

Subject 2200

April 10, 2017

SUMMARY OF TOPICS

The following changes in requirements to the Standard for Stationary Engine Generator Assemblies, UL/ULC 2200, are being proposed for preliminary review and comment only:

1. For Preliminary Review Only: A Joint UL/ULC Standard for Stationary Engine Generator Assemblies, UL/ULC 2200, is proposed which includes several substantive changes and new requirements to address current technology

COMMENTS DUE: MAY 10, 2017

This proposal is for review and comment only (no ballot at this time). Please note that comments on a preliminary review document will not receive a response from the proposal author through CSDS. Instead, the proposal author will be asked to review the comments and adjust the proposals and/or supporting rationale as the author determines to be appropriate. The preliminary review process is an informal mechanism that provides authors with the opportunity to refine their proposals before they advance to the next stage in UL's standards development process.

In some cases, the author of the proposals may choose to discontinue them. In this case, the author need not do anything after preliminary review has ended. Normally, the next step in the process is the more formal STP ballot and stakeholder review process. Only comments posted during the STP ballot and stakeholder review process will be provided with a response in CSDS.

1. For Preliminary Review Only: A Joint UL/ULC Standard for Stationary Engine Generator Assemblies, UL/ULC 2200, is proposed which includes several substantive changes and new requirements to address current technology

RATIONALE

Proposal submitted by: Tim Zgonena, UL LLC

This document contains the Proposed Joint UL/ULC Standard for Stationary Engine Generator Assemblies, UL/ULC 2200. The proposed standard covers stationary engine generator assemblies that reflect today's technology already in production, including gas turbines, small steam engine power generation, and new alternative energy fuel applications in use such as biogas and liquid bio fuels. New sections of the standard also address the use of modern programmable controls for fuel and a wide range of power generation applications.

Hazards addressed by this standard include: electrical (energy, shock, and fire), mechanical (enclosures and moving parts), fuel related (containment and flow control for liquid and gaseous fuels including purge / dilution functions), and prime mover related hazards. These requirements cover relocatable generator assemblies that may be moved from location to location. It is intended that this standard will include the evaluation of the generator assembly including transport means with respect to the hazards addressed by this standard.

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The purpose of this Standard is to enhance health and safety by:

- a) Specifying acceptable criteria for stationary engine generator assemblies;
- b) Serving as a guide for producers, distributors, engineers, contractors, installers, inspectors, and users; and
- c) Promoting understanding regarding materials, manufacturing, and installation of stationary engine generator assemblies.

The availability of a national standard that clearly addresses these products and their minimum performance requirements creates the basis for evaluation of these products that allows inspection authorities to approve product installations with confidence that Code compatibility has been established. Without such a standard, installers and inspection authorities will be compelled to individually adapt other existing regulations in their attempt to establish Code compliance, resulting in inconsistent regulations and market uncertainty.

There are national differences only where standards (U.S. vs. Canadian) are referenced. However, the body of the proposed standard is technically identical for Canada and the U.S.

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ANNEX C (Informative) Markings required to be translated and suggested French and Spanish translations

PROPOSAL

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INTRODUCTION

1 Scope

1.1 These requirements cover stationary engine generator assemblies that are intended for installation and use in ordinary locations in accordance with the following:

- a) The National Electrical Code, NFPA 70;
- b) The Canadian Electrical Code, Part I, CSA C22.1;
- c) The Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, NFPA 37;
- d) Natural Gas and Propane Installation Code, CSA B149.1;
- e) The Code for Digester Gas, Landfill Gas, Biogas Generation and Utilization, ANSI/CSA B149.6;
- f) The Installation Code for Oil-Burning Equipment, CSA B139;
- g) The Standard for Health Care Facilities, NFPA 99;
- h) The Code for Canadian Health Care Facilities, CSA Z8000;
- i) The Standard for Emergency, Standby Power Systems, NFPA 110; and
- j) Emergency Electrical Power Supply for Building, CSA C282.

1.2 Units that incorporate a pressure vessel shall comply with the following:

- a) ASME Boiler and Pressure Vessel Code;
- b) Boiler, Pressure Vessel, and Pressure Piping Code, CSA B51;
- c) Power Piping, ASME B31.1;
- d) Gas-Fired Low Pressure Steam and Hot Water Boilers, ANSI Z21.13 / CSA 4.9; and
- e) Industrial and Commercial Gas-Fired Package Boilers, CSA CAN1-3.1.

1.3 Hazards addressed by this Standard include electrical (energy, shock, and fire), mechanical (enclosures and moving parts), fuel related (containment and flow control for liquid and gaseous fuels including purge / dilution functions), and prime mover related hazards.

1.4 These requirements cover relocatable generator assemblies that may be moved from location to location. Compliance with this Standard includes the evaluation of the generator assembly including transport means with respect to the hazards addressed by this Standard. Compliance with national and local highway and on-road requirements are evaluated separately from this Standard. These requirements include but are not limited to Transport Canada and the US Department of Transportation standards.

1.5 These requirements do not cover relocatable engine generator assemblies that are intended for operation during transport.

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

1.7 These requirements do not cover engine generator assemblies for shipboard marine applications.

2 Components

2.1 Except as indicated in 2.2, a component or auxiliary equipment used as a part of a unit covered by this Standard shall comply with the requirements for that component. See Annex A for a list of standards covering components generally used in the products covered by this Standard. A component shall comply with both the United States and Canadian Standards listed in Annex A.

2.2 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.

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

2.4 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.

3 Units of Measurement

3.1 The values given in SI (metric) units shall be normative. Any other values are for information only.

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

4 Glossary

4.1 In the text of this Standard, the term "unit" refers to any product covered by this Standard.

4.2 For the purpose of this Standard, the following definitions apply.

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

4.4 AMBIENT AIR TEMPERATURE – The temperature, determined under prescribed conditions, of the air surrounding the complete engine generator assembly, switching device or fuse. [IEC 60050-441: IEV ref 441-11-13, modified]

NOTE: For engine generator assemblies, switching devices or fuses installed inside an enclosure, it is the temperature of the air outside the enclosure.

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4.5 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 or programmable control.

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4.6 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, safety shutoff valves, combination metering safety shutoff valves, and auxiliary valves. Also see 4.5.

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4.7 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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4.8 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 4.69 and 4.70.

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

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

4.11 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.”

4.12 BREAKING CAPACITY (of a switching device or a fuse) – A value of prospective current that a switching device or a fuse is capable of breaking at a stated voltage under prescribed conditions of use and behavior. [IEC 60050-441: IEV ref 441-17-08]

NOTE 1: The voltage to be stated and the conditions to be prescribed are dealt with in the relevant publications.

NOTE 2: For switching devices, the breaking capacity may be termed according to the kind of current included in the prescribed conditions, e.g., line charging breaking capacity, cable charging breaking capacity, single capacitor bank breaking capacity, etc.

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

4.14 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.

4.15 CLASS 1 POWER LIMITED CIRCUIT – A circuit which is supplied from a source having a rated output of not more than 30 V and 1000 VA.

4.16 CLASS 2 CIRCUIT – A circuit which is supplied from a Class 2 transformer.

4.17 CLASS 2 TRANSFORMER – A step-down transformer complying with the applicable requirements in CSA C22.2 No. 66-1 / UL 5085-1 and CSA C22.2 No. 66.3 / UL 5085-3.

4.18 CLASS 3 CIRCUIT (not applicable to Canada) – A circuit which is supplied from a Class 3 Transformer.

In Canada, Class 3 circuits are not recognized in the Canadian Electrical Code, Part I.

4.19 CLEARANCE – The shortest distance through air spacing between two conductive parts.

4.20 COMPONENT – Refers to subassemblies used in the construction of the generating assembly.

4.21 CONDUCTIVE PART – A part which is capable of conducting current, although it is not necessarily used for carrying current. [IEC 60050-441: IEV ref 441-11-09, modified]

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

4.23 CONTROL POWER TRANSFORMER (CPT) – A transformer utilized to supply voltage for control circuits and auxiliary devices.

4.24 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.

4.25 COVER – An unhinged portion of an enclosure that covers an opening.

4.26 CREEPAGE DISTANCE – The shortest distance along the surface of an insulating material between two conductive parts.

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

4.28 DEGREE OF PROTECTION – The extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects, and/or ingress of water, and verified by standardized test methods (see CSA C22.2 No. 60529 / IEC 60529).

4.29 DOOR – A hinged portion of an enclosure that covers an opening.

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

4.31 ELECTRONIC FORMAT – Any electronic media content (other than computer programs or system files) provided on commonly available physical media or internet link, which is intended to be used in either an electronic form (such as a text file or PDF) or as printed output derived from the electronic document.

4.32 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.

4.33 ENGINE – A prime mover machine that converts energy into motion that may consume fuel in the process.

4.34 EXTRA-LOW-VOLTAGE (Canada only) – Any voltage not exceeding 30 V.

4.35 EXTRA-LOW-VOLTAGE POWER CIRCUIT (Canada only) – A circuit, such as a valve operator and similar circuits, that is neither a remote control circuit nor a signal circuit, but that operates at not more than 30 V and that is supplied from a transformer or other device restricted in its rated output to 1000 VA and approved for the purpose, but in which the current is not limited in accordance with the requirements for a Class 2 circuit.

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

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

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

4.39 GROUND (earth) – A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth or to some conducting body of relatively large extent that serves in place of the earth. See Figure B1 for examples of the use of the terms “grounding” and “bonding”, with corresponding terms for Canada.

4.40 GROUNDING KIT – A grounding terminal means intended to be field-connected or factory-installed, consisting of connectors (lugs) and hardware, such as bolts, studs, or screws, and suitable for connecting a conductor 14 AWG (2.08 mm²) or larger to equipment required to be grounded, which is in addition to the means for securing conduit or cable armor. It is not intended that a grounding kit consist merely of screws for direct attachment of grounding conductors.

In Canada, a grounding kit can also be referred to as a bonding kit.

4.41 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.

4.42 INSULATION CLASS – The classification of insulation materials for the purpose of establishing temperature limits for the use of the material.

4.43 IMPULSE WITHSTAND VOLTAGE – The specified peak value of impulse voltages, of prescribed form and polarity, that does not cause breakdown under specified conditions of test.

4.44 ISOLATING MEANS (isolating switch or disconnecter) – A mechanical switching device that provides, in the open position, isolating distance in the main circuit from the source of power. [IEC 60050-441: IEV ref 441-14-05, modified]

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4.45 LEAKAGE CURRENT – The current that can be measured as flowing between test points during a dielectric voltage-withstand test.

4.46 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:

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

4.47 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.

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

4.49 LOW-VOLTAGE – For this Standard, ac voltage in the range of 50 to 1,000 Vac and 1,500 Vdc (in Canada, 30 to 750 V). The applicable installation codes refer to voltages above 1,000 Vrms (750 Vrms in Canada) as “high voltage”.

4.50 LOW-VOLTAGE CONTROL COMPARTMENT – A compartment containing only low-voltage components.

4.51 LOW-VOLTAGE, LIMITED-ENERGY (LVLE) CIRCUIT – A circuit involving an alternating current voltage of not more than 30 Vrms (15 Vrms wet), 42.4 V peak (24.2 V peak wet) or a direct current voltage of not more than 42.4 V (30 V wet) 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 95.7.
- 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.

The DC dry voltage limit is 60 V in the US and 42.4 V in Canada, and this Standard includes the lower value for consistency.

4.52 MECHANICAL GUARD (or partition) – A part or barrier that reduces the risk of access to or separating a component from another or prevents the splashing, dripping or spraying of coolant, oil, or fuel that has the potential of causing an electrical fire, fuel fire hazard, or injury to persons.

4.53 MEDIUM-VOLTAGE – For this Standard, a voltage over 1,000 Vac or 1,500 Vdc (in Canada, over 750 V). The applicable installation codes refer to voltages above 1,000 Vrms (750 Vrms in Canada) as “high voltage”.

In Canada, any voltage exceeding 750 V is considered high voltage.

4.54 MEDIUM-VOLTAGE COMPARTMENT – A compartment containing one or more medium-voltage components.

4.55 MEDIUM-VOLTAGE FUSE – A current-limiting fuse intended for use in medium-voltage circuits, capable of interrupting all currents from the rated maximum interrupting current down to the rated minimum interrupting current (where applicable).

See IEEE C37.40, which categorizes different types of current-limiting fuses based on their minimum interrupting current capability:

- a) BACKUP CURRENT-LIMITING FUSE – a current-limiting fuse capable of interrupting all currents from its rated maximum interrupting current down to its rated minimum interrupting current.

b) **FULL-RANGE CURRENT-LIMITING FUSE** – a current-limiting fuse capable of interrupting, under specified conditions, all currents from its rated maximum interrupting current down to the minimum continuous current that can cause the fusible element to melt.

c) **GENERAL-PURPOSE CURRENT-LIMITING FUSE** – a current-limiting fuse capable of interrupting all currents from its rated interrupting current down to the current that causes melting of the fusible element(s) in one hour or more.

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

4.57 OPERATING VOLTAGE – The voltage across two points occurring due to normal operation of the product when controls are set in any position.

4.58 OUTPUT RECEPTACLE – A receptacle that is intended to carry the output power of the generator.

4.59 OVERCURRENT – A current exceeding the rated continuous current. Overcurrents can result from motor starting, overload, short-circuit, or ground faults.

4.60 OVERLOAD – Operating conditions in an electrically undamaged circuit that cause an overcurrent. [IEC 60050-441: IEV ref 441-11-08, modified]

Adapted by UL from IEC 60050-441, International Electrotechnical Vocabulary Chapter 441: Switchgear, Controlgear and Fuses, with permission of the American National Standards Institute (ANSI) on behalf of the International Electrotechnical Commission. All rights reserved.

4.61 OVERVOLTAGE CATEGORY – Grouping of products based on typical installed location with respect to overvoltage protection and available energy.

4.62 POLLUTION – Any addition of contaminants, solid, liquid, or gaseous (ionized gases), and moisture that may produce a reduction of dielectric strength or surface resistivity.

4.63 POLLUTION DEGREE – The level of pollution present at the location on or in a product where the clearance and creepage distance measurement is made and can be controlled by design of the product. For example, enclosures can be used to achieve pollution degree 3, heaters within non-ventilated enclosures can help achieve pollution degree 2, and encapsulation can be used to achieve pollution degree 1.

4.64 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.

4.65 PRIMARY CIRCUIT – Wiring and components that are conductively connected to a power output and or branch circuit.

4.66 RELOCATABLE GENERATOR – An engine generator that is intended to be transported by vehicle, trailer, or other means, between locations prior to service, and it is not permanently installed.

4.67 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 other means of security and is controlled by the authority responsible for the rotating equipment or live component location.

4.68 RISK – Combination of the probability of occurrence of harm (i.e. physical injury or damage to health) and the severity of harm. [ISO 12100, 3.12, modified]

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

4.70 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 V or more and either:

- a) An available continuous power level of 240 VA or more; or
- b) A reactive energy level of 20 J 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.

4.71 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.

4.72 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.

4.73 SAFETY FUNCTION – Function of a machine whose failure can result in an immediate increase of risk(s). [ISO 12100, 3.30]

4.74 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.

4.75 SECONDARY CIRCUIT – A circuit supplied from a secondary winding of an isolating transformer. See Section 29, Transformers.

4.76 SERVICE DISCONNECTING MEANS – Isolating means that disconnects all conductors into a building or other structure from the service entrance conductors.

4.77 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. Service personnel tasks include periodic engine maintenance like changing oil and filters.

4.78 SKIN-TIGHT ENCLOSURE – An enclosure where required clearances are provided through the exterior to the enclosure with maintenance access to parts of the engine generator set from the outside of the enclosure with no accessibility to uninsulated live electrical components.

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

4.80 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.

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

4.82 TOOL – A screwdriver, wrench, or any other special object that is a service access tool that is used to operate a screw, latch, or similar fastening means.

4.83 USER – Any person other than service personnel.

4.84 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 with guarding or barriers in place to prevent the user from accessing rotating machinery or live components.

4.85 WALK-IN ENCLOSURE – An enclosure is where all the required working clearances are provided within the enclosure, similar to when an engine generator set is installed in a machinery or service room.

4.86 WEATHER ENCLOSURE – An enclosure for outdoor use that is integral to the engine generator and protects the engine generator assembly from the wetting of live parts in an outdoor environment while the unit is operating or is in standby.

4.87 WRITTEN FORMAT – A printed document, label, or molded text provided in a physical form as part of or with the product.

4.88 ZERO GOVERNOR REGULATOR (vacuum demand regulator) – A fuel regulating device that allows fuel flow when a partial vacuum is applied to the regulator output port. The regulator stops fuel flow when vacuum demand on the output port is discontinued.

5 Reference Publications

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.

5.2 Throughout this Standard, the CSA and ULC standard references apply to products intended for use in Canada, while the UL standard references apply to products intended for use in the United States. Combined references are commonly separated by a slash (“ / ”).

5.3 The following publications are referenced in this Standard:

Canada	United States
CSA C22.2 No. 107.3, Uninterruptible Power Systems	UL 1778, Uninterruptible Power Systems
CSA C22.2 No. 66-1, Low Voltage Transformers – Part 1: General Requirements	UL 5085-1, Low Voltage Transformers – Part 1: General Requirements
CSA C22.2 No. 66.3, Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers	UL 5085-3, Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers
CSA C22.2 No. 61010-2-030, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits	UL 61010-2-030, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits
CSA C22.2 No. 94.1, Enclosures for Electrical Equipment, Non-Environmental Considerations	UL 50, Enclosures for Electrical Equipment, Non-Environmental Considerations
CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials	UL 746C, Polymeric Materials – Use in Electrical Equipment Evaluations
No equivalent	UL 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
No equivalent	UL 723, Test for Surface Burning Characteristics of Building Materials
CSA C22.2 No. 18.1, Metallic Outlet Boxes	UL 514A, Metallic Outlet Boxes
CSA C22.2 No. 18.3, Conduit, Tubing, and Cable Fittings	UL 514B, Conduit, Tubing, and Cable Fittings
No equivalent	UL 1439, Tests for Sharpness of Edges on Equipment
CSA C22.2 No. 178.1, Transfer Switch Equipment	UL 1008, Transfer Switch Equipment
CSA C22.2 No. 111, General-Use Snap Switches	UL 20, General-Use Snap Switches
CSA C22.2 No. 14, Industrial Control Equipment	UL 508, Industrial Control Equipment
CSA C22.2 No. 100, Motors and Generators	UL 1004-4, Electric Generators
CSA C22.2 No. 0.19, Requirements for Service Entrance Equipment	UL 869A, Reference Standard for Service Equipment
CSA C22.2 No. 18.2, Nonmetallic Outlet Boxes	UL 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
No equivalent	UL 746A, Polymeric Materials – Short Term Property Evaluations
CSA C22.2 No. 75, Thermoplastic-Insulated Wires and Cables	UL 83, Thermoplastic-Insulated Wires and Cables
CSA C22.2 No. 153, Electrical Quick-Connect Terminals	UL 310, Electrical Quick-Connect Terminals
CSA C22.2 No. 198.1, Extruded Insulating Tubing	UL 224, Extruded Insulating Tubing
CSA C22.2 No. 197, PVC Insulating Tape	UL 510, Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
CSA Component Acceptance Service Notice No. 5, Component Acceptance Service for Optocouplers and Related Devices	UL 1577, Optical Isolators

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Canada	United States
CSA C22.2 No. 66.1, Low Voltage Transformers – Part 1: General Requirements	UL 5085-1, Low Voltage Transformers – Part 1: General Requirements
CSA C22.2 No. 66-2, Low Voltage Transformers – Part 2: General Purpose Transformers	UL 506, Specialty Transformers
CSA C22.2 No. 66-3, Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers	
CSA C22.2 No. 47, Air-Cooled Transformers (Dry Type)	UL 1561, Dry-Type General Purpose and Power Transformers
CSA C22.2 No. 5, Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures	UL 489, Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
ULC-S111, Standard Method of Fire Tests for Air Filter Units	UL 900, Air Filter Units
CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials	UL 796, Printed-Wiring Boards
No equivalent	UL 1446, Systems of Insulating Materials – General
No equivalent	UL 746B, Polymeric Materials – Long Term Property Evaluations
CSA C22.2 No. 46, Electric Air Heaters	UL 499, Electric Heating Appliances
CSA C282, Emergency Electrical Power Supply for Buildings	NFPA 110, Emergency and Standby Power Systems
CSA C22.2 No. 107.2, Battery Chargers	UL 1236, Battery Chargers for Charging Engine-Starter Batteries
CSA C22.2 No. 107.1, Power Conversion Equipment	UL 1741, Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources
ULC/ORD-C558, Guide for the Investigation of Internal Combustion Engine-Powered Industrial Trucks	UL 558, Industrial Trucks, Internal Combustion Engine-Powered
CSA C22.2 No. 223, Power Supplies with Extra-Low-Voltage Class 2 Outputs	UL 1310, Class 2 Power Units
CSA 8.3, Thermoplastic Hose And Hose Couplings For Conducting Propane And Natural Gas CGA-8.1, Elastomeric Composite Hose and Hose Couplings for Conducting Propane and Natural Gas	UL 21, LP-Gas Hose
CSA C22.2 No. 0.15, Adhesive Labels	
CSA C22.2 No. 65, Wire Connectors	UL 486A-486B, Wire Connectors
CSA C22.2 No. 65, Wire Connectors	UL 486E, Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
No equivalent	UL 157, Gaskets and Seals
CSA C22.2 No. 14, Industrial Control Equipment	UL 508, Industrial Control Equipment
CSA C22.2 No. 107.1, Power Conversion Equipment	UL 1012, Power Units Other Than Class 2
CSA C22.2 No. 60529, Degrees of Protection Provided by Enclosures (IP Code)	IEC 60529, Degrees of Protection Provided by Enclosures (IP Code)
No equivalent	IEEE C37.40, Service Conditions and Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories
CSA C22.2 No. 144.1, Ground-Fault Circuit-Interrupters	UL 943, Ground-Fault Circuit-Interrupters
CSA C22.2 No. 144, Ground Fault Circuit Interrupters	UL 943C, Outline for Special Purpose Ground-Fault Circuit-Interrupters
CSA C22.2 No. 26, Construction and Test of Wireways, Auxiliary Gutters, and Associated Fittings	UL 870, Wireways, Auxiliary Gutters, and Associated Fittings
CSA C22.2 No. 190, Capacitors for Power Factor Correction	UL 810, Capacitors
CSA-E60384-14, Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains	UL 60384-14, Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains
CSA C22.2 No. 8, Electromagnetic Interference (EMI) Filters	UL 1283, Electromagnetic Interference Filters

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Canada	United States
CSA C22.2 No. 141, Emergency Lighting Equipment	UL 924, Emergency Lighting and Power Equipment
CSA C22.2 No. 29, Panelboards and Enclosed Panelboards	UL 67, Panelboards
CSA C22.2 No. 250.0, Luminaires	UL 1598, Luminaires
CSA C22.2 No. 250.0, Luminaires	UL 2108, Low Voltage Lighting Systems
CSA C22.2 No. 9.0, General Requirements for Luminaires	
National Building Code of Canada – Emergency Lighting	NFPA 101, Life Safety Code
CSA C22.2 No. 31, Switchgear Assemblies	IEEE 1247, IEEE Standard for Interrupter Switches for Alternating Current Rated Above 1000 Volts IEEE C37.20.3, Metal-Enclosed Interrupter Switchgear (1 kV – 38 kV) IEEE C37.20.4, Indoor AC Switches (1 kV to 38 kV) for Use in Metal-Enclosed Switchgear NEMA C37.54, For Indoor Alternating Current High-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear – Conformance Test Procedures NEMA C37.57, For Switchgear – Metal-Enclosed Interrupter Switchgear Assemblies – Conformance Testing NEMA C37.58, For Switchgear – Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear – Conformance Test Procedures
CSA C22.2 No. 253, Medium-Voltage AC Contactors, Controllers, and Control Centres	UL 347, Medium-Voltage AC Contactors, Controllers, and Control Centers
CSA C22.2 No. 0.22, Evaluation Methods for Arc Resistance Ratings of Enclosed Electrical Equipment	IEEE C37.20.7, Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults
C22.2 No. 0.2, Insulation Coordination	UL 840, Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment
CSA C22.2 No. 139, Electrically Operated Valves	UL 429, Electrically Operated Valves UL 428A, Electrically Operated Valves for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations Up to 85 Percent (E0 – E85) UL 428B, Electrically Operated Valves for Diesel Fuel, Biodiesel Fuel, Diesel/Biodiesel Blends with Nominal Biodiesel Concentrations Up to 20 Percent (B20), Kerosene, and Fuel Oil
CSA B51, Boiler, pressure vessel, and pressure piping code ASME B31.3, Process Piping	ASME B31.3, Process Piping
CSA-B149.6, Code for digester gas, landfill gas, and biogas generation and utilization	No equivalent
ULC/ORD-C536, Flexible Metallic Hose	UL 536, Flexible Metallic Hose
ANSI Z21.21 / CSA 6.5, Automatic Valves for Gas Appliances	ANSI Z21.21 / CSA 6.5, Automatic Valves for Gas Appliances
ANSI Z21.18 / CSA 6.3, Gas Appliance Pressure Regulators	ANSI Z21.18 / CSA 6.3, Gas Appliance Pressure Regulators
ULC/ORD-C959, 540 Degrees C and 760 Degrees C Industrial Chimneys	UL 2561, 1400 Degree Fahrenheit Factory-Built Chimneys
ULC-S629, 650 Degrees C Factory-Built Chimneys	UL 103, Factory-Built Chimneys for Residential Type and Building Heating Appliances
CSA C22.2 No. 236, Heating and Cooling Equipment	UL 1995, Heating and Cooling Equipment
CSA C22.2 No. 165, Electric Boilers	UL 834, Heating, Water Supply, and Power Boilers – Electric
CSA CAN1-3.1, Industrial and Commercial Gas-Fired Packaged Boilers	UL 795, Commercial-Industrial Gas Heating Equipment
ANSI Z21.13 / CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers	ANSI Z21.13 / CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers
CSA B149.1, Natural Gas and Propane Installation Code	UL 181, Factory-Made Air Ducts and Air Connectors

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Canada	United States
CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code	ASME Boiler and pressure vessel Code VIII Rules for Construction of Pressure Vessels, Division 1
CAN/CGSB 12.1-M90, Tempered or Laminated Safety Glass	ANSI Z97.1, Safety glazing Materials Used in Buildings – Safety Performance Specifications and Methods of Test
IEC 60695-2-13, Glow-wire ignition temperature (GWIT) test method for materials	IEC 60695-2-13, Glow-wire ignition temperature (GWIT) test method for materials
ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process	ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A90, Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings	ASTM A90, Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM D1525, Standard Test Method for Vicat Softening Temperature of Plastics	ASTM D1525, Standard Test Method for Vicat Softening Temperature of Plastics
ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers Tension	ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers Tension
ASTM E230/E230M, Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples	ASTM E230/E230M, Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus	ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus
ANSI C37.55, Switchgear – Medium-Voltage Metal-Clad Assemblies – Conformance test procedures	ANSI C37.55, Switchgear – Medium-Voltage Metal-Clad Assemblies – Conformance test procedures
NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines	NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
ASME B31.1, Power Piping	ASME B31.1, Power Piping
ASME B1.20.1, Pipe Threads, General Purpose (Inch)	ASME B1.20.1, Pipe Threads, General Purpose (Inch)
NFPA 54/ANSI Z223.1, National Fuel Gas Code	NFPA 54/ANSI Z223.1, National Fuel Gas Code
ASME B36.10M, Welded and Seamless Wrought Steel Pipe	ASME B36.10M, Welded and Seamless Wrought Steel Pipe
ISO 10380, Pipework – Corrugated metal hoses and hose assemblies	ISO 10380, Pipework – Corrugated metal hoses and hose assemblies
ASTM F1120, Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications	ASTM F1120, Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications
ASME B36.19M, Stainless Steel Pipe	ASME B36.19M, Stainless Steel Pipe
ASME B31.11, Slurry Transportation Piping Systems	ASME B31.11, Slurry Transportation Piping Systems
IEEE 4, High-Voltage Testing Techniques	IEEE 4, High-Voltage Testing Techniques
NFPA 79, Electrical Standard for Industrial Machinery	NFPA 79, Electrical Standard for Industrial Machinery
ISO 7000, Graphical symbols for use on equipment – Registered symbols	ISO 7000, Graphical symbols for use on equipment – Registered symbols
ISO 7010, Graphical symbols – Safety colours and safety signs – Registered safety signs	ISO 7010, Graphical symbols – Safety colours and safety signs – Registered safety signs
IEC 60417 Database, Graphical Symbols for Use on Equipment	IEC 60417 Database, Graphical Symbols for Use on Equipment
ISO 19372, Microturbines applications – Safety	ISO 19372, Microturbines applications – Safety
IEC 61508, Functional safety of electrical/electronic/programmable electronic safety-related systems	IEC 61508, Functional safety of electrical/electronic/programmable electronic safety-related systems
IEEE C37.09, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	IEEE C37.09, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

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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 81.2, 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 Section 36, Insulating Materials; or
- b) An insulating boot/barrier made from polyvinyl-chloride, neoprene, silicone rubber 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 and their components may be used to carry current for normal engine operation but the resulting voltage from the current passing through an engine part shall not exceed the voltage levels in Table 8.

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: This requirement does not apply to a meter complying with the requirements in CSA C22.2 No. 61010-2-030 / UL 61010-2-030.

7.2 Enclosures and guards

7.2.1 Whether a mechanical 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, leak 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 guarding means to reduce the risk of unintentional contact with the hazard.

7.2.3 The degree of protection required by 7.2.2 depends upon the general construction and intended use of a guarding means. 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 Section 8, Protection of Users – Accessibility of Uninsulated Live Parts and Moving Parts – and User Servicing, 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.

7.2.5 Mechanical guarding shall be used where necessary on radiant heat sources, fluid system piping unions, flanges, and fittings in the event of a leak to reduce or contain splashing, dripping or spraying of coolant, oil or fuel to reduce the potential risk of causing an electrical fire, fuel fire hazard or injury to persons.

7.3 Access doors, covers, and panels

7.3.1 An access cover shall be a hinged door 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. When the door encloses medium voltage components or wiring, it shall also comply with 7.3.4 and 7.3.5.

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 A or less for loads not exceeding 100 VA;*
- 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 for low voltage equipment that:

- a) Contains no user-serviceable or -operable parts; and*
- b) Is marked in accordance with 95.6.*

7.3.2 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 no less than 90 degrees meets the intent of this requirement.

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

7.3.4 Doors giving access to medium-voltage compartments shall be provided with an interlock that is solely mechanical, such that the door cannot be opened unless all medium voltage components or wiring in the compartment are de-energized. Electrical or electro-mechanical interlocks may be provided in addition to the required mechanical interlock, but shall not replace the requirement for a solely mechanical interlock. (The use of a captive key interlocking system is one method to provide mechanical interlocking.)

7.3.5 Covers giving access to medium-voltage compartments shall comply with all the following conditions:

- a) The cover shall be bolted on all sides with a minimum of two bolts per side;
- b) No bolts are operable by hand, without the use of a tool;
- c) All bolts are captive fasteners;
- d) The cover does not provide access to fuses; and

- e) The cover is marked “DANGER: High Voltage – Do not open cover while generator is operating”.

7.4 Cast metal enclosures

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

Table 1
Thickness of cast-metal enclosures

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

^a The area limitation for metal 1.6 mm (1/16 inch) 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 CSA C22.2 No. 94.1 / 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 Table 2 and Table 3. Uncoated steel shall not be less than 0.81 mm (0.032 inch) thick, zinc-coated steel shall not be less than 0.86 mm (0.034 inch) thick, and nonferrous metal shall not be less than 1.14 mm (0.045 inch) 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 Table 2 and Table 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 Table 2 and Table 3, when uninsulated live parts are located at least 64 mm (2-1/2 inches) from the surface, and 4 gauge sizes less when the uninsulated live parts are located at least 128 mm (5 inches) 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 Table 2 and Table 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 2
Thickness of carbon steel or stainless steel enclosures

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness mm (inch)	
Maximum width ^b	Maximum length ^c	Maximum width ^b	Maximum length	Uncoated	Metal Coated
cm (Inches)	cm (Inches)	cm (Inches)	cm (Inches)		
10.2 (4.0)	Not limited	15.9 (6.25)	Not limited		
12.1 (4.75)	14.6 (5.75)	17.1 (6.75)	21.0 (8.25)	0.51 ^d (0.020)	0.58 ^d (0.023)
15.2 (6.0)	Not limited	24.1 (9.5)	Not limited		
17.8 (7.0)	22.2 (8.75)	25.4 (10.0)	31.8 (12.5)	0.66 ^d (0.026)	0.74 ^d (0.029)
20.3 (8.0)	Not limited	30.5 (12.0)	Not limited		
22.9 (9.0)	29.2 (11.5)	33.0 (13.0)	40.6 (16.0)	0.81 (0.032)	0.86 (0.034)
31.8 (12.5)	Not limited	49.5 (19.5)	Not limited		
35.6 (14.0)	45.7 (18.0)	53.3 (21.0)	63.5 (25.0)	1.07 (0.042)	1.14 (0.045)
45.7 (18.0)	Not limited	68.6 (27.0)	Not limited		
50.8 (20.0)	63.5 (25.0)	73.7 (29.0)	91.4 (36.0)	1.35 (0.053)	1.42 (0.056)
55.9 (22.0)	Not limited	83.8 (33.0)	Not limited		
63.5 (25.0)	78.7 (31.0)	88.9 (35.0)	109.2 (43.0)	1.52 (0.060)	1.60 (0.063)
63.5 (25.0)	Not limited	99.1 (39.0)	Not limited		
73.7 (29.0)	91.4 (36.0)	104.1 (41.0)	129.5 (51.0)	1.70 (0.067)	1.78 (0.070)
83.8 (33.0)	Not limited	129.5 (51.0)	Not limited		
96.5 (38.0)	119.4 (47.0)	137.2 (54.0)	167.6 (66.0)	2.03 (0.080)	2.13 (0.084)
106.7 (42.0)	Not limited	162.6 (64.0)	Not limited		
119.4 (47.0)	149.9 (59.0)	172.7 (68.0)	213.4 (84.0)	2.36 (0.093)	2.46 (0.097)
132.1 (52.0)	Not limited	203.2 (80.0)	Not limited		
152.4 (60.0)	188.0 (74.0)	213.4 (84.0)	261.6 (103.0)	2.74 (0.108)	2.82 (0.111)
160.0 (63.0)	Not limited	246.4 (97.0)	Not limited		
185.4 (73.0)	228.6 (90.0)	261.6 (103.0)	322.6 (127.0)	3.12 (0.123)	3.20 (0.126)

^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 12.7 mm (1/2 inch) 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 0.86 mm (0.034 inch) thick when metal coated and not less than 0.81 mm (0.032 inch) thick when uncoated.

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Table 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	
cm (Inches)	cm (Inches)	cm (Inches)	cm (Inches)	cm (Inches)
7.6 (3.0)	Not limited	17.8 (7.0)	Not limited	0.58 ^d (0.023)
8.9 (3.5)	10.2 (4.0)	21.6 (8.5)	24.1 (9.5)	
10.2 (4.0)	Not limited	25.4 (10.0)	Not limited	0.74 (0.029)
12.7 (5.0)	15.2 (6.0)	26.7 (10.5)	34.3 (13.5)	
15.2 (6.0)	Not limited	35.6 (14.0)	Not limited	0.91 (0.036)
16.5 (6.5)	20.3 (8.0)	38.1 (15.0)	45.7 (18.0)	
20.3 (8.0)	Not limited	48.3 (19.0)	Not limited	1.14 (0.045)
24.1 (9.5)	29.2 (11.5)	53.3 (21.0)	63.5 (25.0)	
30.5 (12.0)	Not limited	71.1 (28.0)	Not limited	1.47 (0.058)
35.6 (14.0)	40.6 (16.0)	76.2 (30.0)	94.0 (37.0)	
45.7 (18.0)	Not limited	106.7 (42.0)	Not limited	1.91 (0.075)
50.8 (20.0)	63.5 (25.0)	114.3 (45.0)	139.7 (55.0)	
63.5 (25.0)	Not limited	152.4 (60.0)	Not limited	2.41 (0.095)
73.7 (29.0)	91.4 (36.0)	162.6 (64.0)	198.1 (78.0)	
94.0 (37.0)	Not limited	221.0 (87.0)	Not limited	3.10 (0.122)
106.7 (42.0)	134.6 (53.0)	236.2 (93.0)	289.6 (114.0)	
132.1 (52.0)	Not limited	312.4 (123.0)	Not limited	3.89 (0.153)
152.4 (60.0)	188.0 (74.0)	330.2 (130.0)	406.4 (160.0)	

^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 12.7 mm (1/2 inch) 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 0.74 mm (0.029 inch) thick.

7.5.3 Table 2 and Table 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 Table 2 and Table 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 Table 2 and Table 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

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- d) An enclosure surface loosely attached to a frame – for example, by spring clips.

7.6 Nonmetallic enclosures

7.6.1 All medium voltage components and wiring shall be enclosed by metal enclosures. Nonmetallic enclosures, covers or doors may be used to enclose or cover low voltage components and wiring only. A polymeric enclosure or polymeric part of an enclosure shall comply with the requirements in CSA C22.2 No. 0.17 / UL 746C.

7.6.2 A component, piece, or 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 25.4 mm (1 inch) 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 101.6 mm (4 inches) 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 4.71) closer than 101.6 mm (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 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 An external polymeric material enclosure having in any single unbroken section, a projected surface area greater than 0.93 m² (10 square feet), or a single linear dimension greater than 1.83 m (6 feet) shall have a flame-spread rating of 200 or less when tested in accordance with UL 723 or IEC 60695-2-13.

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 CSA C22.2 No. 0.17 / 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 CSA C22.2 No. 0.17 / UL 746C.

7.6.6 Engine and exhaust areas that are part of an enclosure that incorporate thermal insulation shall comply with a 20-mm flame test or the requirements of CSA C22.2 No. 0.17 / UL 746C.

7.6.7 Intake plenum areas that are part of an enclosure that incorporate sound insulation lining shall comply with a 20-mm Flame Test or the requirements of CSA C22.2 No. 0.17 / UL 746C or have a flame spread index of 0 – 25 when tested in accordance with UL 723 / IEC 60695-2-13.

7.6.8 For internal areas of the engine generator walk-in enclosure where users or service persons are intended to enter the space to operate or service it, polymeric materials such as polymeric enclosures, polymeric access barriers, walls of an enclosure, or insulation on the walls of an engine generator shall be rated as follows. Any single unbroken section greater than 0.93 m² (10 square feet) or a single linear dimension greater than 1.83 m (6 feet) shall have a maximum flame spread index and smoke developed index as shown in Table 4 as tested in accordance with the UL 723.

Exception: This requirement does not apply to the following:

- a) Wire and cables; and
- b) Materials less than 0.9 mm (0.036 inch) thick directly applied to walls, floors, or ceiling surfaces.

Table 4
Sound and thermal enclosure insulation index

Location within enclosure	Flame spread index	Smoke developed index
Walk-in area	0 – 25	0 – 50
Intake Plenum area	0 – 25	0 – 50
Void area	76 – 200	0 – 450

7.7 Viewing panes

7.7.1 A viewing pane covering an opening in a low voltage area shall be secured in place so that it is not readily displaced in service and provides mechanical protection for the enclosed parts. Viewing panes shall not be placed in medium voltage compartments.

7.7.2 Glass for an opening in a low voltage compartment shall comply with the following dimensions:

- a) Glass for an opening not more than 102 mm (4 inches) in any dimension shall not be less than 1.6 mm (1/16 inch) thick;
- b) Glass for an opening not more than 929 cm² (144 square inches) in area and having no dimension greater than 305 mm (12 inches) shall not be less than 3.2 mm (1/8 inch) thick; and
- c) Glass used to cover an area larger than noted in (b) shall not be less than 3.2 mm (1/8) inch thick and shall:
 - 1) Be of a non-shattering or tempered type, wire reinforced that, when broken, complies with CAN/CGSB 12.1-M90 / ANSI Z97.1; or
 - 2) Be subjected to the test described in 81.1.

7.7.3 Polymeric materials covering an opening in a low voltage compartment shall be subjected to the test described in 81.2.

7.7.4 Viewing panes covering an opening in a medium voltage compartment shall:

- a) Be of clear safety-type glass or wire-reinforced glass or another clear material found suitable with respect to flammability and UV resistance in accordance with CSA C22.2 No. 0.17 / UL 746C; and
- b) Comply with the tests described in Section 82, Mechanical Tests of Viewing Panes for Medium Voltage Compartments.

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 CSA C22.2 No. 18.1 / UL 514A and CSA C22.2 No. 18.3 / 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 Section 24, Spacings.

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 5 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

Table 5
Knockout or hole sizes and dimensions of bushings

Trade size of conduit		Knockout or hole diameter		Bushing dimensions			
				Overall diameter		Height	
mm	(Inches)	mm	(Inches)	mm	(Inches)	mm	(Inches)
15	(1/2)	22.2	(7/8)	25.4	(1)	9.5	(3/8)
20	(3/4)	27.8	(1-3/32)	31.4	(1-15/64)	10.7	(27/64)
25	(1)	34.5	(1-23/64)	40.5	(1-19/32)	13.1	(33/64)
32	(1-1/4)	43.7	(1-23/32)	49.2	(1-15/16)	14.3	(9/16)
40	(1-1/2)	50.0	(1-31/32)	56.0	(2-13/64)	15.1	(19/32)
50	(2)	62.7	(2-15/32)	68.7	(2-45/64)	15.9	(5/8)
65	(2-1/2)	6.2	(3)	81.8	(3-7/32)	19.1	(3/4)
3		92.1	(3-5/8)	98.4	(3-7/8)	20.6	(13/16)
3-1/2		104.8	(4-1/8)	112.7	(4-7/16)	13.8	(15/16)
4		117.5	(4-5/8)	126.2	(4-31/32)	25.4	(1)
4-1/2		130.2	(5-1/8)	140.9	(5-35/64)	27.0	(1-1/16)
5		42.9	(5-5/8)	158.0	(6-7/32)	30.2	(1-3/16)
6		171.5	(6-3/4)	183.4	(7-7/32)	31.8	(1-1/4)

7.8.7 For an enclosure not provided with conduit openings or knockouts, spacings not less than the minimum specified in Section 24, Spacings, 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 CSA C22.2 No. 18.1 / UL 514A.

7.9 Openings in an engine generator or electrical panel 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.

7.9.2 Barriers shall be provided behind all ventilating openings into medium-voltage compartments. The barrier shall be effectively secured in place and shall prevent drawing a straight line from any point outside the enclosure to any medium voltage live part, including insulated parts such as cables (other than shielded cables).

7.9.3 Natural ventilation openings in medium voltage compartments, including perforations, louvers, and openings protected by means of wire screening, expanded metal, or a perforated cover, shall comply with the rod entry test specified in Section 91, Rod Entry Test.

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 1 is required in accordance with 7.9.1. Open bottom engine generator enclosures shall indicate in the installation instruction that they are to be installed on a noncombustible surface.

Exception No. 1: Ventilating openings along the base of an enclosure are not prohibited when there is no access to live electrical components. Ventilating openings in the bottom of an electrical 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 2.

Exception No. 2: Ventilation openings in the bottom of an electrical panel enclosure are not prohibited when the openings incorporate a perforated metal plate as described in Table 6, 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 0.4 mm (0.018 inch) minimum.

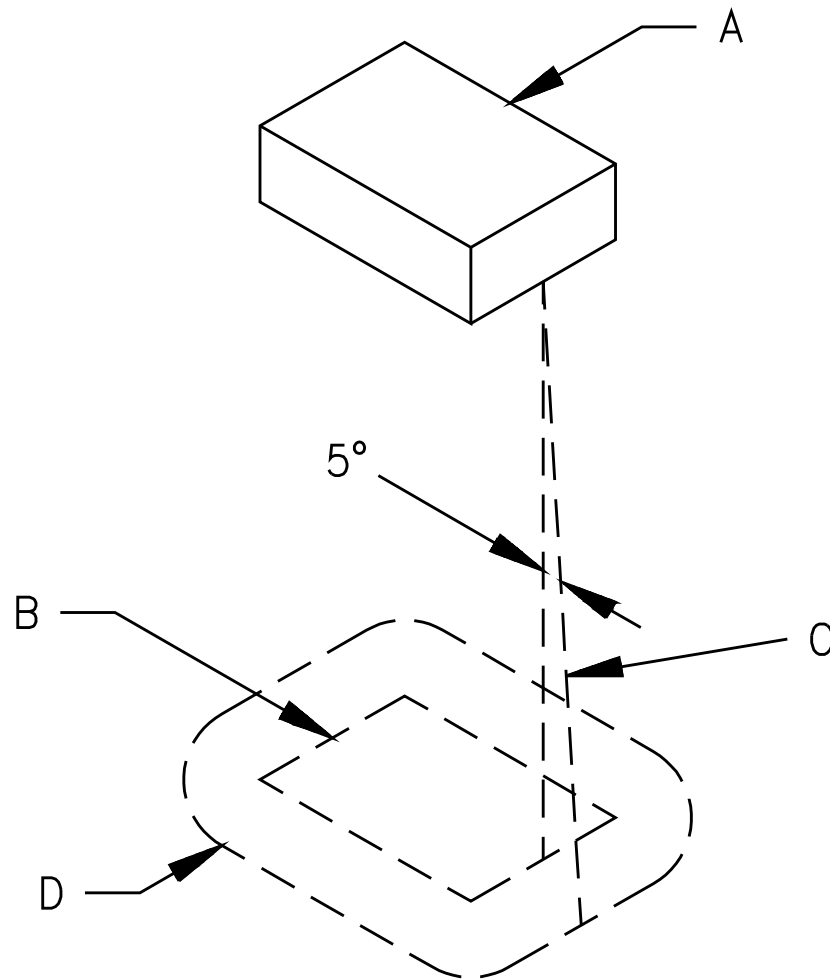
Exception No. 3: The bottom of the enclosure under areas containing only materials classed V-0 or better in accordance with UL 94 shall have openings no larger than 6.4 mm (1/4 inch) square. Openings that are not square shall not have an area greater than 40 mm² (1/16 square inch).

Exception No. 4: Ventilating openings without limitation on their size and number and complying with 8.12 and provided in the base of the engine generator enclosure or 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. 5: Ventilating openings are not prohibited in the bottom panel or along the base 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 1
Enclosure bottom



EB120A

A – Region to be shielded by guard 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.

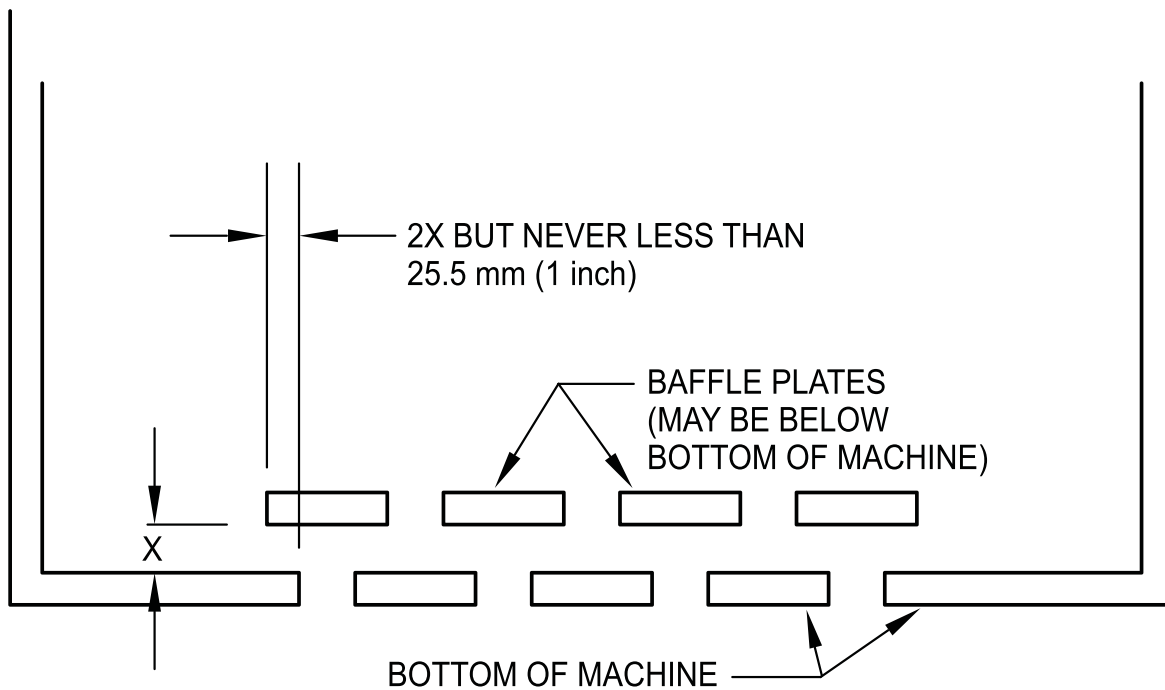
D – Location (horizontal) and minimum area for barrier. The area is that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

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Figure 2
Example of a panel bottom-enclosure baffle



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Table 6
Perforated metal plates for enclosure bottom

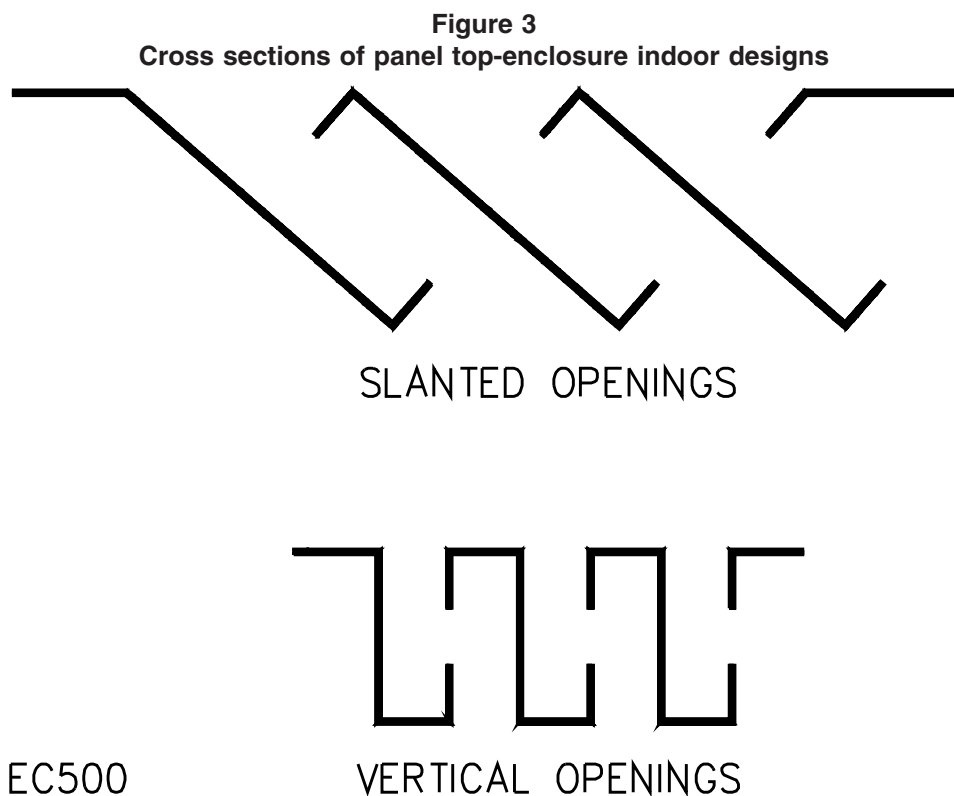
Minimum thickness		Maximum diameter of holes		Minimum spacings of holes center to center	
mm	(inch)	mm	(inch)	mm	(inch)
0.66	(0.026)	1.14	(0.045)	1.70	(0.067)
				233 holes per 645 mm ² (1 inch ²)	
0.66	(0.026)	1.19	(0.047)	2.36	(0.093)
0.76	(0.030)	1.14	(0.045)	1.70	(0.067)
0.76	(0.030)	1.19	(0.047)	2.36	(0.093)
0.81	(0.032)	1.91	(0.075)	3.18	(0.125)
				72 holes per 645 mm ² (1 inch ²)	
0.89	(0.035)	1.90	(0.075)	3.18	(0.125)
0.91	(0.036)	1.60	(0.063)	2.77	(0.109)
0.91	(0.036)	1.98	(0.078)	3.18	(0.125)
0.99	(0.039)	1.60	(0.063)	2.77	(0.109)
0.99	(0.039)	2.00	(0.079)	3.00	(0.118)

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

7.11 Indoor 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 4.8 mm (3/16 inch) 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 3 for examples of top surface openings that prevent direct entry.

Exception: Openings located 1.8 m (6 feet) 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 34.8 mm (3/16 inch). Such openings shall comply with the accessibility requirements in Section 8, Protection of Users – Accessibility of Uninsulated Live Parts and Moving Parts – and User Servicing.



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 UL 1439 shall be employed.

8 Protection of Users – Accessibility of Uninsulated Live Parts 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 Section 41, Protection of Service Personnel.

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:

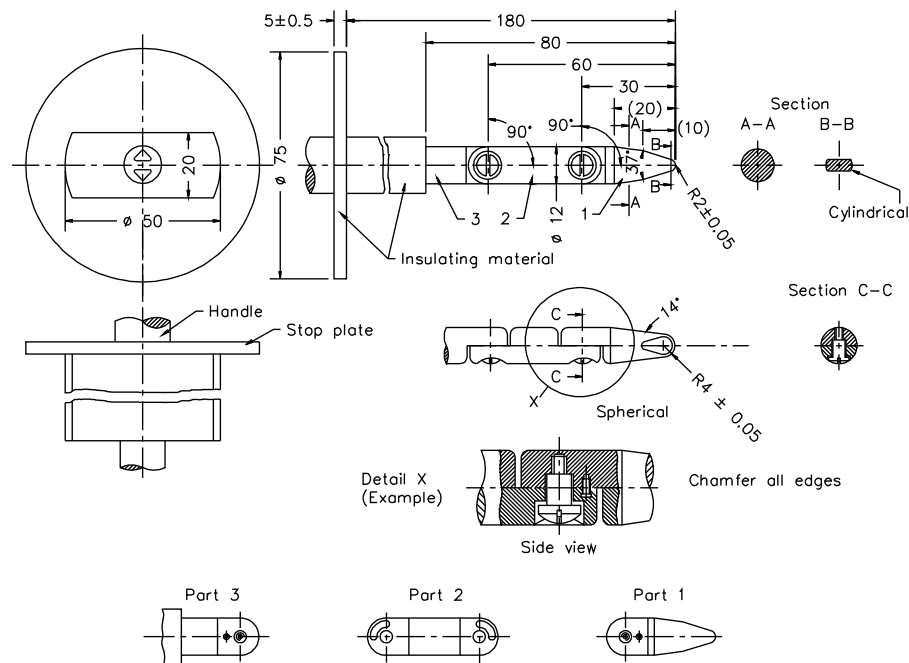
- a) Marked as required by 95.14; and
- b) Provided with instructions as specified in 97.4(s).

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 25.4 mm (1 inch), such a rotating part, live part or wire shall not be contacted by the probe illustrated in Figure 4.
- b) For an opening that has a minor dimension of 25.4 mm (1 inch) or more, such a part or wire shall be spaced from the opening as specified in Table 7.

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

Figure 4
Articulate probe



SA1788A

Table 7
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	
mm	(Inches)	mm	(Inches)
19.1 ^c	(3/4)	114.3	(4-1/2)
25.4 ^c	(1)	165.1	(6-1/2)
31.8	(1-1/4)	190.5	(7-1/2)
38.1	(1-1/2)	317.50	(12-1/2)
47.6	(1-7/8)	393.70	(15-1/2)
54.0	(2-1/8)	444.5	(17-1/2)
d	d	762.0	(30)

^a See 8.8.
^b Between 19.1 and 54.0 mm (3/4 and 2-1/8 inches), interpolation is to be used to determine a value between values specified in the table.
^c Any dimension less than 25.4 mm (1 inch) applies to a generator only.
^d More than 54.0 mm (2-1/8 inches) and not more than 152.4 mm (6 inches).

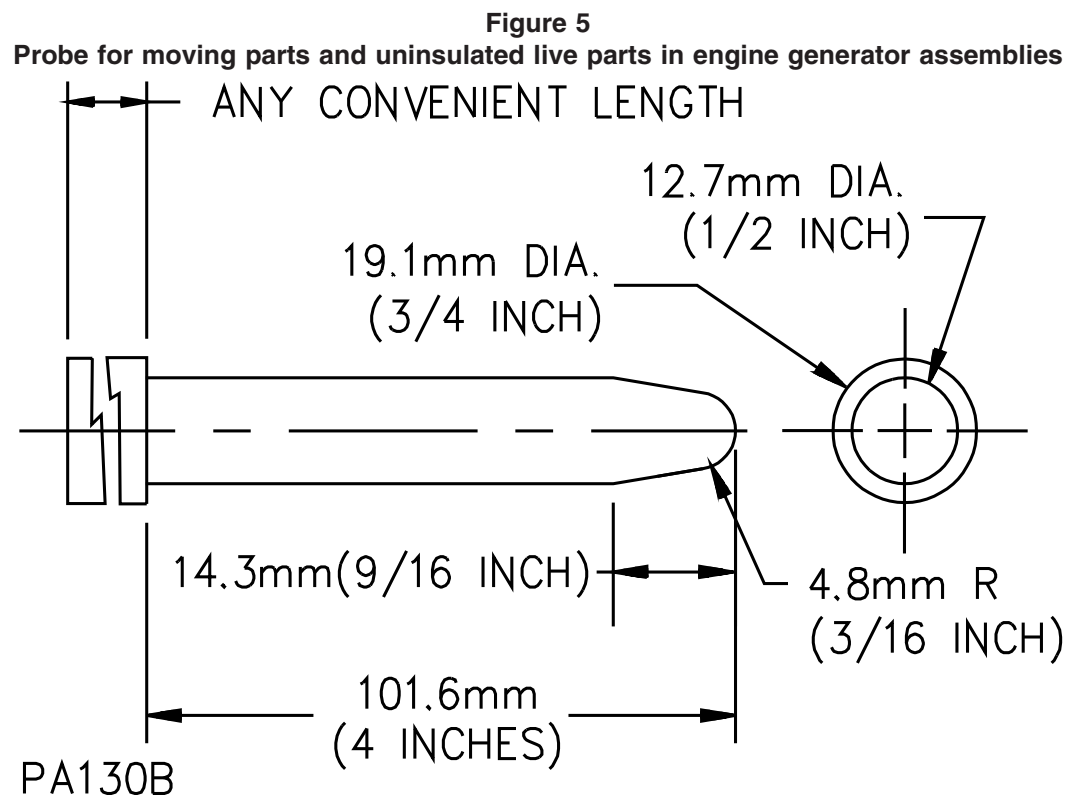
8.5 With respect to a part or wire as specified in 8.4, in an integral enclosure of a generator as specified in the Exception to 8.4:

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

1) A moving part is not contacted by the probe illustrated in Figure 5;

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- 2) Film-coated wire is not contacted by the probe illustrated in Figure 6;
 - 3) In a directly accessible generator (see 8.10), an uninsulated live part is not contacted by the probe illustrated in Figure 4; and
 - 4) In an indirectly accessible generator (see 8.9), an uninsulated live part is not contacted by the probe illustrated in Figure 5.
- b) An opening that has a minor dimension of 19.1 mm (3/4 inch) or more complies when a part or wire is spaced from the opening as specified in Table 7.

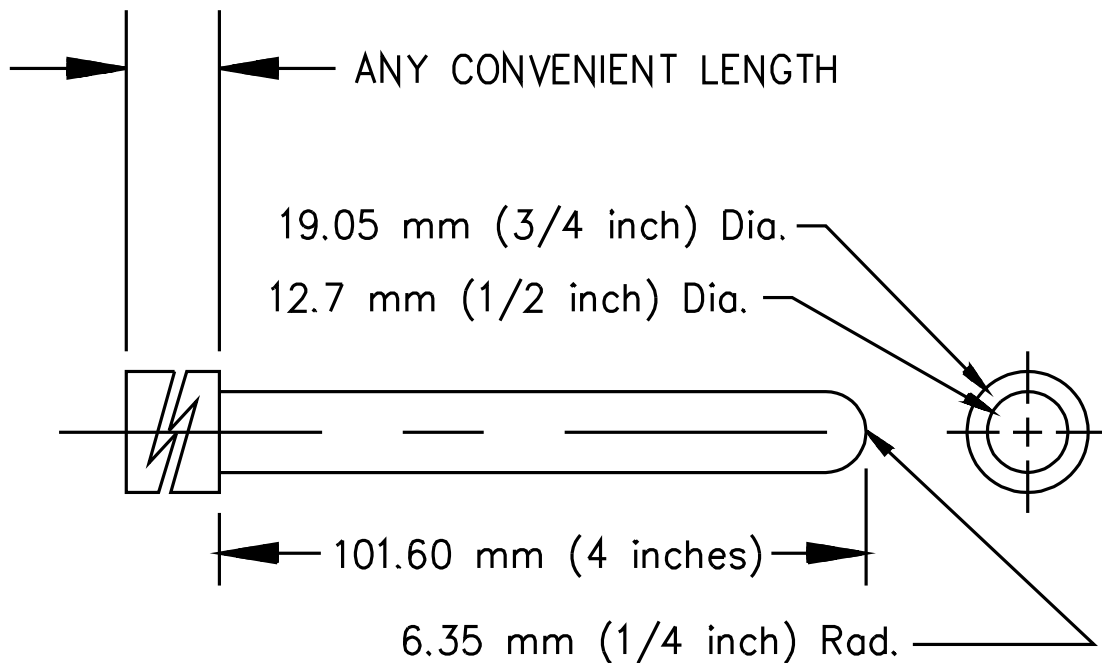


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Figure 6
Probe for film-coated wire in generators



PA140B

8.6 The probes specified in 8.4 and 8.5 and illustrated in Figures 4 – 6 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 4 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 4.4 N (1 pound).

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.

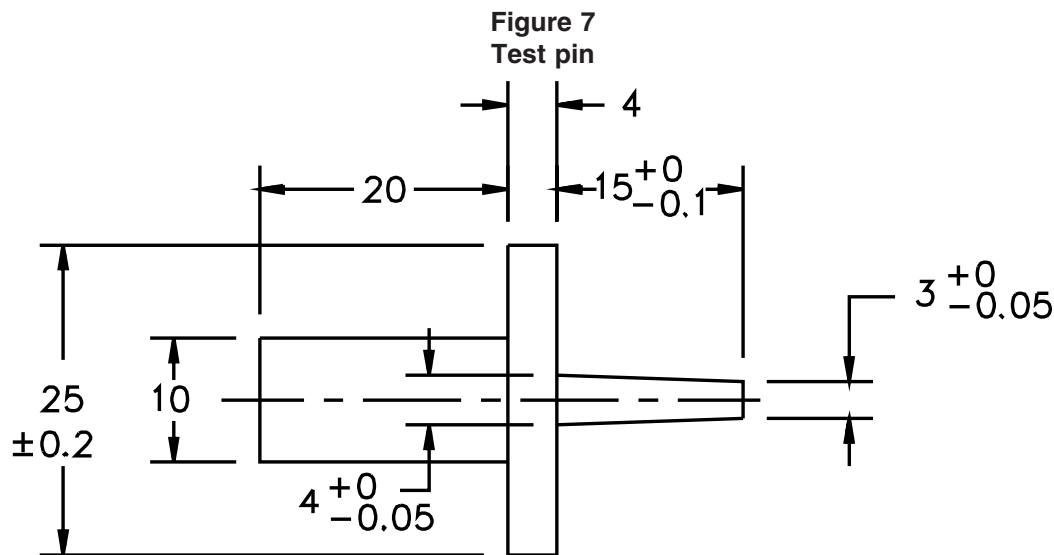
8.9 With reference to the requirements in 8.5, an indirectly accessible generator is a generator:

- 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 4.82);
- 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.

8.10 A directly accessible generator is a generator:

- a) That is contacted without opening or removing any part; and
- b) That is located so as to be accessible to contact.

8.11 The test pin illustrated in Figure 7, when inserted as specified in 8.6 through an opening in an enclosure, shall not touch any uninsulated live part that involves a risk of electric shock.



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Dimensions in millimeters

1 mm = 0.039 inch

8.12 The probe shown in Figure 4 and the test pin shown in Figure 7 are to be inserted as specified in 8.6 into all openings, including those in the bottom of the unit. The probe and test pin are to be inserted into all openings in the bottom that are accessible without tipping, turning over, or otherwise moving the unit from its intended installed position.

8.13 During the examination of a unit to determine whether it complies with the requirements in 8.4 or 8.5, a part of the enclosure that is opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, to give access to a fuse or other overload protective device as described in 7.6, or for other reasons) is to be opened or removed. A fastener, such as a slotted-head thumb screw, that is turned by hand, does not require the use of a tool.

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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 V in dry locations or 30 V in wet locations.

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 97.4.

8.18 Insulated and uninsulated medium voltage components and wiring shall not be accessible to the user. They shall be located behind bolted covers or interlocked doors that are not required to be opened by the user. See 7.9.2 and 7.9.3 with respect to accessibility of medium voltage parts when enclosures are ventilated.

9 Electric Shock

9.1 Voltage

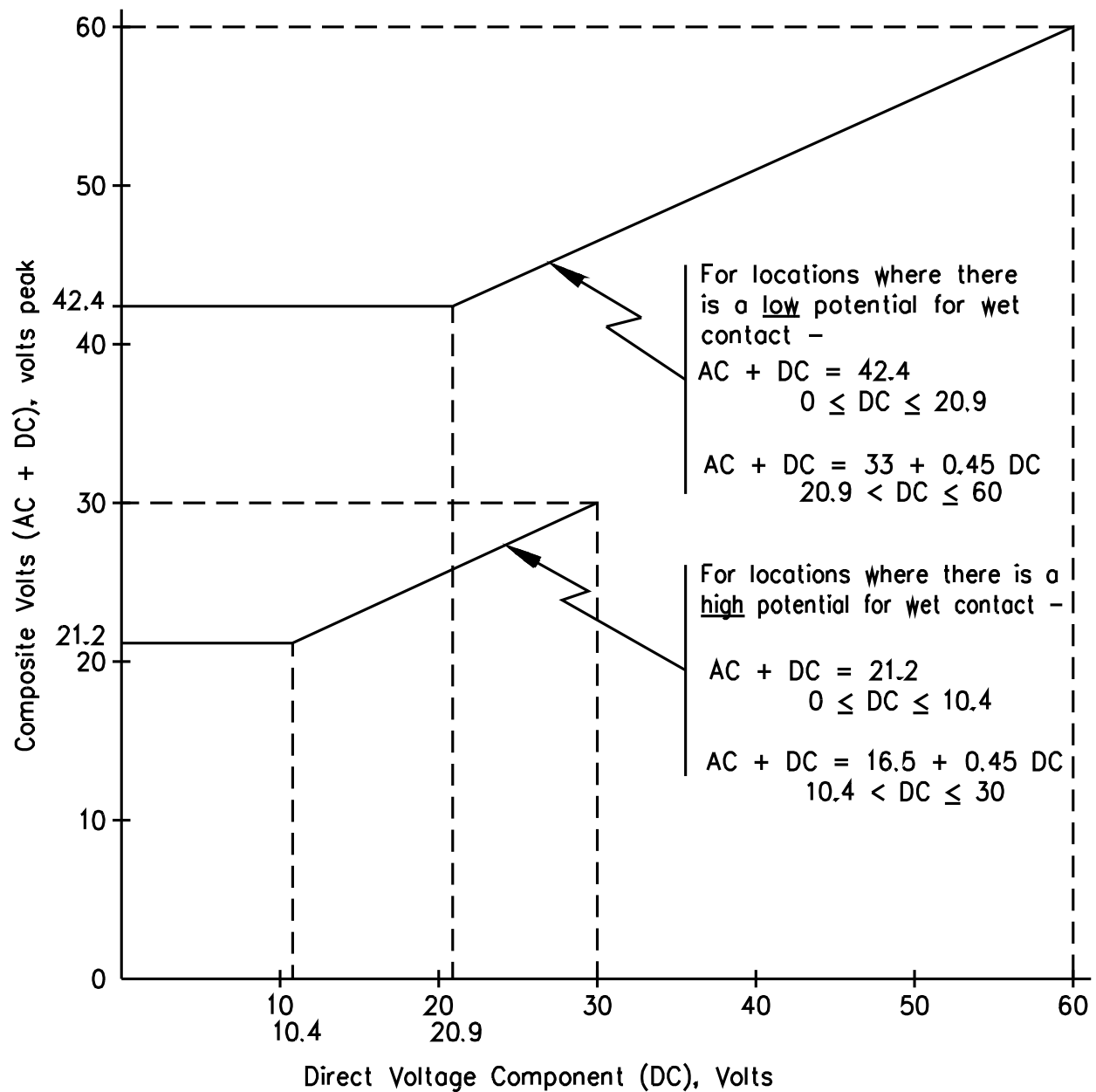
9.1.1 The requirements described in 9.1.2 and 9.2.2 are used to determine when the voltage of an accessible live part poses a risk for electric shock. Determination of whether a live part is accessible to users and service personnel is specified in Section 8, Protection of Users – Accessibility of Uninsulated Live Parts and Moving Parts – and User Servicing, and Section 41, 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 8.

Table 8
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. Non-sinusoidal, ac	42.4 V, peak	21.2 V, peak
3. Pure dc	42.4 ^a 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 8	See Figure 8
^a This value was reduced from 60 V to 42.4 V for consistency with the Canadian Electrical Code, Part I.		

Figure 8
Maximum voltage



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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 and Moving Parts – and User Servicing, and Section 41, Protection of Service Personnel, shall satisfy the following expressions:

$V < 40,000$	where $C < 0.00328$
$V < 729 C^{-0.7}$	where $0.00328 \leq C < 2.67$
$V < 367$	where $2.67 \leq C < 13.9$
$V < 2314 C^{-0.7}$	where $13.9 \leq C < 184.5$ in a DRY environment
$V < 60$	where $C \geq 184.5$ in a DRY environment
$V < 2314 C^{-0.7}$	where $13.9 \leq C < 497$ in a WET environment
$V < 30$	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, and the equation is shown graphically in Figure 9.

Table 9
Risk of electric shock – stored energy current

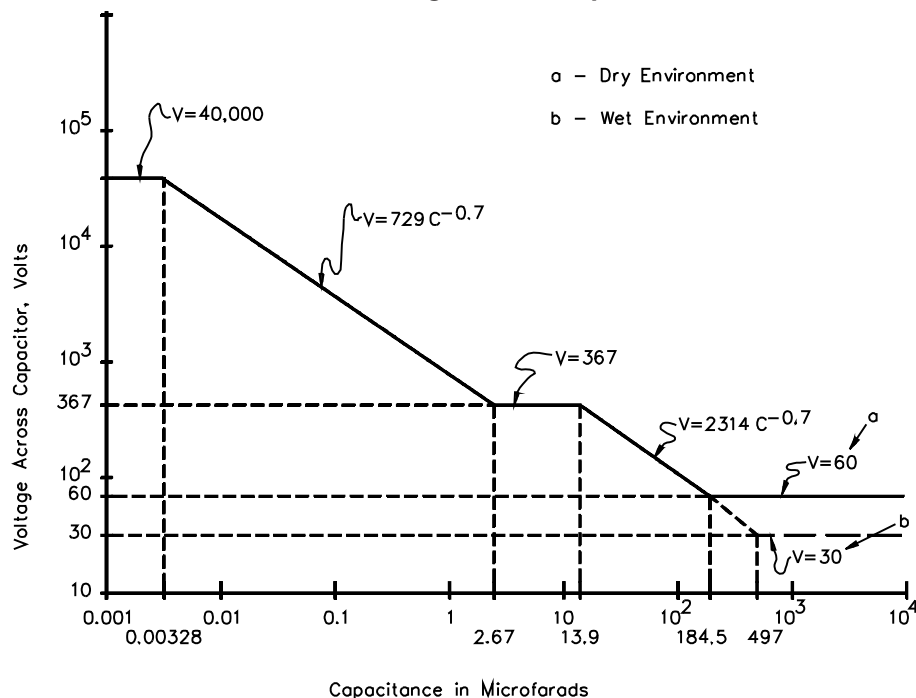
Environment	Capacitance, microfarads ^a	Maximum voltage across the capacitor, Volts
	0.00328 or less	40,000
	0.005	29,749
	0.01	18,313
	0.02	11,273
Wet or Dry	0.05	5,936
	0.1	3,654
	0.2	2,249
	0.5	1,184
	1.0	729
	2.0	449
	2.0	449
	2.67 to 13.9	367
	20.0	284
	50.0	150
	100.0	92.1
	184.5	60.0
Dry only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

Table 9 Continued

Environment	Capacitance, microfarads ^a	Maximum voltage across the capacitor, Volts
	497 or more	30.0

^a See 9.2.1 and Figure 9.

Figure 9
Limited for voltage across capacitance



S3260

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

10 Corrosion Protection

10.1 Sheet steel having a thickness of 3.05 mm (0.12 inch) or more that may be exposed to the weather shall be made corrosion-resistant by one of the following coatings:

- Hot-dipped mill-galvanized sheet steel conforming with the coating designation G60 or A60 in ASTM A653, with not less than 40 percent of the zinc on any side, based on the minimum single spot-test requirement in this ASTM specification. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with ASTM A90.
- A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.010 mm (0.00041 inch) on each surface with a minimum thickness of 0.009 mm (0.00034 inch). The thickness of the coating shall be established by the Metallic Coating Thickness Test of 103.3.

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c) An organic or inorganic protective coating system on both surfaces, applied after forming. The results of an evaluation of the coating system shall demonstrate that it provides protection at least equivalent to that provided by the zinc coating described in 102.12(a). See 7.6, Nonmetallic enclosures, and 103.6, Corrosive atmosphere test.

d) Any one of the means specified in 102.12.

10.2 Sheet steel having a thickness of less than 3.05 mm (0.12 inch) which may be exposed to the weather shall be made corrosion-resistant by one of the following coatings:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G90 in ASTM A653, with not less than 40 percent of the zinc on any side, based on the minimum single spot-test requirement in this ASTM specification. The weight of zinc coating may be determined by any acceptable method; however, in case of question, the weight of coating shall be established in accordance with ASTM A90.

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.015 mm (0.00061 inch) on each surface with a minimum thickness of 0.014 mm (0.00054 inch). The thickness of the coating shall be established by the Metallic Coating Thickness Test of 103.3. An annealed coating shall also comply with 102.15.

c) A cadmium coating not less than 0.025 mm (0.0010 inch) thick on both surfaces. The thickness of the coating shall be established by the Metallic Coating Thickness Test of 103.3.

d) A zinc coating conforming with 102.11 (a) or (b) with one coat of outdoor paint. The coating system shall comply with 102.13.

e) A cadmium coating not less than 0.019 mm (0.00075 inch) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.013 mm (0.00051 inch) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established by the Metallic Coating Thickness Test of 103.3 and the coating system shall comply with 102.12.

10.3 With reference to 102.12 (d) and (e), the results of an evaluation of the coating system shall demonstrate that it provides protection at least equivalent to that provided by the zinc coating as described (G90) in 102.12(a). See 7.6, Nonmetallic enclosures, and 103.6, Corrosive atmosphere test.

10.4 With reference to 102.11 and 102.12, other finishes, including paints, other metallic finishes, and combinations of the two may be accepted when comparative tests with galvanized sheet steel (without annealing, wiping, or other surface treatment) conforming with 102.11 or 102.12(a) as applicable, indicate they provide equivalent protection. See 103.6, Corrosive atmosphere test.

10.5 An annealed coating on sheet steel that is bent or similarly formed or extruded or rolled at edge of holes after annealing shall additionally be painted in the bent or formed area if the bending or forming process damages the zinc coating. If flaking or cracking of a zinc coating at the outside radius of a bent or formed section is visible at 25 power magnification, the zinc coating is considered damaged.

10.6 Simple sheared or cut edges and punched holes are not required to be additionally protected.

10.7 Iron or steel serving as a necessary part of the product but not exposed to the weather shall be plated, painted, or enameled for protection against corrosion.

10.8 Aluminum, stainless steel, and polymeric materials may be used without corrosion-resistant coatings or plating.

10.9 Aluminum shall comply with 10.1(c) in a coastal environment and when in direct contact with a concrete mounting pad.

10.10 Materials not specifically mentioned in this Section shall be evaluated on an individual basis. The tests described in 7.6, Nonmetallic enclosures, and 103.6, Corrosive atmosphere test, may be used for the evaluation.

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, nuts, bolts, and fittings with properly applied thread locking compounds, lock washers, safety wire (locking-wire), screws, nuts and bolts 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 (distorted thread locknut).

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 Control Devices

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 or VA rating.

Exception: This requirement does not apply to engine mounted starter solenoids.

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

12.6 A 240 V or 250 V snap switch used in a circuit involving more than 120 V 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:

- a) The grounded conductor is disconnected by a switch that simultaneously disconnects all conductors of the circuit.
- b) 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 CSA C22.2 No. 178.1 / UL 1008.

12.9 Mechanical and electromechanical switches shall comply with the applicable requirements for switches in CSA C22.2 No. 111 / UL 20, CSA C22.2 No. 14 / 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.

Exception: 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 CSA C22.2 No. 100 / UL 1004-4.