supply a full-wave rectifier, voltage measurement is to be made from either end of the winding to the tap.

25.7 When the control circuit specified in 25.4 is not limited as to available short-circuit current by the construction of a transformer and the circuit includes either one or more resistors, a fuse, a nonadjustable manual-reset protective device, or a regulating network (see 25.11) the circuits in which the current is limited in accordance with 25.8, 25.9, or 25.10 are not required to be investigated.

25.8 A fuse or circuit-protective device provided in the control circuit used to limit the current in accordance with 25.7 shall be rated or set at not more than the values specified in Table 25.1.

Table 25.1
Rating for secondary fuse or circuit protector

Circuit voltage (volts, rms)	Maximum overcurrent protection (amperes)
20 or less	5
More than 20 and not greater than 60	100/V ^a
^a V is the maximum output voltage, regardless of load, with the primary energized in accordance with 43.2.	

25.9 A fuse or circuit protective device is not prohibited from being connected in the primary of a transformer to limit the current in accordance with 25.7 when the protection is equivalent to that specified in 25.8 as determined by conducting the Overcurrent Protection Calibration Test, Section 57.

25.10 One or more resistors or a regulating network used to limit the current in accordance with 25.7 shall be such that the current under any condition of load including short circuit does not exceed the values indicated in 25.4 (b)(1) or (2).

25.11 When a regulating network is used to limit the voltage or current in accordance with 25.4 – 25.10, and the performance is affected by malfunction, either short circuit or open circuit, of any single component – excluding a resistor – the network shall comply with the following:

- a) The environmental tests, and
- b) Critical components shall be derated.

25.12 In a circuit of the type described in 25.7, the secondary winding of the transformer, the fuse or circuit protective device, or the regulating network, and all wiring up to the point at which the current and voltage are limited shall be judged under the applicable requirements in this standard.

26 Accessible Signal Circuits

26.1 The requirements in 26.2 and 26.3 apply to accessible signal circuits having provision for external connections such as RS232 communication ports or similar devices.

26.2 A signal circuit that extends out of a unit shall be isolated from the alternating current input circuit by any of the following:

- a) An optical isolator having an isolation voltage rating of not less than the Dielectric Voltage-Withstand test potential required in 45.4 and complying with the requirements in the Standard for Optical Isolators, UL 1577,
- b) An isolation transformer complying with the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, or
- c) An isolation transformer complying with the requirements in 27.1.

26.3 The maximum voltage and current available from an accessible signal circuit shall comply with the requirements in 25.4 – 25.11.

26.4 The maximum power available from an accessible signal circuit that employs an overcurrent protection device to limit the current as described in the Exception to 25.4 shall not exceed the values specified in Table 26.1.

Table 26.1
Maximum power of accessible signal circuits

Circuit voltage volts, rms	Maximum power, volt-amperes
15 or less	350
More than 15 and not greater than 60	250

27 Transformers

27.1 Transformers provided with the generator assembly shall be evaluated in accordance with the following Standards where applicable:

- a) Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3,
- b) Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411,
- c) Standard for Specialty Transformers, UL 506, and
- d) Standard for Dry-Type General Purpose and Power Transformers, UL 1561.

28 Separation of Circuits

28.1 Factory wiring

28.1.1 Insulated conductors of different circuits (see 28.1.2) within an engine generator assembly, including wires in a terminal box or compartment, shall be either separated by barriers or segregated and shall be so separated or segregated from uninsulated live parts connected to different circuits.

Exception: For insulated conductors of different circuits, when each conductor is provided with insulation intended for the highest of the circuit voltages, no barriers or segregation are required.

28.1.2 For the purpose of the requirement in 28.1.1, different circuits include those separated in Table 28.1.

Table 28.1
Circuit characteristics

Hazardous Voltage Circuits		Non – hazardous Low Voltage Circuits	
Characteristics	Examples	Characteristics	Examples
$> 30 V_{rms}$ (sinusoidal)	output power circuit	$\leq 30 V_{rms}$ (sinusoidal)	starter battery
$> 42.4 V_p$ (non sinusoidal)-	output/sense/monitor/control/feedback circuits (non-sinusoidal) (or output side of these circuits, when isolation ^a provided to low voltage circuits)	$\leq 42.4 V_p$ (non-sinusoidal)	low voltage side of output feedback circuits, when isolation ^a provided
$> 60 V_{DC}$ (if $> 10\%$ ripple, composite voltage, subject to 42.2 V_p limit)	supply voltage for AC/DC starter battery charger, when provided	$\leq 60 V_{DC}$	low voltage side of AC/DC starter battery charger, when provided
Any circuit not isolated from a hazardous voltage circuit, regardless of working voltage (e.g., a 5V control circuit is hazardous when referenced to a 240V output circuit: 5V across circuit, and 240V to ground)	AC convenience receptacles, when provided		control/signal circuits accessible to the user/operator, or intended for external or remote connections (e.g., Class 2 Remote-Control, Signaling Circuits – Article 725 of the NEC)
	engine ignition coil output		
^a isolation that meets applicable requirements including construction, spacings, electrical strength, abnormal operation.			

28.1.3 Segregation of insulated conductors is to be accomplished by clamping, routing, or an equivalent means that maintains permanent separation from insulated and uninsulated live parts and from conductors of a different circuit.

28.2 Separation barriers

28.2.1 A barrier used to provide separation between the wiring of different circuits shall be:

- a) Grounded metal or insulating material complying with the requirements in Insulating Materials, Section 34, and no less than 0.028 inch (0.71 mm) thick, and
- b) Supported so that it is not capable of being readily deformed so as to defeat its purpose.

28.2.2 A barrier used to provide separation between field wiring and parts of a different circuit (field wiring, factory wiring, or uninsulated live parts) shall be spaced no more than 1/16 inch (1.6 mm) from the enclosure walls and interior mechanisms, component-mounted panels, and other parts that serve to provide separated compartments.

28.3 Field wiring

28.3.1 The equipment shall be constructed so that a field-installed conductor of a circuit shall be separated by barriers as specified in 28.2.1 and 28.2.2 or be separated by segregation as specified in 28.3.2 from:

- a) Factory-installed conductors connected to any other circuit unless the conductors of both circuits are insulated for the maximum voltage of either circuit,
- b) An uninsulated live part of another circuit and from an uninsulated live part where short circuit with it results in a risk of fire, electric shock, electrical energy involving high current levels, or injury to persons, and
- c) Field-installed conductors connected to any other circuit unless:
 - 1) Both circuits are Class 2 or Class 3, or
 - 2) Both circuits are other than Class 2 or Class 3, and both circuits are insulated for the maximum voltage of either circuit.

28.3.2 Field installed conductors and the live parts of different circuits as indicated in 28.3.1, may be separated by a minimum of 1/4 inch (6.4 mm). When evaluating the separation requirements the field installed conductors are to be wired as in service and each conductor shall have 6 inches of slack. No more than average care is to be exercised in routing the wiring and stowing the conductor slack into the wiring compartment. The field installed conductors are to be wired as follows:

- a) When each opening is located opposite a set of terminals, it is to be assumed that a conductor entering an opening is to be connected to the terminal opposite that opening.
- b) When each opening is located other than the one opposite the terminal to which it is intended to be connected the potential for it to contact insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be evaluated.

29 Overcurrent Protection

29.1 General

29.1.1 An overcurrent protective device, the intended functioning of which requires renewal, replacement, or resetting, shall be accessible:

- a) From outside of the enclosure, or
- b) Behind a cover (see 7.3.1).

29.1.2 With reference to the requirement in 29.1.1, a control-circuit fuse does not require renewal as an intended function when the fuse and the load are contained within the same enclosure.

29.1.3 The screw shell of a plug-type fuseholder and the contacts including associated live parts that are capable of being contacted by the probe illustrated in Figure 8.1 of an extractor-type fuseholder shall be connected toward the load.

Exception: The screwshell shall not be connected toward the load when the screwshell is in accordance with (c) of Exception No. 2 to 29.1.8.

29.1.4 A fuse and a fuseholder shall have voltage and current ratings intended for the circuit in which they are connected. A fuseholder shall be of the cartridge, plug, or extractor type. Plug fuses shall not be used in a circuit rated more than 125 volts or 125/250 volts, 3-wire.

Exception: Fuses intended to be replaced by only service personnel (see Protection of Service Personnel, Section 39) are not prohibited from being bolted in place.

29.1.5 A plug-type fuseholder shall be of the Type S construction.

29.1.6 A circuit breaker connected in the output circuit shall open all ungrounded conductors.

Exception: When the generator has provision for connection of a grounded neutral conductor, individual single-pole circuit breakers are not prohibited as the protection for each ungrounded conductor of 3-wire single phase circuits or for each ungrounded conductor of a 4-wire, 3-phase circuit, when no conductor involves a potential to ground in excess of 150 volts.

29.1.7 A generator shall be marked in accordance with 68.3.7 when it is provided with overcurrent protection consisting of an interchangeable fuse and when the fuse is:

- a) Accessible to the user, or
- b) Used to comply with the requirements in this standard.

29.1.8 An overcurrent protective device shall not be connected in the grounded (neutral) side of the line.

Exception No. 1: Additional overcurrent protection provided in the grounded side of the supply circuit is not prohibited when the protective device simultaneously disconnects the grounded and ungrounded conductors of the supply circuit.

Exception No. 2: A unit that incorporates a single-pole overcurrent protective device connected in the grounded (neutral) side of the line is not prohibited when:

- a) Each ungrounded circuit conductor is provided with an overcurrent protective device having a current rating no higher than that of the overcurrent protective device in the grounded circuit conductor,
- b) The screw shell of a plug fuseholder and the accessible contact of an extractor fuseholder located in the grounded circuit conductor is connected toward the grounded supply line, and
- c) The unit is marked in accordance with 68.3.12.

29.1.9 Temperature or current-sensitive devices such as temperature limiting thermostats, thermal cutoffs, appliance protectors, fuses, circuit breakers, or similar devices that comply with the Abnormal Tests, Section 54, shall comply with the requirements for such devices.

29.1.10 Overcurrent protection employing solid state component circuitry used for protection of circuits described in (a) – (b) shall comply with the requirements in the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

- a) Control circuits per 29.2.1 – 29.2.7.
- b) Output alternating current power circuits per 29.3.1 – 29.3.3.

Exception No. 1: Overcurrent protection whose performance is not affected by malfunction, either by short circuit or open circuit, of any single component is not required to comply.

Exception No. 2: A solid state overcurrent protection circuit provided in addition to other overcurrent protection devices such as a fuse or circuit breaker that is intended for the application is not required to comply.

29.2 Control circuits

29.2.1 A control circuit that extends from the generator to a remote control panel, status panel, or similar device shall be protected in accordance with 29.2.2 – 29.3.3 to reduce the risk of fire and electric shock that results from overload and short circuit conditions.

29.2.2 The overcurrent protective device specified in 29.2.1 shall be a circuit breaker or fuse that is either:

- a) Intended for branch circuit use, or
- b) A supplementary type.

When the protective device consists of a fuse, the generator shall be marked in accordance with 68.3.7.

29.2.3 A Class 1 power-limited circuit, in accordance with the National Electrical Code, NFPA 70, used to supply an external control circuit shall be supplied from a source having a rated output of no more than 30 volts and 1000 volt-amperes. When the source is other than a transformer, the circuit shall be protected by an overcurrent protection device rated no more than 167 percent of the volt-ampere rating divided by the rated voltage. The overcurrent device shall not be interchangeable with overcurrent devices of higher ratings.

29.2.4 An external control circuit derived from a Class 2 transformer described in 2.10 is not required to be provided with overcurrent protection specified in 29.2.1.

29.2.5 An external control circuit derived from the secondary of a transformer other than that described in 29.2.3 and 29.2.4 shall be provided with overcurrent protection in accordance with 29.2.6 and 29.2.7. For transformers not having a rating, the rated primary or secondary current specified in 29.2.6 and 29.2.7 is to consist of the maximum current during normal operation of the unit.

29.2.6 Except as described in 29.2.7, a transformer used to supply a control circuit shall be provided with overcurrent protection in the primary circuit rated as indicated in Table 29.1.

Exception: When the rated primary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device is not prohibited from being used. Standard ratings of protective devices are specified in Article 240-6 of the National Electrical Code, NFPA 70.

Table 29.1
Primary overcurrent protection for control circuit transformers

Rated primary current, amperes	Maximum rating of overcurrent device, percent of transformer primary current rating
Less than 2	300
2 or more, less than 9	167
9 or more	125

29.2.7 When a control circuit is derived from the secondary of a transformer that is provided with primary circuit overcurrent protection rated at no more than 250 percent of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit when the secondary circuit is protected at no more than 125 percent of the rated secondary current of the transformer.

Exception No. 1: When the rated secondary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device is not prohibited from being used in the secondary circuit. Standard ratings of protective devices are specified in Article 240-6 of the National Electrical Code, NFPA 70.

Exception No. 2: When the rated secondary current of the transformer is less than 9 amperes, the overcurrent protection in the secondary circuit shall be rated or set at no more than 167 percent of the rated secondary current.

29.3 Output alternating current power circuits

29.3.1 An output circuit shall be provided with overcurrent protection for all ungrounded conductors as described in 29.3.3. The voltage rating of the overcurrent protection shall not be less than the rating of the circuit with which it is used. The overcurrent protection device shall be a circuit breaker, fuse or equivalent means intended for use as branch circuit protection and located within 25 feet (7.62 meters) of the generator output terminals.

Exception: The overcurrent protection is not required to be provided with the generator when the installation instructions specify the required overcurrent protection for the output power circuit.

29.3.2 The voltage rating specified in 29.3.1 for a 3-phase circuit shall be based on the phase-to-phase voltage.

29.3.3 The rating of the overcurrent protection shall not exceed the ampacity of the conductors intended to be connected to the generator as determined in accordance with 16.1.4.

30 Air Filters

30.1 Air filters for use in cooling systems shall comply with the requirements in the Standard for Air Filter Units, UL 900, or shall be constructed of materials classed V-2 or HF-2 or less flammable in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: This requirement does not apply to air filters in closed systems. A closed system is defined as that which, although not required to be air tight, is not intended to be vented outside the enclosure.

Exception No. 2: This requirement does not apply to air filters located external to the enclosure and constructed of materials classed HB or HBF or less flammable.

31 Capacitors

31.1 Capacitors used in the construction of the generator shall comply with the requirements in Section 31 of the Standard for Uninterruptible Power Systems, UL 1778.

32 Resistors

32.1 The assembly of a power resistor, such as a wire-wound type requiring a separate support shall be reliable. The resistor shall be prevented from loosening or rotating by a means other than friction between surfaces.

32.2 An assembly employing lock washers complies with the requirement in 32.1.

33 Printed-Wiring Boards

33.1 A printed-wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796, and shall be classed V-0, V-1, or V-2 in accordance with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: A printed-wiring board located outside an enclosure, such as in an external control circuit, and located in a LVLE circuit or a limited-energy circuit is not required to be classed as minimum V-2.

33.2 A resistor, capacitor, inductor, or other part that is mounted on a printed-wiring board to form a printed-wiring assembly shall be secured so that it is not capable of displacing and resulting in a risk of electric shock or fire by a force that is exerted on it during assembly, intended operation, or servicing of the generator set.

33.3 Consideration is to be given to a barrier or a partition that is part of the unit assembly and that provides mechanical protection and electrical insulation of a component connected to the printed-wiring board.

34 Insulating Materials

34.1 The generator insulation system shall comply with the construction requirements contained in the Standard for Systems of Insulating Materials – General, UL 1446.

34.2 A material that is used for the direct support of an uninsulated live part shall comply with the Relative Thermal Index (RTI), Hot Wire Ignition (HWI), High-Current Arc Resistance to Ignition (HAI), and Comparative Tracking Index (CTI) values indicated in Table 34.1. A material is in direct support of an uninsulated live part when:

- a) It is in direct physical contact with the uninsulated live part, and
- b) It serves to physically support or maintain the relative position of the uninsulated live part.

Exception No. 1: The generic materials complying with Table 34.2 are not prohibited for the direct support of uninsulated live parts without additional evaluation.

Exception No. 2: Those materials without HWI Performance Level Category (PLC) values or with HWI PLC values higher (worse) than those required by Table 34.1 shall alternatively be subjected to the end-product Abnormal Overload Test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 3: Those materials without HAI Performance Level Category (PLC) values or with HAI PLC values higher (worse) than those required by Table 34.1 shall alternatively be subjected to the end-product Special Arcing Test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 4: Those materials that are used in devices that do not incorporate contacts are not required to comply with the HAI Performance Level Category (PLC) requirements.

Exception No. 5: Those materials that are used in devices that incorporate contacts and are not used within 1/2 inch (12.7 mm) of the contacts are not required to comply with the HAI Performance Level Category (PLC) requirements.

Exception No. 6: Those materials without CTI Performance Level Category (PLC) values or with CTI PLC values higher (worse) than the CTI required by Table 34.1 shall alternatively be subjected to the end-product Special Arcing Test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 7: Those materials without CTI Performance Level Category (PLC) values or with CTI PLC values higher (worse) than the CTI required by Table 34.1 shall be in compliance with the CTI PLC requirement when:

- a) They have a High-Voltage-Arc Tracking (HVTR) PLC value of 1 or lower (better), or*
- b) The over surface spacings between the uninsulated live parts are at least 1/2 inch (12.7 mm).*

Table 34.1
Minimum material characteristics required for the direct support of uninsulated live parts

UL 94 ^a Flame Class	RTI Elec	HWI ^c	HAI ^c	CTI ^d
HB	b	2	1	4
V-2	b	2	2	4
V-1	b	3	2	4
V-0	b	4	3	4

^a Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

^b The electrical RTI value of a material is to be determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B by test or by use of the generic RTI table. This material characteristic is dependent upon the minimum thickness at which the material is being used and shall not be exceeded during the Temperature Test, Section 44.

^c The HAI and HWI Performance Level Category (PLC) value of a material is to be determined by test in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is dependent upon the minimum thickness at which the material is being used.

^d The CTI PLC value of a material is to be determined by test in accordance with UL 746A. This material characteristic is not dependent upon the minimum thickness at which the material is being used.

Table 34.2
Generic materials used for the direct support of uninsulated live parts

Generic material	Thickness	RTI, °C
Any cold-molded composition (i.e. concrete)	No limit	No limit
Ceramic, Porcelain, and Slate	No limit	No limit
Diallyl Phthalate	0.028 inch (0.71 mm)	105
Epoxy	0.028 inch (0.71 mm)	105
Melamine	0.028 inch (0.71 mm)	130
Melamine-Phenolic	0.028 inch (0.71 mm)	130
Phenolic	0.028 inch (0.71 mm)	150
Unfilled Nylon	0.028 inch (0.71 mm)	105
Unfilled Polycarbonate	0.028 inch (0.71 mm)	105
Urea Formaldehyde	0.028 inch (0.71 mm)	100
NOTE – Each material shall be used within its minimum thickness and its RTI value shall not be exceeded during the Temperature Test, Section 44.		

34.3 Insulating material – such as a relay dust cover, transformer bobbin, inductor bobbin, insulating sheet, encapsulation, or similar material that is used as a barrier in lieu of the required over surface, or through air spacings, or both, shall comply with the requirements in 34.6 – 34.11.

34.4 Vulcanized fiber is not prohibited from being used for insulating bushings, washers, separators, and barriers, and shall not be used as sole support for uninsulated live parts.

34.5 A sensor such as a current transformer, transducer, or similar device shall be provided with insulation that has been evaluated for the maximum voltage and temperature involved in its application, while taking into consideration the presence of other circuits.

34.6 Insulating material is not prohibited from being used as a barrier in lieu of the required spacings per 24.1.1.

34.7 The insulating material specified in 34.6 shall comply with the requirements in 34.8 when:

- a) The material is in direct physical contact with an uninsulated live part;
- b) The material serves to physically support, or maintain the relative position of the uninsulated live part; and
- c) The material is used as a barrier in lieu of the required over surface or through air spacings.

34.8 An insulating material used as noted in 34.6 shall:

- a) Comply with 34.2; and
- b) Be at least 0.028 inch (0.71 mm) thick.

Exception No. 1: A material that complies with 34.2 and does not comply with the thickness limit in (b) shall alternatively be subjected to a 5000 V ac Dielectric Voltage Withstand Test in accordance with the Internal Barrier requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 2: A material that complies with 33.1 and is used in addition to not less than one-half the required through air spacings is not prohibited from being less than 0.028 inch (0.71 mm) thick, and shall be at least 0.013 inch (0.33 mm) thick. This material shall:

- a) Have the required mechanical strength when exposed or otherwise subjected to mechanical damage;*
- b) Be held in place; and*
- c) Be located so that it is not adversely affected by operation of the equipment in service.*

34.9 The two requirements noted in 34.8 are independent of each other. For example, even when a material complies with 33.1 at a thickness less than the 0.028 inch (0.71 mm) limit, then the material still is required to be provided at a thickness at least equal to this 0.028 inch (0.71 mm) limit or at a thickness allowed for by the Exceptions to 34.8.

34.10 An insulating material shall also comply with the requirements in 34.8 when:

- a) The material is in direct physical contact with an uninsulated live part;
- b) The material does not serve to physically support or maintain the relative position of that uninsulated live part; and
- c) The material is used in lieu of the required over surface, or through air spacings.

Exception: The generic insulating materials in Table 34.3 comply for this application without additional evaluation.

Table 34.3
Generic materials used as a barrier per 34.9 and 34.10

Generic material ^a	Minimum thickness	RTI, °C
Aramid Paper	0.010 inch (0.25 mm)	105
Cambric	0.028 inch (0.71 mm)	105
Electric Grade Paper	0.028 inch (0.71 mm)	105
Epoxy	0.028 inch (0.71 mm)	105
Mica	0.006 inch (0.15 mm)	105
Mylar (PETP)	0.007 inch (0.18 mm)	105
RTV	0.028 inch (0.71 mm)	105
Silicone	0.028 inch (0.71 mm)	105
Treated Cloth	0.028 inch (0.71 mm)	105
Vulcanized Fiber	0.028 inch (0.71 mm)	105
^a Each material shall be used within its minimum thickness and its RTI value shall not be exceeded during the Temperature Tests, Section 44.		

34.11 An insulating material shall also comply with the requirements in 34.8 when:

- a) The material is not in direct physical contact with an uninsulated live part;
- b) The material does not serve to physically support, or maintain the relative position of that uninsulated live part; and

- c) The material is used in lieu of the required through air spacings.

Exception No. 1: The generic insulating materials in Table 34.3 comply for this application without additional evaluation.

Exception No. 2: The Hot Wire Ignition (HWI), High – Current Arc Resistance to Ignition (HAI) and Comparative Tracking Index (CTI) Performance Level Category (PLC) requirements do not apply for materials that are located at least 1/32 inch (0.8 mm) from uninsulated live parts.

Exception No. 3: The Hot Wire Ignition (HWI), High – Current Arc Resistance to Ignition (HAI) and Comparative Tracking Index (CTI) Performance Level Category (PLC) requirements and RTI requirements do not apply for materials that are located at least 1/2 inch (12.7 mm) from uninsulated live parts.

35 Adhesives

35.1 An adhesive that is relied upon to reduce a risk of fire, electric shock, or injury to persons shall comply with the requirements for adhesives in the Standard for Polymeric Material – Use in Electrical Equipment Evaluations, UL 746C.

35.2 The requirement in 35.1 also applies to an adhesive used to secure a conductive part, including a nameplate, that when loosened or dislodged:

- a) Energize an accessible dead metal part,
- b) Make a live part accessible,
- c) Reduce spacings below the minimum required values, or
- d) Short-circuit live parts.

36 Battery Heaters and Miscellaneous Heaters

36.1 Battery heaters and heating appliances rated at 600 V or less for use in unclassified locations in accordance with the National Electrical Code (NEC), NFPA 70, shall comply with the Standard for Electric Heating Appliances, UL 499.

37 Engine Starting Equipment

37.1 Generator assemblies shall be provided with starting equipment in accordance with NFPA 110, Emergency and Standby Power Systems, Section 3-5.4.

37.2 When an automatic battery charger is provided in addition to the engine driven charger (NFPA 110, Section 3-5.4.6) of the generator assembly, the charger shall comply with the Standard for Battery Chargers for Charging Engine-Starter Batteries, UL 1236.

38 Battery

38.1 Battery compartment

38.1.1 When a separate lead-acid storage battery is intended to be placed in a compartment provided with, or as part of, the engine generator assembly, it shall be secured in position to prevent contact with conducting materials in the area and be readily accessible for servicing.

38.1.2 The ventilation shall be provided by construction of the engine generator assembly or the enclosure in the manufacturer's installation instructions (See 69.2.1).

38.1.3 There shall be no sparking or arc producing devices located within the battery compartment, (switches, relays, or similar devices).

38.1.4 The interior of a metal compartment housing a lead-acid battery shall be protected against corrosion by two coats of acid resistant paint, two coats of enamel individually baked on, or the equivalent.

38.2 Isolation

38.2.1 A generator having an integral battery charging circuit rated 60 volts, dc – maximum rectifier output voltage – or less shall incorporate isolation as specified in Section 27 between the input ac circuit and the battery circuit.

39 Protection of Service Personnel

39.1 The requirements in this section apply only with regard to service personnel who find they must reach over, under, across, or around uninsulated electrical parts or moving parts to make adjustments or measurements while the engine generator is in operation. For requirements covering accessibility of live parts for protection of users, refer to Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts – and User Servicing, Section 8.

39.2 Live parts shall be so arranged and covers so located as to reduce the risk of electric shock or electrical energy – high current levels while covers are being removed and replaced.

39.3 An uninsulated live part involving a risk of electric shock or electrical energy – high current levels and a moving part that involves a risk of injury to persons shall be located, guarded, or enclosed so as to reduce the risk of unintentional contact by service personnel adjusting or resetting controls, or similar service, or performing mechanical service functions that are performed with the equipment energized, such as lubricating a motor, adjusting the setting of a control with or without marked dial settings, resetting a trip mechanism, or operating a manual switch.

39.4 Live parts involving a risk of electric shock (See Table 9.1) or electrical energy – high current levels – located on the back side of a door shall be either guarded or insulated to reduce the risk of unintentional contact of the live parts by service personnel.

39.5 A component that requires examination, resetting adjustment, servicing, or maintenance while energized shall be so located and mounted with respect to other components and with respect to grounded metal parts that it is accessible for electrical service functions without subjecting the service person to the risk of electric shock, electrical energy– high current, or injury to persons by adjacent moving parts. Access to a component shall not be impeded by other components or by wiring.

39.6 For an adjustment that is to be made with a screwdriver or similar tool when the unit is energized, 39.5 requires that protection be provided so that inadvertent contact with adjacent uninsulated hazardous live parts involving a risk of electric shock is reduced taking into consideration that misalignment of the tool with the adjustment means results when an adjustment is attempted. This protection shall be provided by:

- a) Location of the adjustment means away from uninsulated hazardous live parts, or
- b) A guard to reduce the risk of the tool from contacting uninsulated live parts.

39.7 A live heat sink for a solid-state component, a live relay frame, or similar device involving a risk of electrical shock or electrical energy – high current levels, which are capable of being mistaken for dead metal, shall be guarded to reduce the risk of unintentional contact by the serviceperson or be marked in accordance with 68.3.4.

Exception: A heat sink mounted on a printed wiring board is not required to comply.

39.8 Moving parts that result in injury to persons and that must be in motion during service operations not involving the moving parts shall be located or protected so that unintentional contact with the moving parts is minimized.

40 Inverters, Converters, Controllers and Interconnection System Equipment for Generators

40.1 Engine generators and microturbines that include inverters or converters in their power output shall comply with the requirements in the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

40.2 Engine generators and microturbines with their associated control systems intended for utility interactive operations shall comply with the requirements in the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741. Engine generators and microturbines with their associated control systems that are evaluated for complete utility interactive operations shall be marked in accordance with 68.3.16.

Exception: When engine generators and microturbines are provided with control systems that include features intended to support operation in parallel with the utility grid and these features have not been evaluated for compliance with specific utility interconnection protection standards or requirements, the engine generator or microturbines shall be marked in accordance with 68.3.17 and the instructions specified in 69.1.6.

MECHANICAL SYSTEMS

CONSTRUCTION

41 Fuel Systems

41.1 Gasoline or diesel

41.1.1 General

41.1.1.1 A fuel confining part having internal threads made of drawn brass or machined from brass rod shall be capable of withstanding, without cracking, the 10-day Moist Ammonia-Air Stress Cracking Test, Section 51.

41.1.2 Tanks and fuel pumps

41.1.2.1 Fuel tanks provided as part of the engine generator assembly shall be constructed in accordance with NFPA 37, Chapter 6.

41.1.2.2 Fittings and fill pipe, where soldered or bonded, shall be mechanically secured to the tank in addition to soldering or bonding.

41.1.2.3 When a tank is within or contiguous to the engine compartment the tank location and the facilities for filling shall be such that spillage or leakage drains to the ground and not onto the engine or exhaust-system parts. Spillage tests shall be conducted when required to determine compliance.

41.1.2.4 A fuel tank and fill fitting shall be so located as to reduce the possibility of damage to the tank or its fittings. The fill fitting and exhaust terminus shall be at least 3 feet (0.9 m) apart when installed in accordance with the manufacturer's instructions.

41.1.2.5 External fuel-confining parts of an electrically or mechanically operated fuel pump shall be of metal. Failure of operating parts shall not result in external leakage of fuel. Electrically-operated fuel pumps shall comply with the Standard for Industrial Trucks, Internal Combustion Engine-Powered, UL 558.

41.1.2.6 An automatically operated positive shutoff shall be incorporated in the fuel line. This positive shutoff shall be a part of the carburetor, fuel pump, or similar device, or be a separate fuel solenoid shutoff valve, and shall prevent fuel at 3 pounds per square inch (psi) (20.7 kPa) or less from flooding the carburetor or similar device and spilling into the compartment when the engine generator is not operating.

41.1.3 Fuel lines and fittings

41.1.3.1 Fuel lines shall be of annealed seamless drawn aluminum or steel tubing. Flexible tubing or hose shall be used only where required to absorb vibration.

41.1.3.2 Aluminum tubing shall have a nominal wall thickness of not less than 0.030 inch (0.76 mm), 0.0035 inch (0.089 mm) minus tolerance. Steel tubing shall have a wall thickness of not less than 0.028 inch (0.71 mm) and shall have a corrosion-resistant exterior coating equivalent to that afforded by paint.

41.1.3.3 Flexible tubing or hose shall comply with the Standard for Fuel and Oil Hose, ANSI/SAE J30, and be Types SAE J30 R6, SAE J30 R7, or SAE J30 R9. Tubing and hose shall not pull off fittings or fail when subjected to a 20 pound-force (89 N) axial pull test applied over a 1 minute period. The test shall be conducted at ambient conditions of $21 \pm 5^{\circ}\text{C}$ ($70 \pm 9^{\circ}\text{F}$) with tubing or hose wetted with fuel. Hose shall be subjected to 70 hours at 100°C (212°F) aging and 48 hours of 0.125 inch amplitude vibration at 17 Hz before the pull test.

Exception: Flexible tubing or hose for use with higher pressure diesel fuel injected engines shall be of the type indicated in Table 41.0 which have been found to comply with the requirements in the Standard identified.

Table 41.0
Types of Flexible Tubing or Hose

Identification	Standard
"SAE J517 100R1 Type AT"	Standard for Hydraulic Hose, SAE J517
"SAE J1402"	Standard for Automotive Air Brake Hose and Hose Assemblies, SAE J1402
"SAE 100R5-10/J1402"	Standard for Automotive Air Brake Hose and Hose Assemblies, SAE J1402
"SAE 100R1/EN 853-1SN"	Standard for Hydraulic Hose, SAE J517
"DIN 73379"	Standard for Road Vehicles – Fuel Hoses, DIN 73379-1
"ISO 19013-1"	Rubber Hoses and Tubing for Fuel Circuits for Internal Combustion Engines; Specification Part 1: Diesel Fuels, ISO 19013
"SAE J1597"	Standard for Laboratory Testing of Vehicle and Industrial Heat Exchanges for Pressure Cycle Durability, J1597

41.1.3.4 Fuel-line tubing fittings shall be of the type conforming to the Standard for Automotive Tube Fittings, ANSI/SAE J512, or the Standard for Cast Copper Alloy Fittings for Flared Copper Tubes, ANSI/ASME B16.26, or the equivalent.

Exception: Pressed-in fittings are not prohibited from being used on gravity feed systems.

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

41.1.3.6 Fuel-line hose fittings shall be of the non-adjustable spring clamp or crimp-on type fittings complying with Dry Seal Pipe Threads, SAE J476 and Automotive Tube Fittings, SAE J512.

41.1.3.7 External fuel-confining parts of a filter, except a gasket or seal, shall be of metal. Glass filter bowls are not prohibited when they are located within a compartment in which the system is installed.

41.1.3.8 Fuel lines shall be supported to minimize chafing and to maintain at least a 2 inch (51 mm) clearance from bare exhaust components. Electrical wiring shall not be tied to fuel lines and shall be routed so that it maintains 1/2 inch (12.7 mm) clearance from fuel lines.

41.1.3.9 Fuel feed lines, valves, and fittings shall be located so that any leakage does not run off or drip on electrical- or exhaust-system parts.

41.1.4 Nonmetallic parts

41.1.4.1 A synthetic-rubber part, in contact with gasoline or diesel fuel shall not show excessive volume change or loss of weight when evaluated on the basis of its intended function, following immersion for 70 hours in the test liquid specified in Table 41.1.

Table 41.1
Test liquids for nonmetallic materials

Liquid in contact with part	Test liquid
Gasoline	ASTM Reference Fuels A and C
Diesel	IRM 903 Oil

41.1.4.2 A change in volume of not more than 25 percent swelling or 1 percent shrinkage, and a weight loss (extraction) of not more than 10 percent is considered as indicating compliance with 41.1.4.1.

41.1.4.3 A part made of synthetic rubber which is affected by aging shall not crack or show visible evidence of deterioration following exposure for 96 hours to oxygen at a pressure of 300 psi (2.07 MPa) and a temperature of 70°C (158°F).

41.1.5 Corrosion resistance

41.1.5.1 Where corrosion of a ferrous part interferes with the proper functioning of a part, the part shall be provided with a corrosion-resistant protective coating.

41.1.6 Carburetors

41.1.6.1 Where a side or updraft carburetor is used, it shall be located so that overflow of gasoline due to excess choking flows to ground and does not contact electrical parts and exhaust system, or collect in an engine compartment. Nonmetallic drain hose, when used, shall comply with the fuel resistance, oil resistance, and dry-heat resistance tests of the Standard for Fuel and Oil Hose, ANSI/SAE J30.

41.1.6.2 A downdraft carburetor, when 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.

41.1.6.3 A backfire deflector shall be provided on each combustion air intake and, whether separate or a part of an air cleaner, shall conform with the requirements of Backfire-Deflector Test, Section 49.

Exception: This test is not required for diesel fueled generator assemblies.

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41.2 Liquefied petroleum gas

41.2.1 General

41.2.1.1 Where an LP-Gas fuel system is provided as part of the generator set it shall include the complete fuel system installed at the factory, except as indicated in 41.2.1.2 and 41.2.1.3.

41.2.1.2 Products equipped to use a removable fuel container shall not be shipped without the fuel container unless a metal nameplate that identifies the correct fuel-container assembly to be used is attached adjacent to the container-mounting hardware.

41.2.1.3 A generator assembly arranged for LP-Gas fuel and intended for use with a remotely mounted tank not provided or part of the generator is not prohibited. Paragraphs concerning fuel containers do not apply to generator sets units of this type.

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

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

41.2.1.6 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 (1.75 MPa).

41.2.1.7 All fuel-system components shall be secured to the unit to minimize the risk of loosening due to vibration.

41.2.2 Containers

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

- a) The ASME Boiler and Pressure Vessel Code, Section VIII or
- b) The Specifications of the Department of Transportation (DOT) CFR Title 49, Part 178 for LP-Gas Containers.

41.2.2.2 A fuel container is not prohibited from being fixed to or removable from the generator set.

41.2.2.3 An ASME fuel container shall have a designed working pressure of 312, 343, or 375 psi (2.15, 2.36 or 2.60 MPa). It shall be marked with the ASME "U" symbol and the design working pressure.

41.2.2.4 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.

41.2.2.5 A fuel container shall be located so as to reduce the risk 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.

41.2.2.6 A fuel container shall be secured in place.

41.2.2.7 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.

41.2.2.8 When 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.

41.2.2.9 The use of a quick-closing coupling (a type closing in both directions when uncoupled) in the fuel line shall be determined as complying with the requirements of 41.2.2.8.

41.2.2.10 Welding, when required shall be made only on saddle plates, lugs, or brackets originally attached to the fuel container by the manufacturer.

41.2.2.11 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.

41.2.2.12 A fuel container shall be shielded, when required against direct heat radiation from the engine and exhaust system. See Table 44.2.

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

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

41.2.2.15 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.

41.2.2.16 A removable container employing a hand-operated shutoff valve with an internal excess-flow check valve is not prohibited.

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

41.2.2.18 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 (1.4 mm); except those connections for filling and safety relief valves.

41.2.3 Gauges

41.2.3.1 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.

41.2.3.2 A fixed-tube gauge shall be employed on the fuel container, except as indicated in 41.2.3.3.

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

41.2.3.4 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 does not exceed 80 percent 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.

41.2.3.5 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.

41.2.3.6 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 1/10 inch (2.5 mm)) measured from the top center of the container boss or coupling into which the gauge is installed to the maximum filling level. The exterior of the removable dip tube gauging device shall bear a corresponding "DT" marking.

b) Portable universal type containers that are 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 1/10 inch), measured from the top center of the container boss or coupling into which the gauge is installed to the maximum required 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.

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

41.2.4 Fuel lines and fittings

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

41.2.4.2 Steel tubing shall have a minimum wall thickness of 0.049 inch (1.2 mm) and shall have a corrosion-resistant exterior coating. Paint is a corrosion-resistant coating for this matter. 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.

41.2.4.3 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.

41.2.4.4 Tubing fittings shall be of a type designed for use with LP-Gas.

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

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

41.2.4.7 Fuel lines shall be supported to reduce chafing and to maintain at least a 2-inch (51-mm) clearance from bare exhaust components. Electrical wiring shall not be tied to fuel lines and shall be routed so that it does not inadvertently contact fuel lines.

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

41.2.4.9 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).

41.2.4.10 The fuel container and associated valves and fittings are not prohibited from being tested separately using air pressure of not less than 90 psi (621 kPa).

41.2.4.11 Nonmetallic low pressure propane flexible hoses and fittings shall be subjected to the Volume Change and Extraction Test, Section 66A, the Vibration Test, Section 66B, Aerostatic Leakage Test, Section 66C, and the Hydrostatic Strength Test, Section 66D.

41.2.5 Vaporizers

41.2.5.1 Each vaporizer shall have a valve or plug which can completely drain the vaporizer in the section occupied by the water or other heating medium. Where the engine cooling system drain is so located that it is able to serve as a vaporizer drain, a separate vaporizer drain valve or plug is not required.

41.2.5.2 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).

41.2.5.3 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 corrosion action of exhaust gases and the vaporizer system is designed to prevent excessive pressure.

41.2.5.4 Vaporizers shall not be equipped with fusible plugs.

41.2.6 Safety control and relief devices

41.2.6.1 A spring loaded internal-type safety relief valve with proper start-to-discharge setting and flow capacity, as detailed in 41.2.6.2 – 41.2.6.7, shall be provided on the fuel container.

41.2.6.2 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 percent of the marked design working pressure of the container.

41.2.6.3 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 41.2 which relates the minimum required flow capacity to the outside surface area of the container.

Table 41.2
Safety relief valve capacity

Container surface area,		Minimum flow rate of air	
Square feet	Square meters	CFM	M ³ /m
20 or less	1.86	626	17.73
25	2.32	751	21.27
30	2.79	872	24.69
35	3.25	990	28.03
40	3.72	1100	31.15

41.2.6.4 A safety relief valve on a DOT container shall be set for a start-to-discharge pressure of 375 psi (2.60 MPa) and shall comply with the DOT regulations.

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

41.2.6.6 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.

41.2.6.7 When 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 reduce the risk of its being dislodged by the discharge from the safety relief device and shall be directed upward within 45 degrees of the vertical.

41.2.6.8 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 when the engine stops. 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).

41.2.6.9 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.

41.2.6.10 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.

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

41.2.7 Nonmetallic parts

41.2.7.1 A synthetic-rubber part in contact with LP-Gas shall not show excessive volume change or loss of weight, when evaluated on the basis of its intended function, following immersion for 70 hours in hexane at $23.0 \pm 2.0^{\circ}\text{C}$.

41.2.7.2 A change in volume of not more than 25 percent swelling or 1 percent shrinkage, and a weight loss (extraction) of not more than 10 percent indicates compliance with 41.2.7.1.

41.2.7.3 A part made of synthetic rubber which is affected by aging shall not crack or show visible evidence of deterioration following exposure for 96 hours to oxygen at a pressure of 300 psig (2.07 MPa) and a temperature of 70°C (158°F).

41.2.8 Corrosion resistance

41.2.8.1 When corrosion of a ferrous part interferes with the proper function of a part, the part shall be provided with a corrosion-resistant protective coating. When the corrosion resistance properties of the metal are not known, a sample shall be subjected to the salt-spray test described in Section 52.

Exception: A part made of stainless steel is not required to be tested.

41.2.8.2 A part made of drawn brass or machined from brass rod shall withstand, without cracking, the 10-Day Moist Ammonia Air Stress Cracking Test, Section 51 for copper and copper alloys.

41.3 Natural gas

41.3.1 General

41.3.1.1 Steel pipe (black) employed as gas conduit on an engine generator shall comply dimensionally with the Standard for Welded and Seamless Wrought Steel Pipe, ANSI/ASME B36.10M.

41.3.1.2 Tapped holes for gas valves, pilots or other branch supply lines shall carry not less than 3-1/2 taper pipe threads in accordance with the Standard for Pipe Threads, General Purpose (Inch), ANSI/ASME B1.20.1.

41.3.1.3 Formed supply piping shall have all bends smoothly made without any appreciable reduction in the cross-sectional area, shall reveal no imperfections occasioned by the forming process, shall be annealed where required to remove internal stresses, and shall be thoroughly cleaned inside to remove loose particles.

41.3.1.4 Ends of piping and tubing shall be carefully reamed to remove obstructions and burrs.

41.3.1.5 Copper tubing or tubing with internal copper surfaces, when used for conveying fuel gas, shall be internally tinned or equivalently treated to resist sulphur corrosion.

41.3.1.6 To protect against the effects of normal vibration in service, gas engines shall not be rigidly connected to the gas supply piping.

41.3.1.7 The use of integral metallic and nonmetallic flexible connectors for protection against damage caused by settlement, vibration, expansion, contraction or corrosion complies. When flexible connectors are located so that they are exposed to a fire of short duration the approval shall consider the ability of the connector to stand up under such conditions.

41.3.1.8 Nonferrous tubing employed as gas conduit shall have a wall thickness in accordance with Table 41.3.

41.3.1.8.1 Nonmetallic low pressure natural gas flexible hoses and fittings shall be subjected to the Volume Change and Extraction Test, Section 66A, the Vibration Test, Section 66B, Aerostatic Leakage Test, Section 66C, and the Hydrostatic Strength Test, Section 66D.

Table 41.3
Minimum wall thicknesses for nonferrous tubing

Outside diameter		Minimum wall thickness	
Inch	(mm)	Inch	(mm)
1/8	(3.2)	0.020	(0.51)
3/16	(4.8)	0.025	(0.64)
1/4	(6.4)	0.029	(0.74)
5/16	(7.9)	0.029	(0.74)
3/8	(9.5)	0.032	(0.81)
7/16	(11.1)	0.032	(0.81)
1/2	(12.7)	0.038	(0.97)
9/16	(14.3)	0.038	(0.97)
5/8	(15.9)	0.038	(0.97)
3/4	(19.1)	0.045	(1.14)
7/8	(22.2)	0.045	(1.14)

41.3.1.9 Gas supply piping shall be rigidly supported.

41.3.1.10 Compounds used on threaded joints of gas piping shall be resistant to the action of liquefied petroleum gases.

41.3.1.11 Unions in gas lines shall be of the ground-joint or flanged-joint type including a gasket resistant to the natural gas and intended for the temperature to which it is exposed.

41.3.1.12 A 1/8 inch N.P.T plugged tapping, accessible for test gauge connection, shall be furnished for measuring inlet gas pressure to the unit. The plug used shall not be of the slotted head type.

41.3.1.13 Aluminum tubing shall not be:

- a) Exposed to condensate;
- b) Used if it passes through insulating material of other than neutral reaction, unless the tubing is protected from the insulation; or
- c) Used for water connections.

41.3.2 Gas flow controls

41.3.2.1 General

41.3.2.1.1 No control shall be furnished on an engine generator assembly which allows, by manual operation, gas flow to the engine when it is shutdown.

41.3.2.1.2 An automatic engine shutdown sensor shall be provided to detect when the engine is shutdown.

41.3.2.1.3 The automatic engine shutdown sensor shall cause the automatic safety shutoff valve to close in the event the engine is shutdown.

41.3.2.1.4 Deleted

41.3.2.1.5 Deleted

41.3.2.2 Automatic valves and automatic safety shutoff valves (ASSV)

41.3.2.2.1 All gas to the engine shall pass through at least one automatic valve and one automatic safety shutoff valve. The valves shall be in series and may be in a single control body.

41.3.2.2.2 Automatic safety shutoff valve (ASSV):

- a) Shall close upon shutdown or failure conditions, to automatically stop the flow of gas within one second. The valve closes upon command from the automatic engine shutdown sensor.
- b) Shall be of the type that fails closed.

41.3.2.2.3 Automatic valve:

- a) The automatic valve shall:
 - i) Operate each time there is a call for fuel.
 - ii) Completely stop the flow of gas within 1 second of the engine shutting down for any reason.
 - iii) Be of the type that fails closed.
- b) A zero governor regulator or an auxiliary valve may serve as the automatic valve.

41.3.2.2.4 Automatic valves and automatic safety shutoff valves shall comply with the applicable requirements in the Standard for Automatic Valves for Gas Appliances, ANSI Z21.21, including the following:

- a) Normally closed electrically operated automatic safety shutoff valves shall close upon zero current flow.
- b) Normally closed gas operated automatic safety shutoff valves shall close upon pressure failure to the valve operator.

41.3.2.3 Gas appliance pressure regulators

41.3.2.3.1 A gas appliance pressure regulator shall be supplied with each engine generator.

41.3.2.3.2 Gas appliance pressure regulators, including vent limiters when so equipped, shall comply with the applicable provisions of the Standard for Gas Appliance Pressure Regulators, ANSI Z21.18.

41.3.2.4 Bleeds and Vents

41.3.2.4.1 The gas appliance pressure regulator shall be equipped with either a vent line or a vent limiter.

41.3.2.4.2 A diaphragm type automatic valve incorporating an external bleed shall be equipped with a bleed line.

42 Exhaust Systems

42.1 The exhaust system beyond the manifold shall be supported at least 3 inches (76.2 mm) clear of flammable materials, excluding flexible mountings, and at least 2 inches (50.8 mm) clear of fuel and electrical-system parts and shall not be subject to drippage of fuel, oil, or grease. Reduced spacings (1/2 inch minimum) are evaluated for compliance during the Temperature Test. See Temperature Test, Section 44.

42.2 A muffler when provided shall conform with the test requirements of the Muffler Tests – in the Standard for Industrial Trucks, Internal-Combustion Engine Powered, UL 558.

42.3 When a unit is provided with a partially installed or incomplete exhaust system the information in 69.1.4(t) shall be provided.

PERFORMANCE

43 General

43.1 A generator assembly shall comply with the applicable requirements when tested as described herein. A generator of a type not described specifically herein shall be tested in accordance with the intent of these requirements. When any indications are observed during the test prescribed herein that a generator does not continue to meet the requirements in intended usage, such supplementary tests shall be conducted as applicable.

43.2 A representative sample of a unit is to be subjected to the tests described in Sections 44 – 66.

43.3 A unit marked with one frequency rating is to be tested at that frequency. For a unit marked with a dual frequency rating such as 50/60 hertz or a frequency range such as 50 – 60 hertz, tests are to be conducted at the worst case frequency.

Exception: For a unit marked with a dual frequency rating or a frequency range, the Temperature Test of Section 44, is to be conducted at the worst case frequency.

44 Temperature Test

44.1 The generator assembly is to be tested at full rated load. Parts shall not attain a temperature that damages required corrosion protection, adversely affects operation of safety controls, impairs the value of required thermal or electrical insulation, or results in creeping, distortion, sagging, or similar damage where such damage to the material or part results in a risk of fire or personal injury. The measured temperatures at specific points, corrected when applicable in accordance with 44.3 and with 44.8, shall not be greater than those specified in Tables 44.1 and 44.2 unless otherwise indicated.

Table 44.1
Surface temperature limits

Location	Composition of surface ^a	
	Metal	Nonmetallic
Handles or knobs that are grasped for holding	50°C (122°F)	60°C (140°F)
Handles or knobs that are contacted and do not involve holding; and other surfaces subject to contact and user maintenance	60°C (140°F)	85°C (185°F)
Surfaces subject to casual contact ^a	70°C (158°F)	95°C (203°F)
^a A handle, knob, or similar device, made of a material other than metal that is plated or clad with metal having a thickness of 0.005 inch (0.127 mm) or less is judged as a nonmetallic part.		
^b See the Exception to 44.3.		

Table 44.2
Temperature limits

Materials and components	Degrees	
	°C	°F
A. Generator		
1. Class A insulation systems on coil windings of generators:		
a. In an open generator:		
Thermocouple method	90 ^a	194 ^a
Resistance method	100	212
b. In a totally enclosed generator:		
Thermocouple method	95	203
Resistance method	105	221
2. Class B insulation systems on coil windings of generators:		
a. In an open generator:		
Thermocouple method	110 ^a	230 ^a
Resistance method	120	248
b. In a totally enclosed generator:		
Thermocouple method	120	248
Resistance method	125	257
3. Class F insulation on coil windings of generators:		
a. In an open generator		
Thermocouple method	135	275
Resistance method	145	293
b. In a totally enclosed generator		
Thermocouple method	140	284
Resistance method	150	302
4. Class H insulation on coil windings of generators		

Table 44.2 Continued

Materials and components		Degrees	
		°C	°F
a.	In an open generator		
	Thermocouple method	150	302
	Resistance method	160	320
b.	In a totally enclosed generator		
	Thermocouple method	155	311
	Resistance method	165	329
B.	COMPONENTS		
1.	Capacitors:		
a.	Electrolytic types	65 ^b	149 ^b
b.	Other than electrolytic	90 ^b	194 ^b
2.	Field Wiring Terminals	75 ^c	167 ^c
3.	Vulcanized fiber employed as electric insulation	90	194
4.	Plated bus bar	90 ^d	194 ^d
5.	Unplated bus bar and a joint	75 ^d	167 ^d
6.	Relays, solenoids, and similar components		
a.	Class 105 coil insulation systems:		
	Thermocouple method	90 ^a	194 ^a
	Resistance method	110	230
b.	Class 130 coil insulation systems:		
	Thermocouple method	110 ^a	230 ^a
	Resistance method	120	248
7.	Transformer insulation systems:		
a.	Class 105:		
	Thermocouple method	90 ^a	194 ^a
	Resistance method	95	203
b.	Class 130:		
	Thermocouple method	110 ^a	230 ^a
	Resistance method	120	248
c.	Class 155:		
	Thermocouple method	135 ^a	275 ^a
	Resistance method	140	284
d.	Class 180:		
	Thermocouple method	150 ^a	302 ^a
	Resistance method	160	320
e.	Class 200:		
	Thermocouple method	165 ^a	329 ^a
	Resistance method	175	347
f.	Class 220:		
	Thermocouple method	180 ^a	356 ^a
	Resistance method	190	374
8.	Phenolic composition employed as electrical insulation or as a part the deterioration of which results in a risk of fire or electric shock	150 ^e	302 ^e
9.	Wood and other combustible material	90	194
10.	Rubber- or thermoplastic-insulated wire and cord	60 ^{e,f}	140 ^{e,f}
11.	Other types of insulated wires	g	g
12.	A surface upon which a generator is to be mounted in service, and surfaces that are adjacent to the generator when so mounted	90	194

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Table 44.2 Continued on Next Page

Table 44.2 Continued

Materials and components	Degrees	
	°C	°F
13. Any point on or within a terminal box or compartment of a generator on which field-installed conductors rest	60 ^c	140 ^c
14. Thermoplastic sealing compound	h	h
15. Selenium rectifier	75 ^{i,e}	167 ^{i,e}
16. Power semiconductor	j	j
17. Printed-wiring board	k	k
18. Fuel		
a. Gasoline or diesel fuel in a fuel tank	75	167
b. LP-gas in a fuel tank	l	l
19. Sealing compound	340°C (140°F) less than melting point	

^a At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by means of a thermocouple is not prohibited from being 5°C (9°F) higher than that specified when the temperature of the coil as measured by the resistance method is not more than specified.

^b A capacitor that operates at a temperature of more than 65°C (149°F) for electrolytic and more than 90°C (194°F) for other types is not prohibited from being judged on the basis of its marked temperature limit.

^c The temperature observed on the terminals and at points within a terminal box of a generator shall not attain a temperature higher than the temperature marking required in 69.1.4 (m) and (n).

^d For a bus bar having a current density in accordance with 22.2.9, it is not required to measure the temperature since it has characteristics which result in temperatures not exceeding the indicated values.

^e The temperature limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to a compound that has been investigated and found to have the required heat-resistant properties.

^f A short length of rubber- or thermoplastic-insulated cord inside the generator is not prohibited from being exposed to a temperature of more than 60°C (140°F) when supplementary insulation intended for the measured temperature and of adequate dielectric properties is employed on each individual conductor.

^g The maximum temperature is not to exceed the temperature limit of the wire except as noted in footnote f.

^h The sealing compound temperature limit is 15°C (27°F) less than the softening point of the compound as determined in accordance with the Test Method for Vicat Softening Temperature of Plastics, ASTM D1525.

ⁱ A temperature limit of 85°C (185°F) is not prohibited when the stack assembly is insulated with phenolic composition or other insulating material intended for a temperature of 150°C (302°F).

^j For a power-switching semiconductor or similar device, the temperature limit on the case is the maximum case temperature specified by the semiconductor manufacturer.

^k For a printed-wiring board, the temperature limit is the specified limit of the board.

^l Temperature shall not exceed that which raises the pressure within an LP-gas container to more than 80 percent of the design working pressure of an ASME container or 120 percent of the minimum service pressure of a DOT fuel container.

44.2 A temperature is determined to be constant when 3 consecutive readings taken at intervals of 10 percent of the previously elapsed duration of the test, and not less than 15 minutes, indicate no increase greater than 2°C (4°F).

44.3 During the temperature test, the temperature of a surface that is capable of being contacted by the user shall not be more than the value specified in Table 44.1. When the test is conducted at a room temperature of other than 25°C (77°F), the results are to be corrected to that temperature.

Exception: A unit is not prohibited from exceeding the temperature limits specified for surfaces subject to casual contact in Table 44.1 when it is:

- a) A fixed unit so that the risk of contact by people is reduced,*
- b) Marked as required by 68.3.5, and*

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c) Provided with instructions as specified in 69.1.4(i).

44.4 With reference to 44.1, the test conditions for a generator having a 120/240 volt, single-phase output shall include maximum unbalanced load capability of the unit in accordance with the marking described in 67.2(b).

44.5 A thermocouple junction and the adjacent thermocouple lead wires are to be held securely in thermal contact with the surface of which the temperature is being measured.

44.6 Coil and winding temperatures are to be measured by thermocouples located on exposed surfaces, or by the resistance method. In a generator, the thermocouple is to be mounted on the integrally applied insulation of the coil wire.

44.7 The temperature of a winding is determined by the resistance method by comparing the resistance of the winding at a temperature to be determined with the resistance at a known temperature according to the formula:

$$T = \frac{R}{r} (k + t) - k$$

In which:

T is the temperature of the winding in degrees C,

R is the resistance of the coil at the end of the test in ohms,

r is the resistance of the coil at the beginning of the test in ohms,

t is the room temperature in degrees C at the beginning of the test, and

k is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum. Values of the constant for other conductors are to be determined.

The winding is to be at room temperature at the start of the test.

44.8 All temperature limit values in Table 44.2 are based on an ambient temperature of 25°C (77°F). However, tests are not prohibited from being conducted in other ambients as described in Table 44.3 when measured temperatures are corrected by subtracting the test ambient, and then adding the rated ambient for compliance, to the measured temperatures.

Table 44.3
Permitted test ambient

Ambient temperature rating of unit	Test ambient temperature
1. 25°C (77°F)	Range of 10 – 40°C (50 – 104°F)
2. Range of 25 – 40°C (77 – 104°F)	Range of 20 – 40°C (68 – 104°F)
3. Above 40°C (104°F)	Rated ambient ^a
^a Allowable tolerances are: Minus – not less than 5°C (9°F) below rated ambient. Plus – not specified.	

44.9 When a unit is rated for an ambient temperature higher than 25°C (77°F), the rating shall be indicated in the instruction manual in accordance with 69.1.4(j).

44.10 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm²) and not smaller than 30 AWG (0.05 mm²). When thermocouples are used in determining temperatures in electrical equipment, it is common practice to employ a temperature-indicating instrument with thermocouples consisting of 30 AWG iron and constantan wire. Such equipment is to be used wherever reference temperature measurements by thermocouples are required. The thermocouples and related instruments are to be accurate and calibrated in accordance with standard laboratory practice. The thermocouple wire is to conform with the requirements listed in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

45 Dielectric Voltage-Withstand Test – General

45.1 The test potential specified in 45.4 is obtained from any convenient source having a capacity of at least 500 volt-amperes. The capacity is not prohibited from being lower when a meter is located in the output circuit, and the test potential is maintained except in case of breakdown. The voltage of the source is to be continuously adjustable. Starting at zero, the applied potential is to be increased at a rate of 200 volts per second until the required test value is reached. The leakage current shall not exceed 5mA.

45.2 Direct-current potential is used for an ac circuit. When used a test potential of 1.414 times the applicable rms value of alternating-current voltage specified in 45.4 is to be applied.

45.3 Printed-wiring assemblies and other electronic-circuit components that are damaged by application of the test potential or that short-circuit the test potential are to be removed, disconnected, or otherwise rendered inoperative before the dielectric voltage-withstand tests are made. Testing a representative subassembly instead of an entire unit is not prohibited. Individually shunting the semiconductor devices in the unit before the test is made to avoid destroying them in the case of a malfunction elsewhere in the secondary circuits is not prohibited.

45.4 While at operating temperature, the ac and when provided, dc power circuits shall withstand without breakdown the application of a sinusoidal potential of 1000 plus twice rated voltage (see 45.5) at a frequency in the range of 40 – 70 hertz applied for 1 minute between output (including generator) current carrying parts and dead metal parts.

Exception: For a dc circuit, either an alternating-current or a direct-current potential is used. When an alternating current potential is used, the potential is to be the value indicated above, divided by 1.414.

45.5 With reference to 45.4 the test potential between ac power circuits and dead metal parts is to be based on the phase-to-ground voltage rating. The test potential for other points involving the ac power circuit is to be based on the phase-to-phase voltage rating or the voltage rating of the other circuit, whichever is greater.

Exception: This test does not apply when the voltage potential is less than 30 volts (RMS).

46 Harmonic Distortion Test

46.1 When tested as described in 46.2 the total rms of the harmonic voltages, excluding the fundamental, delivered by a generator shall not exceed 5 percent of the fundamental rms output voltage rating, for Class 1 circuits, 20 percent for Class 2 circuits and 30 percent for Class 3 circuits and the rms voltage of any single harmonic shall not exceed 15 percent of the nominal fundamental rms output voltage rating for Class 3 circuits.

46.2 With reference to the requirement in 46.1 the generator is to be connected to a linear load having an adjustable impedance so the generator is able to deliver power at rated power factor. The measurements are to be made at open circuit and with the generator delivering 50 and 100 percent of rated power.

46.3 Exceeding the output voltage distortion levels of 46.1 is not prohibited when the unit is intended for use with a specific load device and is so marked in accordance with 68.2.20. The Temperature Test, Section 44 shall be conducted using the specified load. The temperature on the load shall not exceed the intended values applicable to the load equipment involved.

46.4 Exceeding the output voltage distortion levels of 46.1 is not prohibited when the unit is intended for use with a specific type of device and is so marked in accordance with 68.2.20. The instruction manual shall contain the information described in 69.1.4(r) when a specific type of device is used.

46.5 Exceeding the output voltage distortion levels of 46.1 is not prohibited when the temperatures measured on loads supplied by the nonsinusoidal waveform do not exceed the temperatures measured using the sinusoidal waveform by more than 5°C (9°F), and shall not exceed the intended values applicable to the load equipment involved.

47 Output Voltage And Frequency Fluctuation Test

47.1 When tested as described in 47.2 the output voltage shall be within 90 to 110 percent of the nominal output voltage rating and the frequency shall be within 91 to 108 percent nominal output frequency rating.

47.2 With reference to the requirement in 47.1 the generator is to be connected to a linear load having an adjustable impedance so the generator is able to deliver power at rated power factor. With the generator in a steady state condition, fluctuation measurements are to be made at open circuit and with the generator delivering 50 and 100 percent of rated power.

48 Blocked Inlet Test

48.1 The generator assembly shall be arranged for test as described for the Temperature Test, Section 44, and when operating at maximum rated capacity the circulator air flow is to be gradually restricted. This is to be accomplished by gradually blocking the circulating air inlet openings; first to one half of their open area, and then to complete blockage of the inlet grille area. The test is to be continued, under each of the restrictions, until equilibrium conditions are attained, the product shuts down or for 5 minutes after the alarm is activated. There shall be no burning, charring, smoke or other evidence of damage to the product or enclosure which creates a risk of fire or personal injury with continued use. The product is not required to be operable following the test.

Exception: This test is not required for open type generator assemblies.

49 Backfire-Deflector Test

49.1 A backfire deflector under backfire conditions shall contain a visible flame front within its confines and shall not be displaced, physically damaged or distorted or show evidence of burning or smoldering of internal parts; and, when of the oil-bath type, shall be free of any overflow or discharge that results in the accumulation of oil on electrical, hot-engine, or exhaust-system parts.

Exception: This test is not required for generator assemblies that employ diesel engines.

49.2 A complete engine generator unit is to be used for this test. The backfire deflector (air cleaner, oil-bath or dry-element type) and connecting hose are to be removed from the engine. The spark timing and other ignition adjustments are to be made as required to obtain sharp backfires under the following conditions. The engine is to be alternately raced and idled, and the ignition switch is to be operated to alternately energize and de-energize the ignition system. During this test, the intensity of the backfire and the issuance and extent of the accompanying flame are to be noted.

49.3 The backfire deflector (air cleaner) is then to be installed on the engine in the intended location. An oil-bath type deflector (air cleaner) is to be filled to the marked "full-level line" of the bowl. Paper is to be placed beneath the intake orifices of an oil-bath type and over adjacent surfaces of parts that are affected by accumulations of oil.

49.4 The engine is then to be operated in the several manners determined in the preliminary test to provide for the most severe backfire conditions. At least ten and not more than twenty severe backfires are to be produced.

49.5 Observation for containment of flame are to be made under semidarkened conditions by a minimum of two observers. No visible flame is to be in evidence at any time during the tests. In the tests of an oil-bath type, paper is not to show evidence of oil deposits in the form of droplets.

49.6 A dry-type filter element is to be tested in the above manner and a separate sample is to be subjected to a flame source of an intensity that results in the media burning or glowing. When the flame source is removed, a filter media shall not continue to burn or smolder.

Exception: This test is not required for filter elements used on engines that do not backfire when tested as described in 49.2.

50 Neutral to Ground Potential Measurement Test

50.1 In accordance with 18.1.7 a generator having a lead or terminal identified as a grounded circuit that is not grounded at the unit itself is to be subjected to this test. The generator is to:

- a) Operate with no load connected to the output ac terminals, and
- b) Deliver maximum rated output alternating current into a load.

The electric energy available between the grounded conductor of the ac output circuit and ground shall not produce a risk of electric shock (see Electric Shock, Section 9).

51 10-Day Moist Ammonia-Air Stress Cracking Test

51.1 After being subjected to the conditions described in 51.2 – 51.5 fuel-confining brass parts containing more than 15 percent zinc shall show no evidence of cracking when examined using 25X magnification.

51.2 A test sample shall be subjected to the physical stresses normally imposed on or within a part as the result of assembly with other components or with tubing or piping. Such stresses shall be applied to the sample prior to and maintained during the test.

51.3 Female pipe-threaded ends are to be engaged with brass plugs or fittings tightened to the degree normally found to produce a leaktight assembly.

51.4 Three samples are to be degreased and then continuously exposed in a set position for 10 days to a moist ammonia-air mixture maintained in a glass chamber 305 by 305 by 305 mm (12 by 12 by 12 inches) having a glass cover.

51.5 600 ml of aqueous ammonia having a specific gravity of 0.94 is maintained to be at the bottom of the glass chamber below the samples. The samples are to be positioned 38.1 mm (1-1/2 inch) above the aqueous ammonia solution and supported by an inert tray. The moist ammonia air mixture in the chamber is to be maintained at atmospheric pressure and at a temperature of $34 \pm 2^{\circ}\text{C}$ ($93 \pm 3.6^{\circ}\text{F}$).

52 Salt Spray Test

52.1 The corrosion resistance of a metallic material is to be determined in accordance with 52.2. The samples shall show no signs of deterioration or corrosion.

52.2 Specimens of the material are to be supported vertically and exposed to salt spray (fog) for 50 hours in accordance with the Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117.

53 LP-Gas Container Load Tests

53.1 An LP-Gas fuel container shall be secured in place on the product in a manner capable of withstanding loadings in any direction equal to four times the filled weight of the container.

53.2 For this test, the container is to be empty of fuel and is to be so secured in the manner covered by the manufacturer's instructions. Loadings are to be applied in any convenient manner capable of being measured by gauges or weights.

54 Abnormal Tests

54.1 General

54.1.1 A generator assembly shall not emit flame or molten metal or become a risk of fire, electric shock, or injury to persons (see 54.1.3) when subjected to the tests specified in 54.1.2 – 54.5.1. Using separate samples for conducting these tests is not prohibited.

54.1.2 Following each test, the Dielectric Voltage-Withstand Test, Section 45 is to be conducted. The potential is to be applied across the points indicated in 45.4.

Exception: Conducting more than one abnormal test on a sample, or conducting the dielectric voltage-withstand test after completion of all abnormal tests is not prohibited.

54.1.3 A risk of fire, electric shock, or injury to persons exists when:

- a) Flame, burning oil, or molten metal is emitted from the enclosure of the generator as evidenced by ignition, glowing, or charring of the cheesecloth or tissue paper,
- b) The insulation breaks down when tested in accordance with 54.1.2 or live parts are made accessible (see Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 8),
- c) Cracking, rupturing, or bursting of the battery case or cover, when such damage results in user contact with battery electrolyte, or
- d) Explosion of the battery supply where such explosion results in a risk of injury to persons.

54.1.4 During these tests, on enclosed type generator assemblies, all ventilating openings of the generator assembly are to be covered with a single layer of cheesecloth loosely over the entire enclosure. The cheesecloth is to be untreated cotton cloth running 14 – 15 yards per pound (28 – 30 m²/kg), and having, for any square inch (6.45 cm²), a count of 32 threads in one direction and 28 in the other direction.

54.1.5 The enclosure of the unit is to be connected directly to ground.

54.1.6 Each test is to be continued until further change as a result of the test condition does not occur. When an automatically reset protector functions during a test, the test is to be continued for 7 hours. When a manual reset protector functions during a test, the test is to be continued until the protector operates for 10 cycles using the minimum resetting time, and not at a faster rate than 10 cycles of operation per minute. Termination of the test occurs when:

- a) Opening or shorting of one or more components such as capacitors, diodes, resistors, solid state devices, printed wiring board traces, or similar components,
- b) Opening of the intended overcurrent protection device described in 54.1.6, or
- c) Opening of an internal fuse.

Exception No. 1: When the manually reset protector is a circuit breaker that complies with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489, it is to be operated for 3 cycles using the minimum resetting time and not at a rate faster than 10 cycles of operation per minute.

Exception No. 2: A manual reset protector that becomes inoperative in the open condition shall be operated between 10 cycles, and 3 cycles.

54.2 Overspeed test

54.2.1 The product, as arranged for operation in its intended manner, shall be subjected to an overspeed condition conducted at no-load open throttle speed of the engine with no overspeed protection. When overspeed protection, e.g., an electrical or mechanical cut off switch (other than a governor) is provided, the test shall be run at the maximum speed controlled by the overspeed device. The test is to be conducted for a period of 1 minute. There shall be no evidence of fire or risk of personal injury as a result of this test.

Exception: For units provided with governors for overspeed protection, this test shall be performed with the governor in the failed position or defeated.

54.3 Output overload test

54.3.1 Generator winding temperatures shall not exceed the temperature limits in Table 44.2. This test is to be conducted after thermal stabilization is reached during the mode of operation that has output power. While delivering maximum rated output power to an adjustable resistive load connected to the output ac circuit, the generator is to be subjected to the overload test described in 54.3.2.

54.3.2 The ac load is to be increased in increments of 10 percent of the maximum output rating and held for 1/2 hour at each increment until:

- a) Further change as a result of the test condition does not occur; or
- b) The unit shuts down.

Exception: Thermal stabilization is obtained with a load adjusted to result in maximum obtainable output power without causing operation of overcurrent protective devices, followed by increased incremental loading as described above.

54.4 AC output short circuit test

54.4.1 The generator is to be connected and operated as in the normal temperature test. While operating the AC output is to be shorted. Shorting is to include from line to line and line to neutral.

Exception: The above test is not required to be conducted when the overcurrent protection device is rated no more than 125 percent of the rated output circuit current and having a short-circuit interruption rating not less than the maximum fault current available from the generator output tested.

54.5 Component short- and open-circuit test

54.5.1 A component, such as a capacitor, diode, solid state device, or similar component connected in the input and output alternating current and direct current power circuits are to be short- or open-circuited, any two terminals one at a time, during any condition of operation including startup.

Exception: This test is not required where circuit analysis indicates that no other component or portion of the circuit is overloaded.

54.6 DC output short circuit test

54.6.1 This test is to be conducted on generator assemblies:

- a) That have an integral battery charging circuit, or
- b) Whose direct current output of the generator is intended to be used with a remote battery supply, or
- c) Direct current power circuit of a remote battery supply/cabinet assembly for use with a generator and investigated under the requirements of this standard.

54.6.2 The test shall be conducted in accordance with the requirements for DC circuits in the Standard for Uninterruptible Power Systems, UL 1778.

54.6.3 During the tests described by 54.6.1 (a) and (c), batteries intended to be used with the generator shall be fully charged. During the test described by 54.6.1(b), batteries are not to be connected. The tests specified in 54.6.1 (b) and (c) are not prohibited from being combined into one test with the batteries connected.

Exception No. 1: A battery supply complies with the requirements when it complies with the following:

- a) An overcurrent protection device is employed having a short-circuit interrupting rating not less than the maximum fault current available from the battery supply, and*
- b) The maximum current from the battery supply during the reserve mode – see 54.1 – does not exceed the ampacity rating of the conductors connected to the batteries. Table 310-16 of the National Electric Code, NFPA 70 is to be used for determining conductor ampacity.*

Exception No. 2: The above test is not required when the overcurrent protection device is rated not more than 125 percent of the rated output circuit current and having a short-circuit interruption rating not less than the maximum fault current available from the generator output tested.

55 Overtemperature Protection – Overload and Endurance Operation Tests

55.1 When incorporated in the generator assembly a protective device shall comply when subjected to:

- a) An Overload Test consisting of making and breaking for 50 cycles of operation, at a rate of 6 cycles per minute, a current of 150 percent of rated value, at the rated voltage and power factor.
- b) An Endurance Test consisting of making and breaking rated current, voltage, and power factor for 1000 cycles for a manual reset protector or 6000 cycles for an automatic reset protector, at a rate of 6 cycles per minute when the nature of the device performs this rate of operation.

55.2 There shall be no electrical or mechanical failure of the device, nor undue burning or pitting of the contacts.

55.3 The rate of operation indicated in 55.2 is not prohibited from being less than 6 cycles per minute when the nature of the device does not permit faster cycling.

56 Grounding Impedance Test

56.1 In accordance with 20.8, when penetration of nonconductive coatings is not determined by examination, a measurement of the grounding path resistance is to be made. The impedance at 60 hertz between the point of connection of the equipment-grounding means and the metal part that is required to be bonded to ground shall not be more than 0.1 ohm when measured in accordance with 56.2. The resistance of the equipment grounding conductor of a power supply cord shall not be included in the resistance measurement.

56.2 Compliance with 56.1 is to be determined by passing a current of 25 amperes derived from a 60 hertz source with a no-load voltage not exceeding 6 volts between the following points and measuring the voltage across these points:

- a) The equipment grounding connection, and
- b) The metal part in question.

57 Overcurrent Protection Calibration Test

57.1 A fuse, or circuit protective device, provided for protection of secondary circuits in accordance with 25.9 shall meet the requirements in Section 29 of the Standard for Class 2 Power Units, UL 1310.

58 Strength of Terminal Insulating Base and Support Test

58.1 In accordance with the requirement in 16.1.9, an insulating base or support and the bus or strap upon which pressure wire connectors for field wiring are mounted shall be subjected to the force created when the connectors, securing short lengths of conductors sized as described in 16.1.4, are torqued to 110 percent of the value marked on the unit. The results meet the intent of the requirement when the base is not damaged as defined in 58.2.

Exception: The test is not required for wire connectors that are part of a component such as a terminal block, circuit breaker, switch, or similar device.

58.2 With reference to 58.1, damage has occurred when the base insulating material cracks or rotates; bosses, recesses, or deforms in some way to prevent turning; does not perform its intended function; straps or bus bars bend or twist; or members other than the wire connector move at electrical joints. Minor chipping or flaking of brittle insulating material is not prohibited when the performance is not otherwise impaired. Momentary flexing of metallic members without permanent deformation is not prohibited.

59 Mechanical Strength Tests for Metal Enclosures

59.1 In accordance with 24.1.4, an external metal enclosure of a unit intended for use in a controlled environment having reduced spacings between uninsulated live metal parts and the enclosure shall be subjected to the two tests described in 59.3 and 59.4. The tests shall not result in:

- a) Permanent distortion to the extent that spacings are reduced below the values specified in 24.1.4,
- b) Transient distortion that produces contact of the enclosure with uninsulated live parts other than those connected in a low-voltage circuit, and
- c) Development of openings that expose uninsulated live parts that involve a risk of electric shock or electrical energy – high current levels. Any openings resulting from the tests are to be judged under the requirements in Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 8.

59.2 Enclosures built in accordance with Exception No. 2 of 7.5.2 shall be subjected to the test described in 59.5. Doors and covers built in accordance with Exception 2 of 7.5.2 shall be subjected to the tests described in 59.3 and 59.4. Wet location units shall apply these tests as preconditioning for the rain test in Section 73, Performance. The tests shall not result in:

- a) Transient or permanent distortion to the extent that spacings are reduced below the values specified in Table 24.1;
- b) Development of openings that expose uninsulated live parts that involve a risk of electric shock or electrical energy – high current levels. Any openings resulting from the tests are to be judged under the requirements in Section 8, Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts; or
- c) Wetting of live parts after this preconditioned unit is subjected to the rain test in Section 73.1.

59.3 For the first test specified in 59.1, the enclosure is to be subjected to a 25-pound force (111-N) for 1 minute. The force is to be applied to the outside of the enclosure at various locations likely to result in the greatest distortion or damage by means of a steel hemisphere 1/2 inch (12.7 mm) in diameter.

59.4 For the second test specified in 59.1, the enclosure is to be subjected to an impact of 5 foot-pounds (6.8 J). The impact is to be applied at various locations likely to result in the greatest distortion or damage by means of a smooth, solid, steel sphere 2 inches (50.8 mm) in diameter and having 1.18 pounds (535 g) mass. The sphere is to fall freely from rest through a vertical distance of 51 inches (1.29 m) at various locations on the outside of the enclosure. The method of test is to be as described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

59.5 For the test specified in 59.2, the enclosure is to be subjected to a 100-pound force (445-N) for 1 minute. The force is to be applied to the outside of the enclosure at various locations likely to result in the greatest distortion or damage by means of a steel hemisphere 1/2 inch (12.7 mm) in diameter.

60 Cycling Test

60.1 In accordance with 16.4.1 an enclosure door, cover or hood that is positioned or moved in normal use shall be subjected to 1000 cycles of operation and then be subjected to the tests in Section 71 for Outdoor-Use Units.

60.2 The enclosure door, cover or hood shall not crack, deform, or allow wetting of live parts or the entrance of water.

61 Evaluation of Reduced Spacings on Printed-Wiring Boards

61.1 General

61.1.1 In accordance with (a) in Exception No. 3 to 24.1.1, printed-wiring board traces of different potential having reduced spacings are judged by conducting:

- a) A dielectric voltage-withstand test described in 61.2.1 and 61.2.2 for a generator investigated for use in a controlled environment, or
- b) A shorted trace test described in 61.3.1 for a generator investigated for use in either a controlled or general environment.

61.2 Dielectric voltage-withstand test

61.2.1 A printed-wiring board as specified in 61.1.1 shall withstand for 1 minute without breakdown the application of a dielectric withstand potential between the traces having reduced spacings in accordance with 45.1 and 45.2 or Table 44.1 as applicable.

61.2.2 Power-dissipating component parts, electronic devices, and capacitors connected between traces having reduced spacings are to be removed or disconnected in such a manner that the spacings and insulations, rather than these component parts, are subjected to the full dielectric voltage-withstand test potential.

61.3 Shorted trace test

61.3.1 Printed-wiring board traces specified in 61.1.1 are to be short-circuited, one location at a time, and the test is to be conducted as described in 54.1.1 – 54.1.3, 54.1.5 and 54.1.6. As a result of this test:

- a) The overcurrent protection associated with the branch circuit to the rotary generator shall not open, and
- b) A wire or a printed-wiring board trace shall not open.

When the circuit is interrupted by opening of a component, the test is to be repeated twice using new components, as required.

Exception: Opening of an internal overcurrent protective device meets the intent of the requirement and the test is not required to be repeated.

62 Bonding Conductor Test

62.1 A bonding conductor that does not comply with 20.9 (a) or (b) does comply when using separate samples for each test, neither the bonding conductor nor the connection opens when:

- a) Carrying currents equal to 135 and 200 percent of the rating or setting of the intended branch-circuit overcurrent-protective device for the times specified in Table 62.1, and
- b) Three samples are subjected to a limited-short-circuit test using a test current as specified in Table 62.2 while connected in series with a nonrenewable fuse having a rating equal to the intended branch-circuit overcurrent-protective device.

Exception: When a fuse that is smaller than that indicated in (a) and (b) is employed in the unit for protection of the circuit to which the bonding conductor is connected, then the magnitude of the test current and size of fuse used during the test is not prohibited from being based on the rating of the smaller fuse.

Table 62.1
Duration of overcurrent test

Rating or setting of branch-circuit overcurrent protective device, amperes	Test time, minutes	
	135 percent of current	200 percent of current
0 – 30	60	2
31 – 60	60	4
61 – 100	120	6
101 – 200	120	8

Table 62.2
Circuit capacity for bonding conductor short-circuit test

Rating of unit, volt-ampere		Volts	Capacity of test circuit, amperes
Single phase	3-phase		
0 – 1176	0 – 832	0 – 250	200
0 – 1176	0 – 832	251 – 600	1000
1177 – 1920	833 – 1496	0 – 600	1000
1921 – 4080	1497 – 3990	0 – 250	2000
4081 – 9600	3991 – 9145	0 – 250	3500
9601 or more	9146 or more	0 – 250	5000
1921 or more	1497 or more	251 – 600	5000

62.2 The test circuit described in 62.1(b) is to have a power factor of 0.9 – 1.0 and a closed-circuit test voltage as specified in 43.2. The open-circuit voltage is to be 100 – 105 percent of the closed-circuit voltage. Each test is to be performed on each of the three samples.

63 Impact Tests

63.1 Impact on glass covered openings

63.1.1 With reference to 7.7.1(b), a glass covered opening shall withstand a 2-1/2 foot-pound (3.38 J) impact without cracking or breaking to the extent that a piece is released or dropped from its normal position.

63.1.2 The impact specified in 63.1.1 is to be applied by means of a smooth, solid steel sphere 2 inches (50.8 mm) in diameter and having 1.18 pounds (535 g) mass. The sphere is to fall freely from rest through a vertical distance of 25 inches (63.5 cm).

63.2 Impact – guards over moving parts

63.2.1 In accordance with 6.3, a part of a unit as described in 6.1 and 6.2 is to be subjected to an impact of 5 foot-pounds (6.8 J) on any surface that is exposed to a blow during normal use. This impact is to be produced by dropping a steel sphere, 2 inches (50.8 mm) in diameter and weighing 1.18 pounds (535 g), from a height of 51 inches (1.29 m) to produce the 5-foot-pound (6.8 j) impact. For surfaces other than the top, the steel sphere is to be suspended by a cord and to swing as a pendulum, dropping through a vertical distance of 51 inches (1.29 m) to strike the surface.

63.2.2 A unit is to be subjected to the impact test described in 63.2.1 with or without any attachment specified by the manufacturer so as to result in the most severe test.

63.2.3 When a part as specified in 6.1 is made of a polymeric material, the impact test is to be first conducted on a sample or samples in the as-received condition. The test is then to be repeated on a different sample or samples that have been cooled to room temperature after being conditioned for 7 hours in an air oven operating at 10°C (18°F) higher than the maximum operating temperature of the material, and not less than 70°C (158°F). While being conditioned, a part is to be supported in the same manner in which it is supported on the generator set.

63.2.4 Upon being removed from the oven specified in 63.2.3 and before being subjected to the impact test, no sample shall show signs of checking, cracking, or other deleterious effects from the oven conditioning, and no sample shall be distorted so as to result in a risk of injury to persons.

63.2.5 After the impact test required by 63.2.1, any openings resulting from the test shall comply with the accessibility requirements described in Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts – and User Servicing, Section 8.

64 Heat Sink Temperature Cycling Test

64.1 Where required by Exception No. 2 to 22.3.1, a current-carrying, aluminum heat sink shall be subjected to the test described in 64.2 and 64.3.

64.2 Three samples of the heat sink/solid state component assemblies are to be subjected to this test. After completion of the 500th cycle described in 64.3, a temperature of the solid state component for each sample shall not be more than 15°C (27°F) higher than the temperature during the 24th cycle and neither temperature shall be more than the rating of the solid state component.

64.3 The samples are to be subjected to 500 cycles of current-on and current-off operations. During the current-on time, the samples are to be carrying maximum rated current. The duration of the current-on and current-off times shall be the length of time required to reach stable temperatures. Stable temperatures are obtained when three successive readings taken at not less than 10 minute intervals indicates no more than 2°C (3.6°F) variation between any two readings. Forced-air cooling is a way to reduce the current-off time with the concurrence of those concerned.

65 Ignition Test Through Bottom-Panel Openings

65.1 In accordance with Exception No. 3 to 7.10.1, a ventilated, bottom-panel construction is judged by conducting the tests described in 65.2 – 65.5.

65.2 Openings in a bottom panel shall be so arranged and small in size and few in number that hot, flaming No. 2 fuel oil (see 65.4) poured three times onto the openings from a position above the panel is extinguished as it passes through the openings.

65.3 A sample of the complete, finished bottom panel is to be supported in a horizontal position a short distance above a horizontal surface under a hood or in another area that is ventilated and free from drafts. Bleached cheesecloth running 14 – 15 square yards to the pound (28 – 30 m²/kg mass) and having, for any square inch (6.4 cm²), 32 threads in one direction and 28 in the other, is to be draped in one layer over a shallow, flat-bottomed pan that is of a size and shape to cover completely the pattern of openings in the panel and is not large enough to catch any of the oil that runs over the edge of the panel or otherwise does not pass through the openings. The pan is to be positioned with its center under the center of the pattern of openings in the panel. The center of the cheesecloth is to be 2 inches (50.8 mm) below the openings. Use of a metal screen or wired-glass enclosure surrounding the test area is a way to reduce the risk of splattering oil, causing injury to persons.

65.4 A small metal ladle no more than 2-1/2 inches (63.5 mm) in diameter, with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, is to be partially filled with 10 cubic centimeters of No. 2 fuel oil, which is a medium-volatile distillate having a minimum API gravity of 30 degrees, a flash point of 110 – 190°F (43.3 – 87.7°C), and an average calorific value of 136,900 Btu per gallon (38.2 MJ/L) (see the American Society for Testing and Materials Specification for Fuel Oils, ASTM D396). The ladle containing the oil is to be heated and the oil is to be ignited. The oil is to flame for 1 minute and then is to be poured at the rate of, and no less than, 1 cubic centimeter per second in a steady stream onto the center of the pattern of openings from a position 4 inches (102 mm) above the openings. It is to be observed whether the oil ignites the cheesecloth.

65.5 Five minutes after completion of the pouring of the oil, the cheesecloth is to be replaced with a clean piece and a second 10 cubic centimeter of hot, flaming oil is to be poured from the ladle onto the openings, and it is again to be observed whether the cheesecloth is ignited. Five minutes later, a third identical pouring is to be made. The cheesecloth shall not ignite in any of the three pourings.

66 Bus Bar Tests

66.1 An aluminum bus bar employing a coating specified in Exception No. 3 of 22.2.1 or a bus bar that has a clamped joint construction described in Exception No. 2 of 22.2.3 and Exception No. 3 of 22.2.4, respectively, shall be subjected to the tests described in 66.2 – 66.4.

66.2 The temperature of the bus bar joint shall be measured during the temperature test described in Temperature Test, Section 44, and comply with the maximum temperature specified in Table 44.2.

66.3 The temperature rise at the joint during the five hundredth cycle shall not be more than 15°C (27°F) higher than the temperature rise at the end of the twenty-fifth cycle.

66.4 The test sample is to consist of an assembly of bus bars connected together to form a series circuit. The bus bars are to be clamped together with the joint construction used in actual production. The number and size of the bus bar are to represent the maximum ampere rating and the maximum current density in which the joint construction is employed. This sometimes requires more than one test. The length of each bus bar is to be 2 feet (609 mm). The bus bar is to be connected to a power supply by any means that does not affect the joint temperature. The power supply is to be adjusted to deliver a value of current that results in a temperature of 75°C (135°F) above room temperature at the joint. The assembly is then to be subjected to a 500-cycle test. At the end of the 24th cycle, the current is to be readjusted to bring the temperature of the joint to 75°C (135°F) above room temperature; and this current value is to be maintained for the remainder of the cycling test. At the end of the 25th and 500th cycles, the temperatures are to be recorded. The temperatures are to be measured on both sides of the joint as close as possible to the bolt or rivet. The cycling rate is to be 3 hours on and 1 hour off. The on period during which temperatures are recorded is to be extended to more than 3 hours only when required for the joint to attain thermal equilibrium.

Exception: The length of the bus bar is not prohibited from being less than 2 feet (609 mm) with the concurrence of those concerned.

66A Volume Change and Extraction Test

66A.1 General

66A.1.1 The Volume Change and Extraction Test is a sequence of tests. The test sequence is a Pull test on three samples of the hose assembly in the as received condition to obtain a pull out force for the samples. Three samples of the hose assembly are then to be conditioned during the Aging test and followed by a Pull test. The pull force of the as-received samples shall be compared to the pull force of the conditioned samples.

66A.1.2 Nonmetallic low pressure propane and natural gas flexible hoses and fittings shall be subjected to the tests specified in 66A.2 – 66A.4.

Exception: This test sequence is not conducted on low pressure propane and natural gas hoses evaluated to the Standard for LP-Gas Hose, UL 21 or metal flexible fuel hoses.

66A.2 Pull test – as received

66A.2.1 The samples shall withstand a 60 pound-force (267 N) pull.

66A.2.2 Three samples of the fuel hose assembly (hose and end fittings) are to be tested. Each sample is to be mounted in a tensile strength testing machine and operated with a rate of travel of 0.5 inch/minute (12.7 mm/minute) until the specified pull force has been reached.

66A.3 Aging test

66A.3.1 The samples shall not show visual signs of deterioration or loss of flexibility after aging.

66A.3.2 Three representative samples of the fuel hose assembly are to be subjected to 70 hours in an air-circulating oven maintained at a temperature of 100°C (212°F). The samples are to be subjected to a pull test after temperature conditioning.

66A.4 Pull test - after the aging test

66A.4.1 The samples shall maintain at least 70 percent [42 pounds (187 N)] of their longitudinal pull force.

66A.4.2 The three samples of the fuel line assembly (fuel line and end fittings), which were subjected to the Aging test, are to be used for this test. Each sample is to be mounted in a tensile strength testing machine and operated with a rate of travel of 0.5 inch/minute (12.7 mm/minute) until:

- a) The hose or fitting breaks, cracks, splits;
- b) The fitting separates from the hose; or
- c) The minimum pull force has been obtained.

66B Vibration Test

66B.1.1 During and following this test, the hose assembly samples shall withstand the vibration without showing signs of degradation or leakage.

66B.1.2 Two samples of the hose assembly are to be subjected to vibration while pressurized to normal operating pressure. The two samples are to be prepared one in the horizontal position, the other in the vertical, and both with one end fixed. They are to be mounted on the vibration machine and subjected to 48 hours vibration of 0.125 inch (3.175 mm) amplitude at a frequency of 17 Hz.

66C Aerostatic Leakage Test

66C.1.1 The hose assemblies shall not leak.

66C.1.2 Three samples of 18 inch (457 mm) long flexible hose assemblies are to be subjected to this test. Each sample is to have one end of the assembly plugged and the other hose end aerostatically pressurized to 1.5 times operating pressure for 5 minutes. The hose assemblies shall be checked for leakage by being immersed in water or an equivalent method.

66D Hydrostatic Strength Test

66D.1.1 The hose assembly shall not leak.

66D.1.2 Three samples of 18 inch (457 mm) long flexible fuel line assemblies are to be subjected to this test. Each sample is to have one end plugged and the other hose end is to be hydrostatically pressurized to 4 times operating pressure for 1 minute and checked for leakage. The fuel line assemblies shall be checked for leakage by being immersed in water or an equivalent method.

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RATING

67 Details

67.1 The ac output of a unit shall have the following ratings:

- a) Voltage,
- b) Frequency,
- c) Number of phases except for a unit intended for single-phase only,
- d) Amperes volt-amperes, or watts, and
- e) Power factor, when less than unity unless the rating is expressed in:
 - 1) Watts and volt-amperes, or
 - 2) Watts and amperes.
- f) RPM
- g) Insulation system class
- h) Rated ambient temperature or rated temperature rise

67.2 The electrical rating of a unit shall include the following:

- a) The electrical rating for a 3-phase generator that is limited to either a delta or wye connection shall indicate the phase configuration, and
- b) The electrical rating for a generator having a 3-phase output or a single-phase output with a neutral conductor shall indicate the unbalanced load capability of the generator.

MARKING

68 Details

68.1 General

68.1.1 Unless otherwise stated, all markings are required to be permanent, that is, either by being molded, die-stamped, paint-stenciled; stamped or etched metal that is permanently secured; or indelibly stamped on a pressure-sensitive label secured by adhesive that, upon investigation, is found to comply with the requirements in the Standard for Marking and Labeling Systems, UL 969.

68.2 Content

68.2.1 A unit shall be plainly and permanently marked where it is readily visible, after installation, with:

- a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the generator is identified,
- b) A distinctive catalog number or the equivalent,
- c) The electrical ratings specified in, Section 67, and
- d) The date or other dating period of manufacture not exceeding any three consecutive months.

Exception No. 1: The manufacturer's identification is not prohibited from being in a traceable code when the unit is identified by the brand or trademark owned by a private labeler.

Exception No. 2: The date of manufacture is not prohibited from being abbreviated, or being in a nationally accepted conventional code, or in a code affirmed by the manufacturer, when the code:

- a) Does not repeat in less than 20 years, and*
- b) Does not require reference to the production records of the manufacturer to determine when the unit was manufactured.*

68.2.2 With reference to the requirement in 68.2.1(c) the symbols described in (a) – (c) are not prohibited from being used for markings:

- a) A circuit intended to be connected to a direct-current supply shall be identified by plus and minus markings and the symbol illustrated in Figure 68.1. See 68.2.3.
- b) A circuit intended to be connected to an alternating-current supply shall be identified by markings indicating that the supply shall be alternating current. The markings shall include the supply-circuit frequency or supply-circuit frequency-range rating (cycles per second, cycles/second, hertz, c/s, cps, or Hz). The symbol illustrated in Figure 68.2 is an example of this marking. See 68.2.3.
- c) The number of phases shall be indicated when the unit is designed for use on a polyphase circuit. The symbol illustrated in Figure 68.3 is an alternative for the word "phase." See 68.2.3.

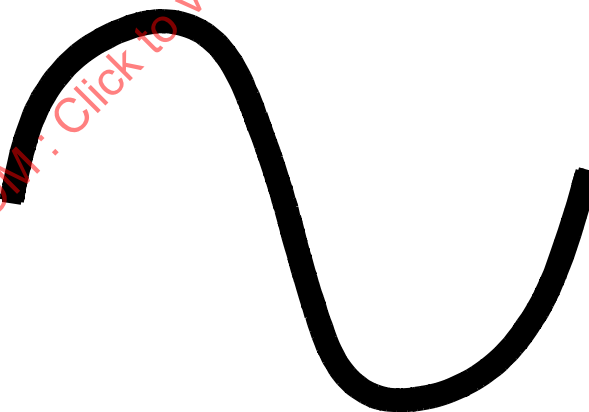
Figure 68.1
Direct current symbol



IEC5031

IEC publication 60417 DB, Symbol 5031

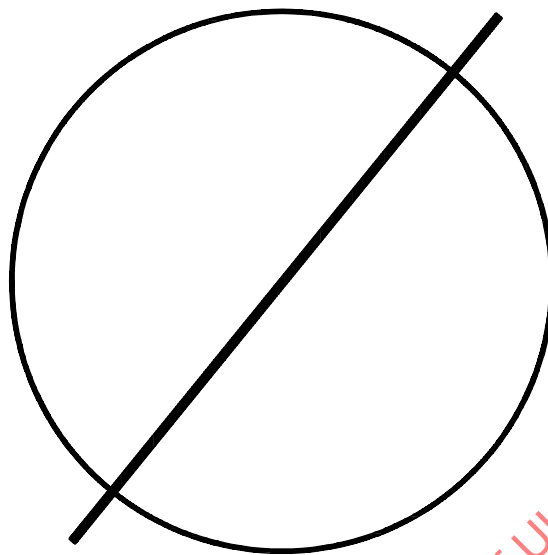
Figure 68.2
Alternating current symbol



IEC5032

IEC Publication 60417 DB, Symbol 5032

Figure 68.3
Phase symbol



SM510

68.2.3 Where the symbol referenced in 68.2.2 (a), (b), or (c) is used, the information described in 69.1.4(h) shall be provided.

68.2.4 When a unit is produced or assembled at more than one factory, each unit shall have a distinctive marking – which is not prohibited from being in code – by which it is identified as the product of a particular factory.

68.2.5 The operating positions of a handle, knob, or other means intended for manual operation by the user shall be marked.

68.2.6 Wiring terminals shall be marked to indicate the proper connections for the unit, or a wiring diagram coded to the terminal marking shall be securely attached to the equipment.

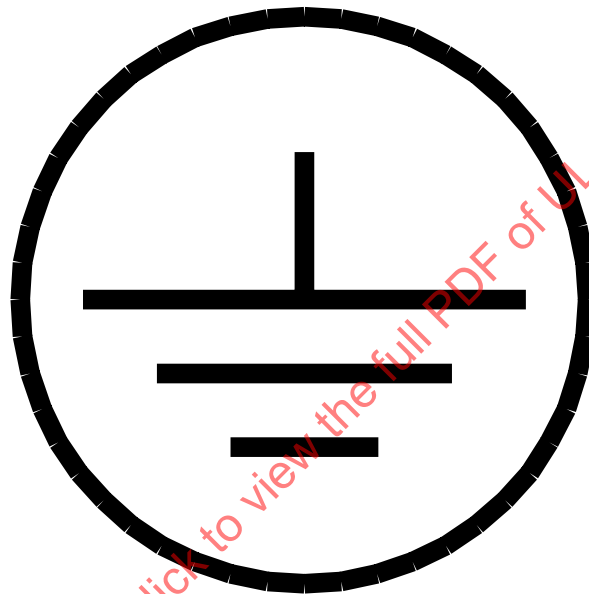
68.2.7 Equipment field-wiring terminals shall be marked:

- a) "Use Copper Conductors Only" when the terminal is intended only for connections to copper wire.
- b) "Use Aluminum Conductors Only" or "Use Aluminum or Copper-Clad Aluminum Conductors Only" when the terminal is intended only for connection to aluminum wire.
- c) "Use Copper or Aluminum Conductors" or "Use Copper, Copper-Clad Aluminum, or Aluminum Conductors" when the terminal is intended for connection to either copper or aluminum wire.

68.2.8 In accordance with 19.15, a pressure wire connector intended for connection of an equipment-grounding conductor shall be identified by:

- a) "G," "GR," "GND," "Ground," "Grounding," or similar wording,
- b) A marking on a wiring diagram attached to the unit, or
- c) The symbol illustrated in Figure 68.4 on or adjacent to the connector or on a wiring diagram provided on the unit. See 68.2.10.

Figure 68.4
Symbol for equipment grounding conductor



IEC Publication 60417 DB, Symbol 5019

68.2.9 With reference to 68.2.8(c), the following requirements apply when the symbol illustrated in Figure 68.4 is used:

- a) The information described in 69.1.4(h) shall be provided in the instruction manual, and
- b) The symbol is be used for identifying only the field wiring equipment grounding terminal. However, a symbol as shown in Figure 68.4 except with the circle omitted, is an alternate way for identifying various points within the unit that are bonded to ground.

Exception: When the symbol illustrated in Figure 68.4 is used with one of the other means of identification specified in 68.2.8 (a) and (b), the information is not required to be provided.