



# UL 1776

## STANDARD FOR SAFETY

### High-Pressure Cleaning Machines

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UL Standard for Safety for High-Pressure Cleaning Machines, UL 1776

Third Edition, Dated June 7, 2002

### **SUMMARY OF TOPICS**

***This revision to ANSI/UL 1776 dated October 19, 2023, includes a correction to markings for three-phase products; [113.5.4](#).***

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated August 11, 2023.

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**UL 1776**

**Standard for High-Pressure Cleaning Machines**

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**June 7, 2002**

This ANSI/UL Standard for Safety consists of the Third Edition including revisions through October 19, 2023.

The most recent designation of ANSI/UL 1776 as an American National Standard (ANSI) occurred on October 19, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 1776 on August 23, 2000. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in ULSE's Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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**APPENDIX A**

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**APPENDIX B Rechargeable Battery-Powered Machines (Normative)**

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## INTRODUCTION

### 1 Scope

1.1 These requirements cover portable, stationary, and fixed high-pressure cleaning machines in which the discharge line is hand supported and manipulated, and intended for household, farm, or commercial/industrial applications.

1.2 The electrical products covered by these requirements are intended for use in ordinary locations and for connection to branch circuits rated 600 volts or less in accordance with the National Electrical Code, NFPA 70.

1.2.1 These requirements also cover portable rechargeable battery-powered high pressure cleaning machines for indoor or outdoor use with rechargeable non-user and user-replaceable batteries; see Appendix B.

1.3 These requirements do not cover:

- a) High-pressure water cutting or cleaning products developing nozzle pressure and flow rates in excess of those for a Type 4 pressure cleaning machine as specified in [2.2.33A](#),
- b) Products employing universal motors rated more than 250 volts,
- c) Sand blasters or other products using cleaning solutions containing insoluble particulates,
- d) Products that develop steam within a heated vessel or are connected to an external source of steam, and
- e) Carpet cleaners, dishwashers, clothes-washing machines, water-picks, and other products that are covered under separate requirements.

1.4 A coin-operated product is investigated under these requirements and under such additional requirements as are applicable to the product under consideration.

### 2 Glossary

#### 2.1 General

2.1.1 For the purpose of this standard, the following definitions apply.

#### 2.2 All products

2.2.1 ALUMINUM COATED STEEL – An aluminum coated steel in which the bond between the steel and the aluminum is an iron-aluminum alloy.

2.2.2 AUTOMATICALLY CONTROLLED PRODUCT – A product is considered to be automatically controlled if:

- a) The repeated starting of the product, beyond one complete predetermined cycle of operation to the point where some form of operating control opens the circuit, is independent of any manual control;
- b) During any single predetermined cycle of operation, the motor is caused to stop and restart one or more times;

c) Upon energizing the product, the initial starting of the motor may be intentionally delayed beyond normal, conventional starting; or

d) During any single predetermined cycle of operation, automatic changing of the mechanical load may reduce the motor speed sufficiently to reestablish starting-winding connections to the supply circuit.

2.2.3 BASE – The main supporting frame or structure of the assembly, exclusive of legs or wheels.

2.2.4 BYPASS (UNLOADER or PRESSURE REGULATING) VALVE – A valve used on the discharge side of a pump that will open automatically at a predetermined differential pressure so as to direct part or all of the pump discharge back to the supply tank or pump inlet. It may be provided as part of a pump assembly, or it may be a separate valve that is piped into the pump discharge system at the time of installation. The valve may be manually set in a partially opened position to control flow through a nozzle or pressure at a nozzle.

2.2.5 COMBUSTIBLE MATERIAL – Material made of or surfaced with wood, compressed paper, plant fibers, or other material that will ignite and burn. Such material shall be considered as combustible even though flameproofed, fire-retardant treated, or plastered.

2.2.6 CONTROL, LIMIT – A safety control responsive to changes in liquid level, pressure, or temperature, normally set beyond the intended operating range of the product to limit its operation.

2.2.7 CONTROL, REGULATING (OPERATING) – A control, other than a safety control or interlock.

2.2.8 CONTROL, SAFETY – Automatic controls, including relays, switches, and other auxiliary devices used in conjunction therewith to form a safety control system, that will reduce the risk of fire, electric shock, or injury to persons during operation of the product.

2.2.9 DIFFERENTIAL PRESSURE – The difference in pressure, measured at the discharge port, between the value obtained with the product operating and after shutdown.

2.2.10 ELECTRICAL CIRCUITS –

a) HIGH-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

b) LOW-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 30 volts alternating current (42.4 peak) or direct current and supplied by a primary battery or by a standard Class 2 transformer or by a combination of a transformer and a fixed impedance having output characteristics in compliance with what is required for a Class 2 transformer. A circuit derived from a source of supply classified as a high-voltage circuit, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit.

c) SAFETY-CONTROL CIRCUIT – A circuit involving one or more safety controls.

2.2.11 GUN – A hand-held mechanical device used to control and direct cleaning fluid flow.

2.2.12 HANDLES –

a) GUIDING HANDLE – The handle by which the operator supports the least percentage of product weight when the product is in use, transported, or both. This includes the handle of a hand-supported nozzle, lance, or wand.

- b) SUPPORT HANDLE – The handle by which the operator supports the greatest percentage of product weight when the product is in use, transported, or both. This includes the handle of a pushcart mounted product, or any handle used to transport the product.
- 2.2.13 HAZARDOUS FLUID – A gas or liquid considered to be highly corrosive or toxic, for example, a strong acid or alkali, ammonia, or perchlorethylene.
- 2.2.14 HORSEPOWER, HYDRAULIC – A measure of hydraulic power developed by a product and calculated by multiplying the flow rate (gpm) by the fluid pressure (psig) as measured at the discharge nozzle and dividing by the constant 1714.
- 2.2.15 INJECTION, SKIN – A puncture of human skin caused by exposure to high-pressure liquid or air.
- 2.2.16 INTERLOCK – A switch or control intended to monitor the physical state of a required condition and to furnish an indication of that state to a safety-control circuit by means of a switch contact closure.
- 2.2.17 LANCE – Tubing or piping used to extend the nozzle.
- 2.2.18 MAXIMUM GOVERNED SPEED – The maximum speed an engine is capable of attaining as limited by a governor or other means, and set by the manufacturer of the engine.
- 2.2.19 NORMAL USE AND MAINTENANCE – Those actions performed in application of the product to its intended purpose, or for the product's continued operation, in accordance with the use and care instructions provided by the manufacturer with each product.
- 2.2.20 NOZZLE – A device with one or more openings for discharge of the fluid from the system. A nozzle restricts the fluid flow in order to obtain the desired pressure, velocity, spray patterns, and the resulting volume of flow.
- 2.2.21 NOZZLE CONTROL – The portion of a system controlling discharge of solution from the nozzle at the discretion of the operator. The flow of solution from the pump may be stopped, bypassed, or diverted to accomplish nozzle control.
- 2.2.22 PRODUCT, FIXED – A product intended to be electrically connected in a permanent manner.
- 2.2.23 PRODUCT, PORTABLE – A product provided with a length of flexible cord and an attachment plug for connection to the power supply and capable of being carried or conveyed, or that is not capable of being carried, but is mounted on wheels and can be readily moved. This does not include products which are intended to be fastened in place or located in a dedicated space.
- 2.2.24 PRODUCT, REMOTELY CONTROLLED – A product that is out of the sight of the operator who is at the starting device.
- 2.2.25 PRODUCT, STATIONARY – A cord-connected product that is intended to be fastened in place or located in a dedicated space.
- 2.2.26 RATED PRESSURE – The minimum and maximum operating pressures recommended by the manufacturer of the product.
- 2.2.27 READILY ACCESSIBLE – Capable of being reached easily and quickly for operation or adjustment without the use of a tool.

2.2.28 REGULATED PRESSURE – The minimum and maximum operating pressures obtainable by adjustment of the pressure-regulating valve.

2.2.29 RELIEF SYSTEM – An automatic pressure-actuated device or system used to relieve excess pressure.

2.2.30 RELIEF VALVE – A valve that will open at a predetermined differential pressure to limit the pressure developed in the system. The valve may relieve to atmosphere.

2.2.31 TYPE 1 PRESSURE CLEANING MACHINE – A machine developing fluid pressure of 100 psig (690 kPa) or less as measured at the discharge nozzle.

2.2.32 TYPE 2 PRESSURE CLEANING MACHINE – A cleaning machine developing hydraulic horsepower not greater than 8 horsepower and fluid pressure greater than 100 psig (0.69 MPa), but not greater than 3200 psig (22.06 Mpa), as measured at the discharge nozzle.

2.2.33 TYPE 3 PRESSURE CLEANING MACHINE – A cleaning machine developing hydraulic horsepower greater than 8 horsepower or fluid pressure greater than 3200 psig (22.06 MPa) as measured at the discharge nozzle. However, the cleaning machine shall not develop hydraulic horsepower greater than 23 horsepower or fluid pressure greater than 5000 psig (34.48 MPa) in any case.

2.2.33A TYPE 4 PRESSURE CLEANING MACHINE – A cold-water cleaning machine not equipped with an electric or fuel fired heat exchanger, developing hydraulic horsepower greater than 23 horsepower or fluid pressure greater than 5000 psig (35 MPa). However, the cleaning machine shall not develop fluid pressure greater than 30,000 psig (206.8 MPa) in any case.

2.2.34 THERMOSTAT – An automatic control that is actuated by temperature change in order to maintain temperatures between predetermined limits.

2.2.35 VALVE, LUBRICATED-PLUG TYPE – A valve of the plug and barrel type constructed for maintaining a lubricant between the bearing surfaces.

2.2.36 WAND – Tubing or piping used to extend the nozzle. A wand is similar to a lance, but usually constructed of a lighter material.

### 2.3 Fuel-fired products

2.3.1 AIR SHUTTER – An adjustable device that varies the size of the air inlet, or inlets, regulating primary or secondary air.

2.3.2 AIR SHUTTER, AUTOMATICALLY OPERATED – An air shutter operated by an automatic control.

2.3.3 AIR SHUTTER, MANUALLY OPERATED – An air shutter that is manually set and locked in the desired position.

2.3.4 ANTIFLOODING DEVICE – A primary-safety control that causes the fuel flow to be shut off upon a rise in fuel level or upon receiving excess fuel, and that operates before the unintended discharge of fuel can occur.

### 2.3.5 BURNER

a) AUTOMATICALLY-LIGHTED – A burner in which fuel to the main burner is turned on and ignited by action of the automatic control.

- b) GAS – A device for the final conveyance of the gas, or a mixture of gas and air, to the combustion zone.
- c) MANUALLY-LIGHTED – One in which fuel to the main burner is turned on only by hand and ignited under supervision.
- d) MECHANICAL-ATOMIZING TYPE – A power-operated burner that prepares and delivers the oil and all or part of the air by mechanical process in controllable quantities for combustion. Some examples are air and steam atomizing, high- and low-pressure atomizing, horizontal rotary, vertical rotary atomizing, and vertical rotary wall-flame burners.
- e) MECHANICAL-DRAFT TYPE – A burner that includes a power-driven fan, blower, or other mechanism as the principal means for supplying air for combustion.
- f) NATURAL-DRAFT TYPE – A burner that depends principally upon the natural draft created in the flue to induce into the burner the air required for combustion.
- g) VAPORIZING TYPE – A burner consisting of an oil-vaporizing bowl or other receptacle to which liquid fuel may be fed in controllable quantities; the heat of combustion being used to vaporize the fuel, with provision for admitting air and mixing it with the oil vapor in combustible proportions.
- 2.3.6 BURNER HEAD, GAS – That portion of a burner beyond the outlet end of the mixer tube that contains the ports.
- 2.3.7 COMBUSTION – The rapid oxidation of fuel accompanied by the production of heat, or heat and light. Complete combustion of a fuel is possible only in the presence of an adequate supply of oxygen.
- 2.3.8 COMBUSTION CHAMBER – The portion of a product in which combustion occurs.
- 2.3.9 COMBUSTION DETECTOR – That part of a primary-safety control that is responsive directly to flame properties.
- 2.3.10 COMBUSTION PRODUCTS – Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inerts, but excluding excess air.
- 2.3.11 CONDENSATE – The liquid that separates from a gas, including flue gases, due to a reduction in temperature.
- 2.3.12 CONSTANT-LEVEL VALVE – A device for a constant level of fuel within a reservoir for delivery to the burner.
- 2.3.13 CONTROL INPUT, COMBUSTION – A control that automatically regulates the firing rate at predetermined air-fuel ratio in accordance with load demand. It may be a type that positions the air and fuel supplies for low fire and for high fire as required to meet the load demands, or it may be a modulating type that gradually varies the air and fuel supplies within limits to meet the load demand.
- 2.3.14 CONTROL, PRIMARY SAFETY, COMBUSTION SAFEGUARD – A control that responds directly to flame properties, sensing the presence of flame and, in event of ignition failure or unintentional flame extinguishment, causing safety shutdown.
- 2.3.15 CONTROL, PRIMARY SAFETY – The automatic safety control intended to prevent abnormal discharge of fuel at the burner in case of ignition failure or flame failure.
- 2.3.16 EXCESS AIR – Air that passes through the combustion chamber and the product flues in excess of that theoretically required for complete combustion.

2.3.17 **FLAMMABLE FLUID** – A gas or liquid considered to be flammable or combustible, such as acetylene, petroleum base hydraulic oil, fuel oil, gasoline, kerosene, or similar petroleum product, liquefied-petroleum gas (LP-Gas), or manufactured or natural fuel gas.

2.3.18 **FLUE COLLAR** – The portion of a product that is constructed for attachment of the chimney or vent connector.

2.3.19 **FLUE GASES** – Combustion products and excess air.

2.3.20 **FUEL OIL** – Any hydrocarbon oil as defined by Specifications for Fuel Oils, ANSI/ASTM D396-80.

2.3.21 **GAS VENT** – The piping and fittings for conveying flue gases to the outside atmosphere.

2.3.22 **HEAT EXCHANGER, DIRECT** – A heat exchanger in which heat generated in the combustion chamber of the product is transferred directly through walls of the heat exchanger to the heating medium such as steam or water, held in close contact with the combustion-chamber walls. It is a self-contained combustion and heat-transfer device.

2.3.23 **HEAT EXCHANGER, INDIRECT** – A heat exchanger that encloses or contains a heating medium such as steam or water, the heat from which is transferred to another heating medium separately contained in close contact with or directed through the heat exchanger.

2.3.24 **HEATING SURFACES** – All surfaces that transmit heat directly from flame or flue gases to the medium to be heated.

2.3.25 **IGNITION, CONTINUOUS** – Ignition by an energy source that is continuously maintained throughout the time the burner is in service, whether the main burner is firing or not.

2.3.26 **IGNITION, INTERMITTENT** – Ignition by an energy source that is continuously maintained throughout the time the burner is firing.

2.3.27 **IGNITION, INTERRUPTED** – Ignition by an energy source that is automatically energized each time the main burner is fired and subsequently is automatically shut off during the firing cycle.

2.3.28 **IGNITION, MANUAL** – Ignition by an energy source that is manually energized and where the fuel to the pilot is lighted automatically when the ignition system is energized.

2.3.29 **LINING, COMBUSTION CHAMBER** – The interior surfaces of a combustion chamber that are exposed to combustion during use of the product.

2.3.30 **LIQUEFIED-PETROLEUM GAS (LP-GAS)** – Fuel gases, including commercial propane, predominantly propane or propylene or commercial butane, predominantly butane, isobutane, and butylene, or both.

2.3.31 **LP-GAS AIR MIXTURE** – Liquefied-petroleum gases distributed at relatively low pressures and normal atmospheric temperatures that have been diluted with air to produce desired heating value and utilization characteristic.

2.3.32 **MAIN BURNER FLAME-ESTABLISHING PERIOD** – The interval of time the main burner fuel safety-shutoff valves are permitted to be open before the primary-safety control is required to supervise the main burner flame.

2.3.33 **MANIFOLD, GAS BURNER** – The conduit of a product that supplies gas to the individual burner.

2.3.34 MIXER, GAS – The combination of mixer head, mixer throat, and mixer tube.

a) MIXER HEAD – That portion of an injection type burner, usually enlarged, into which primary air flows to mix with the gas stream.

b) MIXER THROAT – That portion of the mixer that has the smallest cross-sectional area and that lies between the mixer head and the mixer tube.

c) MIXER TUBE – That portion of the mixer that lies between the throat and the burner head.

2.3.35 MIXER FACE, GAS – The air inlet end of the mixer head.

2.3.36 ORIFICE – The opening in a cap, spud, or other device whereby the flow of gas is limited and through which the gas is discharged to a burner.

2.3.37 ORIFICE CAP (HOOD) – A movable fitting having an orifice that permits adjustment of the flow of gas by the changing of its position with respect to a fixed needle or other device.

2.3.38 ORIFICE SPUD – A removable plug or cap containing an orifice that permits adjustment of the flow of gas either by substitution of a spud with a different sized orifice or by the motion of a needle with respect to it.

2.3.39 PILOT – A flame that is utilized to ignite the fuel at the main burner or burners.

2.3.40 PILOT, CONTINUOUS – A pilot that burns without turndown throughout the entire time the burner assembly is in service, whether the main burner is firing or not.

2.3.41 PILOT FLAME-ESTABLISHING PERIOD – The length of time fuel is permitted to be delivered to a proved pilot before the flame-sensing device is required to detect pilot flame.

2.3.42 PILOT, EXPANDING – A pilot that burns at a low turndown throughout the entire time the burner is in service whether the main burner is firing or not. Upon a call for heat, the pilot is automatically expanded so as to ignite the main burner as intended. This pilot may be turned down at the end of the trial-for-ignition period for the main burner.

2.3.43 PILOT, INTERMITTENT – A pilot that is automatically lighted each time there is a call for heat. The pilot burns during the entire period that the main burner is firing.

2.3.44 PILOT, INTERRUPTED – A pilot that is automatically lighted each time there is a call for heat. The pilot fuel is cut off automatically at the end of the main burner flame-establishing period.

2.3.45 PILOT, PROVED – A pilot flame supervised by a primary-safety control that senses the presence of the pilot flame prior to permitting the main burner fuel to be delivered for combustion.

2.3.46 PRIMARY AIR – The air introduced into a burner that mixes with the fuel before it reaches the ignition zone.

2.3.47 PRODUCT, FLUE – The flue passages within a product.

2.3.48 PUMP, AUTOMATIC OIL – A pump, not an integral part of a burner, that automatically pumps oil from the supply tank and delivers the oil by gravity under a constant head to an oil-burning product. The pump is intended to stop pumping automatically in case of total breakage of the oil-supply line between the pump and the product.

2.3.49 PUMP, OIL-TRANSFER – An oil pump, automatically or manually operated, that transfers oil through continuous piping from a supply tank to an oil-burning product or to an auxiliary tank, and that is not intended to stop pumping automatically in case of total breakage of the oil supply line between the pump and the product.

2.3.50 PURGE – To introduce air into the combustion chamber and the product flue passages in such volume and manner as to completely replace the air or gas-air mixture contained therein.

2.3.51 RADIATION SHIELD – A separate panel or panels interposed between heating surfaces and adjacent objects to reduce heat transmission by radiation.

2.3.52 REGULATOR, GAS-PRESSURE – A device for controlling and maintaining a uniform outlet gas pressure.

2.3.53 RESPONSE TIME – FLAME FAILURE – The interval between the occurrence of flame extinguishment and de-energizing the safety shutoff means.

2.3.54 SAFETY SHUTDOWN – The action of shutting off all fuel and ignition energy to the product by means of a safety control or controls such that restart cannot be accomplished without manual reset.

2.3.55 SECONDARY AIR – The air externally supplied to the flame at or beyond the point of ignition.

2.3.56 STRAINER, PRIMARY – The strainer through which all oil first passes on way to burner, being upstream from any other strainer.

2.3.57 STRAINER, SECONDARY – A strainer downstream from the primary strainer, interposed in the fuel line between the primary strainer and the point at which fuel is delivered for combustion.

2.3.58 TRIAL-FOR-IGNITION PERIOD – That period of time the main burner fuel is permitted to be delivered into the ignition zone before the main flame-sensing device is required to detect main flame.

2.3.59 VALVE, BURNER-INPUT CONTROL – An automatic-control valve for regulating the input of fuel to a burner.

2.3.60 VALVE, MANUAL FUEL SHUTOFF – A manually operated valve in the fuel line for the purpose of completely turning on or shutting off the fuel supply.

2.3.61 VALVE, FUEL CONTROL – An automatically or manually operated device for controlling the fuel supply.

a) METERING (REGULATING) VALVE – A fuel control valve for regulating burner input.

b) SAFETY VALVE – A normally closed valve of the on and off type, without any bypass to the burner, that is actuated by a safety control or by an emergency device.

2.3.62 VALVE, SAFETY SHUTOFF – A valve that is automatically closed by the safety control system or by an emergency device. Such valve may be of the automatic or manually opened type.

2.3.63 ZERO GOVERNOR – A regulating device that is normally adjusted to deliver gas at atmospheric pressure within its flow rating.

### 3 Components

3.1 Except as indicated in [3.2](#), a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

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

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

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

3.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

### 4 Units of Measurement

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

#### 4A Undated References

4A.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.

4A.2 The following publications are referenced in this Standard:

ASTM E1575, *Standard Practice for Pressure Water Cleaning and Cutting*

EN 1829-1, *High pressure water jet machines – Safety requirements – Part 1: Machines*

EN 1829-2, *High pressure water jet machines – Safety requirements – Part 2: Hoses, hose lines and connectors – incorporating corrigendum*

### 5 Accessories

5.1 A functional accessory that is made available or recommended by the manufacturer for use with a product shall be included in the investigation of the product.

### 6 Instructions

6.1 Operating and installation instructions, or equivalent information, shall be provided with each product. These instructions are to be used as a guide in the examination and test of the product and for this purpose a final-printed edition is not required.

6.2 The instructions shall include such directions and information as deemed necessary by the manufacturer for the proper installation, maintenance, and use of the product. See Instruction Manual, Sections [114](#) – [117](#).

## CONSTRUCTION – ALL PRODUCTS

### 7 Assembly

7.1 A product shall include all of the components necessary for its intended function and installation, and shall be furnished as a complete assembly. The product may be shipped as two or more subassemblies.

7.2 The product shall be constructed so that parts can be reassembled in the intended manner after being dismantled to the extent needed for user servicing.

7.3 A product shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it may be subjected in normal use, without increasing the risk of fire, electric shock, or injury to persons due to total or partial collapse, loosening or displacement of parts, malfunction of components, or other serious defects.

7.4 A product, if not assembled by the manufacturer as a unit, shall be arranged in major subassemblies. Incorporation of a subassembly into the final assembly shall not require alteration, cutting, drilling, threading, welding, or similar tasks by the installer. Two or more subassemblies that must bear a definite relationship to each other for the intended installation or operation of the product shall be arranged and constructed so that they may be incorporated into the complete assembly only in the correct relationship with each other and without need for alteration or alignment, or such subassemblies shall be assembled, tested, and shipped from the factory as one unit.

7.5 With reference to [7.4](#), portions of a product considered to constitute major subassemblies are:

- a) Heat exchanger, including its base, heating chamber, casing, and safety controls;
- b) Burner or heating element;
- c) Pump; and
- d) Engine or motor not included as part of the pump.

7.6 A product intended to be mounted on a wall or ceiling shall be provided with means to facilitate installation in accordance with the instructions provided by the manufacturer. Any specific parts needed to accomplish installation shall be provided with the product.

7.7 A radiation shield or baffle employed to prevent temperatures in excess of those intended shall be:

- a) Assembled as part of the product,
- b) Part of a subassembly that must be attached to the product for its intended operation, or
- c) Constructed so that the machine cannot be assembled for operation without first attaching a required shield or baffle in its intended position.

### 8 Materials

#### 8.1 General

8.1.1 A part in contact with the fluid to be handled shall be resistant to the action of the fluid if malfunction of the part will result in a risk of injury to persons.

## 8.2 Fluid-confining parts

8.2.1 Fluid-confining and operating parts of a product that may malfunction so as to allow leakage or introduce a risk of injury to a person, shall have the strength and durability to permit normal operation of the parts and the assembly.

8.2.2 With reference to the requirements in [8.2.1](#), a material of a fuel-confining or operating part shall have a melting point (solidus temperature) of not less than 510°C (950°F) and a tensile strength of not less than 10,000 psig (69 MPa) at 204°C (400°F).

*Exception: This requirement does not apply to a valve disc or soft seat, an epoxy seal, a seal ring, a diaphragm, or a gasket.*

8.2.3 A brazing material used for joining fluid-confining parts for LP-Gas service shall have a melting point (solidus temperature) of not less than 538°C (1000°F).

## 8.3 Nonmetallic materials

8.3.1 Among the factors to be considered when judging the acceptability of a nonmetallic material are mechanical strength, resistance to impact, moisture absorption, combustion, and distortion at temperatures to which the material is to be subjected under conditions of normal use. All these factors are to be evaluated with respect to aging. See [11.6](#).

8.3.2 A nonmetallic enclosure, frame, guard, or similar parts, in which breakage or deterioration may result in a risk of injury to persons shall comply with the requirements for Enclosures and Guards, Section [49](#).

8.3.3 A nonmetallic fuel tank shall comply with the requirements for fuel tanks specified in [104.3.1](#) – [104.6.3](#), as applicable.

## 8.4 Requirements for hose assemblies of Type 4 cleaning machines

### 8.4.1 Mechanical requirements

8.4.1.1 All parts of a hose assembly as well as the connectors and the hose itself shall not fail under the burst pressure specified by the manufacturer.

8.4.1.2 For hose assemblies with maximum allowable working pressure between 5000 psig (35 Mpa) and 30,000 psig (206.8 MPa) the burst pressure shall be at least 2.5 times the maximum allowable working pressure. Compliance is determined by the Burst Pressure Test of 66A.3.

### 8.4.2 Thermal requirements for hose assemblies of Type 4 cleaning machines

8.4.2.1 The hose shall be suitable for operating temperatures above -10 °C and below +70 °C. Compliance is determined by the Cold Bend Test of 66A.2.

### 8.4.3 Requirements for tensile strength of hose assemblies

8.4.3.1 The pressure hose shall withstand a tensile force equivalent to that generated by a pressure equal to 1.5 times the maximum allowable working pressure or 225 pound force (1000 N), whichever is lower. Compliance is determined by the Tensile Test of 66A.4.

## 8.4.4 Requirements for loosening of connectors

8.4.4.1 The design shall prevent unintended loosening of connectors while the hose assembly is under pressure. If adequate mechanical measures are not possible, the manufacturer shall provide appropriate warnings and instructions.

NOTE: For maximum allowable working pressure under 7250 psig (50 MPa), standard hydraulic connectors are considered to satisfy this requirement. Pin-lock nuts (swivel nuts which are fixed with a stainless steel pin) at connectors are only permissible up to 7250 psig (50 MPa) maximum allowable working pressure.

## 9 Protection Against Corrosion

9.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, painting, or other equivalent means, if corrosion of such unprotected parts could result in a risk of fire, electric shock, or injury to persons.

*Exception No. 1: Surfaces of sheet-steel and cast-iron parts within an enclosure may not be required to be protected against corrosion if the oxidation of the metal due to the exposure to air and moisture is not appreciable. The thickness of metal and temperature are also to be considered.*

*Exception No. 2: This requirement does not apply to bearings, laminations, or minor parts of iron or steel, such as washers, screws, and similar parts.*

9.2 If deterioration of a liquid container provided as a part of a product would result in a risk of fire or electric shock, the container shall be of a material that is resistant to corrosion by the liquid intended to be used therein.

9.3 Metals and alloys shall not be used in combinations that cause galvanic action that can cause deterioration or corrosion of cabinets or enclosures.

9.4 Hinges and other attachments shall be resistant to corrosion or protected as specified in [9.1](#).

9.5 Each sheet steel cabinet and electrical enclosure exposed to the effects of weathering shall be protected against corrosion by the means specified in [Table 9.1](#) or by other metallic or nonmetallic coatings that have been shown to give equivalent protection.

*Exception: This requirement does not apply to a metal part, such as a decorative grille, that is not required for compliance with the requirements of this standard.*

**Table 9.1**  
**Corrosion protection**

Type of cabinet and enclosure	No. 16 MSG/GSG and heavier <sup>a</sup>	Lighter than No. 16 MSG/GSG <sup>a</sup>
Outer cabinet that protects motors, wiring, or enclosed current-carrying parts	See <a href="#">9.6</a>	See <a href="#">9.7</a>
Inside enclosure that protects current-carrying parts other than motors	See <a href="#">9.6</a>	See <a href="#">9.7</a>
Outer cabinet that is the sole enclosure of current-carrying parts	See <a href="#">9.7</a>	See <a href="#">9.7</a>

<sup>a</sup> See [Table 11.1](#) and [Table 11.2](#) for specified minimum thickness.

9.6 Where [Table 9.1](#) references [9.6](#), a cabinet or enclosure exposed to weathering shall be provided with one of the following coatings:

- a) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G60 or A60 in Table I of ASTM Designation A653/A653M, Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, as described in [9.9](#).
- b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied on each surface to an average thickness of not less than 0.00041 inch (0.01041 mm) and to a minimum thickness of 0.00034 inch (0.00864 mm). The thickness of the coating shall be established by the Metallic-Coating-Thickness Test, Section [75](#). An annealed coating shall also comply with the requirements in [9.10](#).
- c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. (The acceptability of the paint is to be determined by consideration of its composition or by corrosion tests if these are considered necessary.)

9.7 Where [Table 9.1](#) references [9.7](#), a cabinet or enclosure exposed to weathering shall be provided with one of the following coatings:

- a) Hot-dipped mill-galvanized sheet steel conforming with the coating Designation G90 in Table I of ASTM Designation A653/A653M, Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, as described in [9.9](#).
- b) A zinc coating, other than that provided on hot-dipped mill galvanized sheet steel, uniformly applied on each surface to an average thickness of not less than 0.00061 inch (0.01549 mm) and to a minimum thickness of 0.00054 inch (0.01372 mm). An annealed coating shall also comply with the requirements in [9.10](#).
- c) A cadmium coating not less than 0.001 inch (0.0254 mm) thick on both surfaces.
- d) A zinc coating complying with [9.6](#) (a) or (b) plus one coat of outdoor paint as specified in item c of [9.6](#) on each surface.
- e) A cadmium coating not less than 0.00075 inch (0.01905 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.0005 inch (0.0127 mm) thick on both surfaces plus two coats of outdoor paint on both surfaces. (The acceptability of the paint is to be determined by consideration of the composition or by corrosion tests if these are considered necessary.)

Coating thicknesses specified in (b), (c), and (e) are to be established by the Metallic-Coating-Thickness Test, Section [75](#).

9.8 With reference to [9.5](#), other finishes, including paints, special metallic finishes, and combinations of the two may be capable of being used when comparisons with galvanized-sheet steel (without annealing, wiping, or other surface treatment) that complies with [9.6](#)(a) or [9.7](#)(a), as applicable, indicate they provide equivalent protection. Among the factors to be taken into consideration when judging the equivalency of such coating systems are exposure to salt spray, moist carbon dioxide-sulfur dioxide-air mixtures, moist hydrogen sulfide-air mixtures, light and water.

9.9 The hot-dipped mill-galvanized sheet steel mentioned in [9.6](#) and [9.7](#) shall have not less than 40 percent of the zinc on any side, as determined by the minimum single spot test requirement in this ASTM Designation. The weight of zinc coating shall be determined by any recognized method; however, where results are in question, the weight of coating is to be established in accordance with the test method of ASTM Designation A90-93. An A60 (alloyed) coating shall also comply with the requirements in [9.10](#).

9.10 A hot-dipped mill galvanized A60 (alloyed) coating or an annealed zinc coating that is bent or similarly formed after annealing and that is not otherwise required to be painted shall be painted in the bent or formed area if the bending or forming process damages the zinc coating. However, areas on the

inside surface of a cabinet or enclosure into which water does not enter during the applicable water-spray test specified in [84.5.1](#) – [84.6.1](#), need not be painted.

9.11 If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is determined to be damaged and shall be painted. Simple sheared or cut edges and punched holes are not considered to be formed, but extruded and rolled edges and holes shall conform with [9.10](#).

9.12 Nonferrous cabinets and enclosures may be employed without corrosion protection. The thickness of the material is to be judged on the basis of its strength and rigidity.

## 10 Thermal Insulating Material

10.1 Thermal insulation shall be of such nature, and so located and mounted or supported, that it will not be adversely affected by the normal operation of the product.

10.2 Thermal insulation that is not rigid shall be mounted or supported so that it will not sag if sagging may introduce a risk of fire, electric shock, or injury to persons.

10.3 Adhesive material employed for mounting thermal insulation shall be acceptable for use at the temperature the adhesive may attain when the product is tested in accordance with these requirements and at minus 17.8°C (0°F). Determination of the acceptability of an adhesive may be omitted if the thermal insulation is mechanically supported by at least one rivet, or the equivalent, per square foot (929 square cm) of material.

10.4 Combustible or electrically conductive thermal insulation shall be spaced from uninsulated live parts of the product in accordance with the requirements for dead metal parts specified in Spacings, Section [30](#).

10.5 Some types of mineral-wool thermal insulation contain conductive impurities in the form of slag that make it not capable of being used if in contact with uninsulated live parts. See Insulation-Resistance Test Following Humidity Conditioning, Section [79](#).

## ELECTRICAL SYSTEMS AND DEVICES

### 11 Frame and Enclosure

11.1 An enclosure shall be formed and assembled so that if abused during shipment, installation, or normal use, it will have the strength and rigidity necessary to resist under abuse, a total or partial collapse that will result in a reduction of spacings, loosening or displacement of parts, or other serious defects.

11.2 An enclosure for individual electrical components, an outer enclosure, or a combination of the two is to be evaluated in determining compliance with [11.1](#).

11.3 An outer cabinet is to be investigated with respect to its size, shape, thickness of metal and particular application. Sheet steel less than 0.026 inch (0.66 mm) thick if uncoated or 0.029 inch (0.74 mm) thick if galvanized or of nonferrous sheet metal less than 0.036 inch (0.91 mm) thick shall not be used, except for relatively small areas or for surfaces that are curved or otherwise reinforced.

11.4 Sheet metal for the enclosure of individual electrical components shall comply with the applicable requirements in [Table 11.1](#) or [Table 11.2](#).

Exception: An individual enclosure of metal thinner than that specified in [Table 11.1](#) or [Table 11.2](#), as applicable, may be employed if the strength and rigidity of the outer enclosure and construction and location of the individual component will not increase the risk of fire, electric shock, or injury to persons.

**Table 11.1**  
**Minimum thickness of sheet metal for electrical enclosures carbon steel or stainless steel**

Without supporting frame <sup>a</sup>		With supporting frame or equivalent reinforcing <sup>a</sup>		Minimum thickness in inches (mm)	
Maximum width, <sup>b</sup>	Maximum length, <sup>c</sup>	Maximum width, <sup>b</sup>	Maximum length, <sup>c</sup>	Uncoated	Metal coated
Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)	(MSG)	(GSG)
4.0 (10.2)	Not limited	6.25 (15.9)	Not limited	0.020 <sup>d</sup> (0.51)	0.023 <sup>d</sup> (0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)	(24)	(24)
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026 <sup>d</sup> (0.66)	0.029 <sup>d</sup> (0.74)
7.0 (17.8)	8.75 (22.2)	10.0 (25.4)	12.5 (31.8)	(31.8)	(22)
8.0 (20.3)	Not limited	12.0 (30.5)	Not limited	0.032 (0.81)	0.034 (0.86)
9.0 (22.9)	11.5 (29.2)	13.0 (33.0)	16.0 (40.6)	(20)	(20)
12.5 (31.8)	Not limited	19.5 (49.5)	Not limited	0.042 (1.07)	0.045 (1.14)
14.0 (35.6)	18.0 (45.7)	21.0 (53.3)	25.0 (63.5)	(18)	(18)
18.0 (45.7)	Not limited	27.0 (68.6)	Not limited	0.053 (1.35)	0.056 (1.42)
20.0 (50.8)	25.0 (63.5)	29.0 (73.7)	36.0 (91.4)	(16)	(16)
22.0 (55.9)	Not limited	33.0 (83.8)	Not limited	0.060 (1.52)	0.063 (1.60)
25.0 (63.5)	31.0 (78.7)	35.0 (88.9)	43.0 (109.2)	(15)	(15)
25.0 (63.5)	Not limited	39.0 (99.1)	Not limited	0.067 (1.70)	0.070 (1.78)
29.0 (73.7)	36.0 (91.4)	41.0 (104.1)	51.0 (129.5)	(14)	(14)
33.0 (83.8)	Not limited	51.0 (129.5)	Not limited	0.080 (2.03)	0.084 (2.13)
38.0 (103.4)	47.0 (119.4)	54.0 (137.2)	66.0 (167.6)	(13)	(13)
42.0 (106.7)	Not limited	64.0 (162.6)	Not limited	0.093 (2.36)	0.097 (2.46)
47.0 (119.4)	59.0 (149.9)	68.0 (172.7)	84.0 (213.4)	(12)	(12)
52.0 (132.1)	Not limited	80.0 (203.2)	Not limited	0.108 (2.74)	0.111 (2.82)
60.0 (152.4)	74.0 (188.0)	84.0 (213.4)	103.0 (261.6)	(11)	(11)
63.0 (160.0)	Not limited	97.0 (246.4)	Not limited	0.123 (3.12)	0.126 (3.20)
73.0 (185.4)	90.0 (228.6)	103.0 (261.6)	127.0 (322.6)	(10)	(10)

<sup>a</sup> A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

- 1) single sheet with single formed flanges (formed edges),
- 2) a single sheet which is corrugated or ribbed, and
- 3) an enclosure surface loosely attached to a frame, for example, with spring clips.

<sup>b</sup> The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

<sup>c</sup> For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.

<sup>d</sup> Sheet steel for an enclosure intended for outdoor use shall comply with the requirements for outdoor equipment.

**Table 11.2**  
**Minimum thickness of sheet metal for electrical enclosures aluminum, copper, or brass**

Without supporting frame <sup>a</sup>		With supporting frame or equivalent reinforcing <sup>a</sup>				Minimum thickness, inches (mm)		
Maximum width <sup>b</sup> ,		Maximum length <sup>c</sup> ,		Maximum width <sup>b</sup> ,			Maximum length,	
Inches	(cm)	Inches	(cm)	Inches	(cm)		Inches	(cm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023 <sup>d</sup>
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	(0.58)
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)	(0.74)
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	(0.91)
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)	(1.91)
25.0	(63.4)	Not limited		60.0	(152.4)	Not limited		0.095
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)

<sup>a</sup> See item a of [Table 11.1](#)  
<sup>b</sup> See item b of [Table 11.1](#)  
<sup>c</sup> See item c of [Table 11.1](#)  
<sup>d</sup> See item d of [Table 11.1](#)

11.5 Sheet metal to which a wiring system is to be connected in the field shall not be less than:

- a) 0.032 inch (0.81 mm) thick if uncoated steel,
- b) 0.034 inch (0.86 mm) thick if galvanized steel, and
- c) 0.045 inch (1.14 mm) thick if nonferrous.

11.6 An enclosure of polymeric material shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

11.6.1 When protectors are provided for compliance with the abnormal operation test but not relied upon for overload protection as specified in [25.2](#), a stalled rotor test is conducted with the protector in the circuit for 7 hours, and then the protector is shorted and the test continued until ultimate conditions are observed. A manually reset protector is to be energized for 10 cycles of protector operation, with the protector being reset quickly after it has opened the circuit.

11.7 The enclosure of a remotely or automatically controlled product shall prevent molten metal, burning insulation, flaming particles, or similar objects from falling on combustible materials, including the surface upon which the product is supported.

11.8 The requirement in [11.7](#) will require that a switch, relay, solenoid, or similar parts be individually and completely enclosed, except for terminals, unless it can be shown that malfunction of the component would not result in a risk of fire, or there are no openings in the bottom of the product enclosure. It will also necessitate the use of a barrier of noncombustible material:

a) Under a motor unless:

- 1) The structural parts of the motor or of the product provide the equivalent of such a barrier;
- 2) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the product when the motor is energized under any of the following applicable fault conditions:
  - i) Open main winding;
  - ii) Open starting winding;
  - iii) Starting switch short-circuited; and
  - iv) Capacitor of permanently-split capacitor motor short circuited – the short-circuit is to be applied before the motor is energized, and the rotor is to be locked;
- 3) The motor is provided with a thermal motor protector – a protective device that is sensitive to temperature and current – that will prevent the temperature of the motor windings from exceeding 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle and from exceeding 150°C (302°F) with the rotor of the motor locked; or
- 4) The motor complies with the requirements for impedance-protected motors, and the temperature of the motor winding will not exceed 150°C (302°F) during the first 72 hours of operation with the rotor of the motor locked.

b) Under wiring, unless it is marked VW-1 (FR-1).

11.9 The barrier specified in [11.8](#) shall be horizontal, shall be located as illustrated in [Figure 11.1](#), and shall not have an area less than that described in that illustration. Openings for drainage, ventilation, and similar functions may be employed in the barrier, provided such openings would not permit molten metal, burning insulation, or similar objects to fall on combustible material.

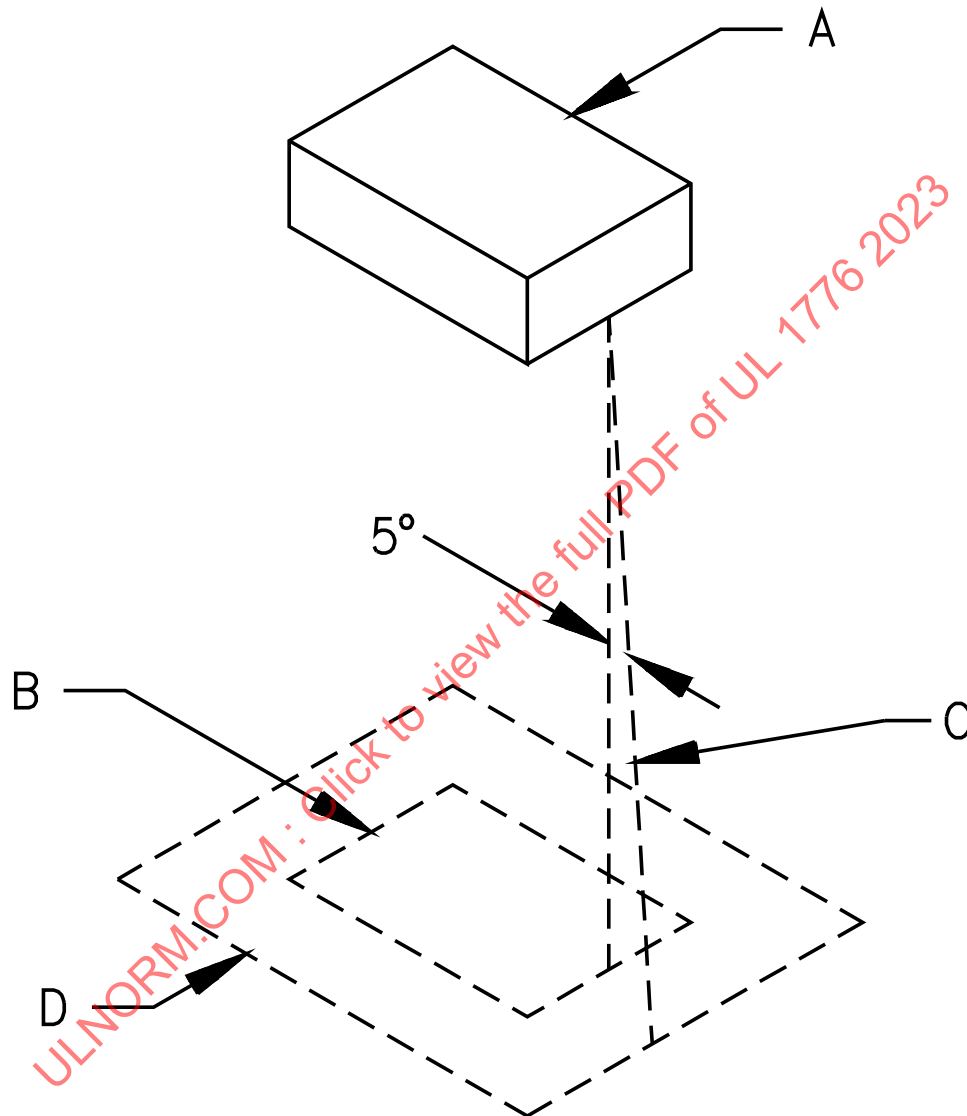
11.10 A door or cover of an enclosure shall be hinged or pivoted if it allows access to a fuse or any motor overload protective device, the intended protective functioning of which requires renewal; or a protective device, such as the manual reset overload protective device.

*Exception: A hinged cover is not required if fuses of the following types are enclosed:*

- a) Fuses connected in low-voltage circuits;
- b) Extractor-type fuses that have their own enclosures;
- c) Control-circuit fuses, provided that the control-circuit loads (other than fixed loads, such as pilot lamps) are housed in the same enclosure as the fuses; or

d) Supplementary-type fuses rated 2 amperes or less used in small, auxiliary resistance heaters having a rating of 100 watts or less.

**Figure 11.1**  
**Location and extent of barrier**



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A – Region to be shielded by barrier. This will consist of the entire component if it is not otherwise shielded and will consist of the unshielded portion of a component that is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on a horizontal plane.

C – Inclined line that traces out minimum area of barrier. The line is always

- 1) tangent to the component,
- 2) inclined 5 degrees from the vertical, and
- 3) oriented so as to trace out the maximum area on a horizontal plane.

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.

11.11 A required hinged cover shall not depend solely upon screws or similar means to hold it closed, but shall be provided with an automatic latch or equivalent.

11.12 Compliance with the requirements of [11.11](#) may be achieved by use of:

- a) A spring latch, magnetic latch, dimple, or equivalent mechanical arrangement that will hold the door in place and requires some physical effort on the user's part to open, or
- b) A cover interlocking mechanism, as described in [11.13](#) and provided as the sole means for securing the cover or panel.

11.13 An interlocking mechanism is considered to comply with the requirements in [11.12](#) if it:

- a) Secures the cover in the closed position when engaged, and
- b) Must be engaged before parts in a high-voltage circuit can be energized.

11.14 A door or cover that provides direct access to a fuse in other than a low-voltage circuit shall shut closely against a 1/4-inch (6.4-mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle straps fastened to it. Flanges or angle straps shall fit closely against the outside of the wall of the box and shall overlap the edges of the box by not less than 1/2 inch (12.7 mm). A construction affording equivalent protection is also capable of being used (for example, a combination of flange and rabbet or a construction that locates the fuse enclosure within an outer enclosure).

11.15 A strip used to provide rabbets or an angle strip fastened to the edges of a door shall be:

- a) Secured at not less than two points not more than 1-1/2 inches (38 mm) from each end of each strip and,
- b) Spaced between the end fastenings not more than 6 inches (152 mm) apart.

11.16 A cord-connected product that is provided with keyhole slots, notches, hanger holes, or similar features, for hanging on a wall shall be constructed so that the hanging means is not accessible without removing the product from the supporting means.

11.17 To determine whether a product complies with the requirement in [11.16](#), any part of the enclosure or barrier that can be removed without the use of tools to gain access to the hanging means is to be removed.

11.18 An opening provided for hanging the product shall be located or guarded so that a nail, hook, or similar part cannot be made to:

- a) Displace a part that could create a risk of fire or electric shock, and
- b) Contact one of the following:
  - 1) An uninsulated live part.
  - 2) Magnet wire.
  - 3) Internal wiring.
  - 4) Moving parts.
  - 5) Any other part likely to create a risk of fire or electric shock.

11.19 An enclosure for electrical components shall have provision for drainage if the enclosure employs knockouts or unthreaded openings.

## 12 Adhesives Used to Secure Parts

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

12.2 The requirement in [12.1](#) also applies to an adhesive used to secure a conductive part, including a nameplate, that may, if loosened or dislodged:

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

## 13 Handles and Gripping Areas

13.1 For a portable product, the entire surface available for gripping a handle and the designated gripping area of a lance shall have outer surfaces of insulating material that comply with the requirements for Tests on Gripping Areas, Section [85](#).

*Exception: The cart handle of a metal cart need not be insulated when both of the following conditions are met:*

- a) *The handle is reliably isolated from the voltage and grounding path, and therefore will not be energized during normal operation, servicing operation, or abnormal operating conditions.*
- b) *The cart is reliably isolated from the supporting surface of the product.*

## 14 Mechanical Assembly

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

14.2 A switch, lampholder, attachment-plug receptacle, motor-attachment plug, or similar component shall be securely mounted and shall be prevented from turning. See [14.4](#).

*Exception No. 1: A switch need not be prevented from turning if all four of the following conditions are met:*

- a) *The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during normal operation of the switch.*
- b) *The means for mounting the switch makes it unlikely that operation of the switch will loosen it.*
- c) *The spacings are not reduced below the minimum required values if the switch rotates.*
- d) *The normal operation of the switch is by mechanical means rather than by direct contact by persons.*

*Exception No. 2: A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the minimum required values.*

14.3 Uninsulated live parts shall be secured to the base or mounting surface so that they will be prevented from turning or shifting in position, if such motion may result in a reduction of spacings below the minimum acceptable values.

14.4 The means for preventing the turning or shifting mentioned in [14.2](#) and [14.3](#) shall consist of more than friction between surfaces – for example, a properly applied lock washer, is acceptable as the means for preventing a small stem-mounted switch or other device, having a single-hole mounting means, from turning.

## 15 Accessibility of Uninsulated Live Parts and Film-Coated Wire

15.1 To reduce the risk of unintentional contact that may involve a risk of electric shock from an uninsulated live part or film-coated wire, an opening in an enclosure shall:

- a) Be spaced from the opening as specified in [Table 15.1](#), if the opening has a minor dimension of 1 inch (25.4 mm) or more, and
- b) Not be contacted by the probe illustrated in [Figure 15.1](#), if the opening has a minor dimension (see [15.4](#)) less than 1 inch (25.4 mm).

*Exception: In an integral enclosure of a motor, other than one used in either a hand-held product or a hand-supported portion of a product.*

- a) An opening that has a minor dimension less than 3/4 inch (19.1 mm) is acceptable if:
  - 1) Film-coated wire cannot be contacted by the probe illustrated in [Figure 15.3](#);
  - 2) In a directly accessible motor (see [15.5](#)), an uninsulated live part cannot be contacted by the probe illustrated in [Figure 15.4](#); and
  - 3) In an indirectly accessible motor (see [15.5](#)), an uninsulated live part cannot be contacted by the probe illustrated in [Figure 15.2](#).
- b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in [Table 15.1](#).

**Table 15.1**  
**Minimum acceptable distance from an opening to a part that may involve a risk of electric shock or injury to persons**

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

<sup>a</sup> See [15.4](#).

<sup>b</sup> Between 3/4 inch and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table.

<sup>c</sup> Any dimension less than 1 inch applies to a motor only.

<sup>d</sup> More than 2-1/8 inches, but not more than 6 inches (152.0 mm).

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Figure 15.1  
Articulate probe with web stop

