UL 1776

STANDARD FOR SAFETY

High-Pressure Cleaning Machines

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 February 4, 2022 includes the following changes in requirements:

– Machines Provided without an Attachment Plug; 16.1.1, 113.5.4

– Type 4 Cleaning Machines; 1.3, 2.2.33A, 4A.2, Section 8.4, 54.8, 54.9, Section 54A, Section 54B, 55.5, 55.5A, 55.7, 55.8 – 55.10, 58.4, Section 66A, 111.2, 112.3.6, 113.1.9, Section 113.1A, 115.2, Section 115A and Section 115B

– UL 969A Cord Tag Requirements; 76.1.2 and 76.2.1

– Aligning GFCI Requirements with the US National Electric Code; 16.1.8, 16.1.8A, 27.4, 113.5.1, 115.2 and 115.3

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated October 29, 2021.

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UL 1776

Standard for High-Pressure Cleaning Machines

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The most recent designation of ANSI/UL 1776 as an American National Standard (ANSI) occurred on February 4, 2022. 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 UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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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 ºC and below +70 ºC. 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[a]	Lighter than No. 16 MSG/GSG[a]
Outer cabinet that protects motors, wiring, or enclosed current-carrying parts	See 9.6	See 9.7
Inside enclosure that protects current-carrying parts other than motors	See 9.6	See 9.7
Outer cabinet that is the sole enclosure of current-carrying parts	See 9.7	See 9.7

[a] 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[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		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[d]	(0.51)	0.023[d]	(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[d]	(0.66)	0.029[d]	(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)	

[a] 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.

[b] 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.

[c] 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.

[d] 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[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness, inches
Maximum width[b],		Maximum length[c],		Maximum width[b],		Maximum length,		
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	(mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d]
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)

[a] See item a of Table 11.1
[b] See item b of Table 11.1
[c] See item c of Table 11.1
[d] 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;

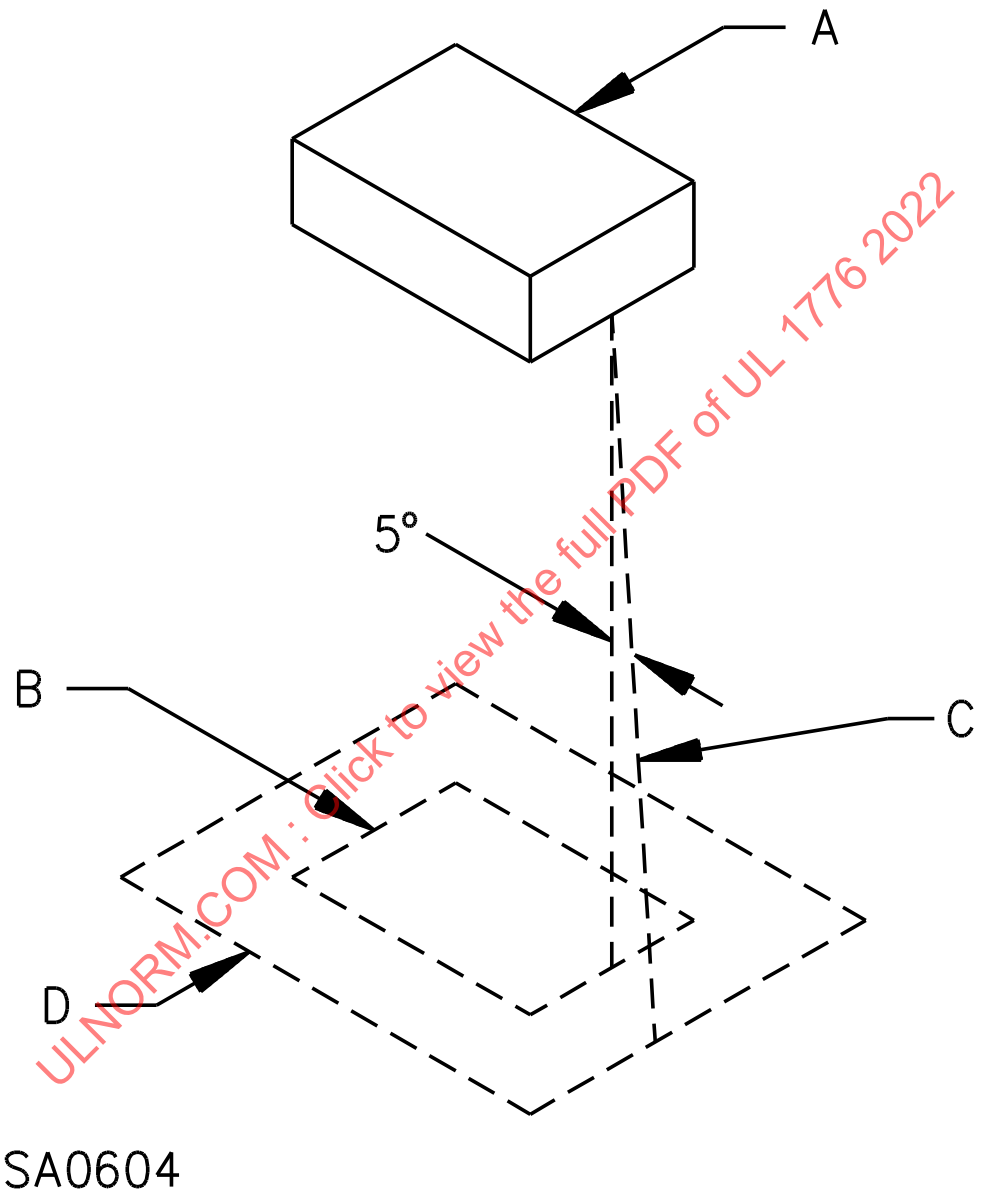
b) Extractor-type fuses that have their own enclosures;

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



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[a] of opening inches[b] (mm)		Minimum distance from opening to part, inches[b] (mm)	
3/4[c]	(19.1)	4-1/2	(114.0)
1[c]	(25.4)	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(190.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(444.0)

Table 15.1 Continued on Next Page

Table 15.1 Continued

Minor dimension[a] of opening inches[b] (mm)	Minimum distance from opening to part, inches[b] (mm)	
d	30	(762.0)

[a] See 15.4.

[b] Between 3/4 inch 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 1 inch applies to a motor only.

[d] More than 2-1/8 inches, but not more than 6 inches (152.0 mm).

Figure 15.1

Articulate probe with web stop

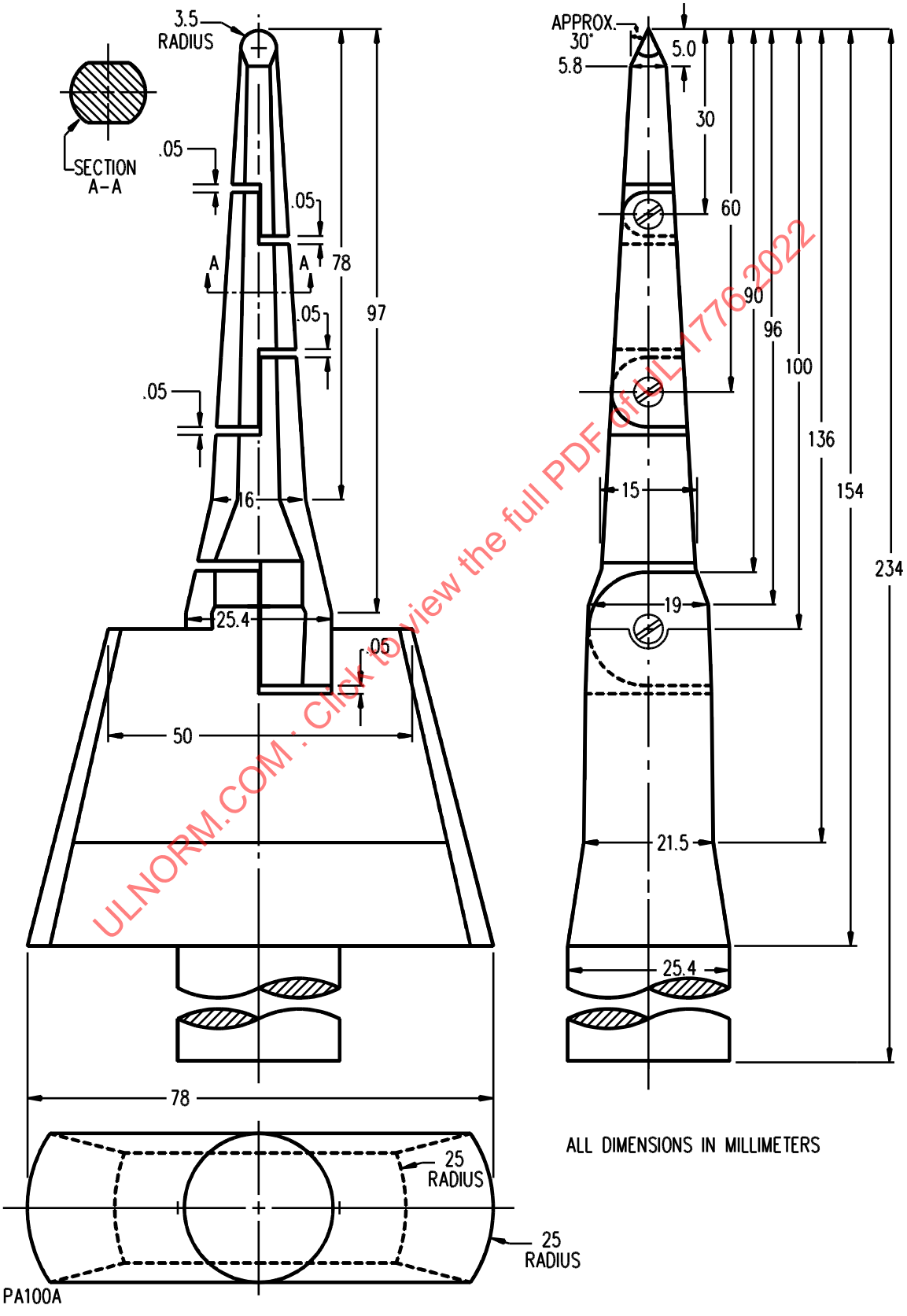


Figure 15.2

Straight probe with tapered tip

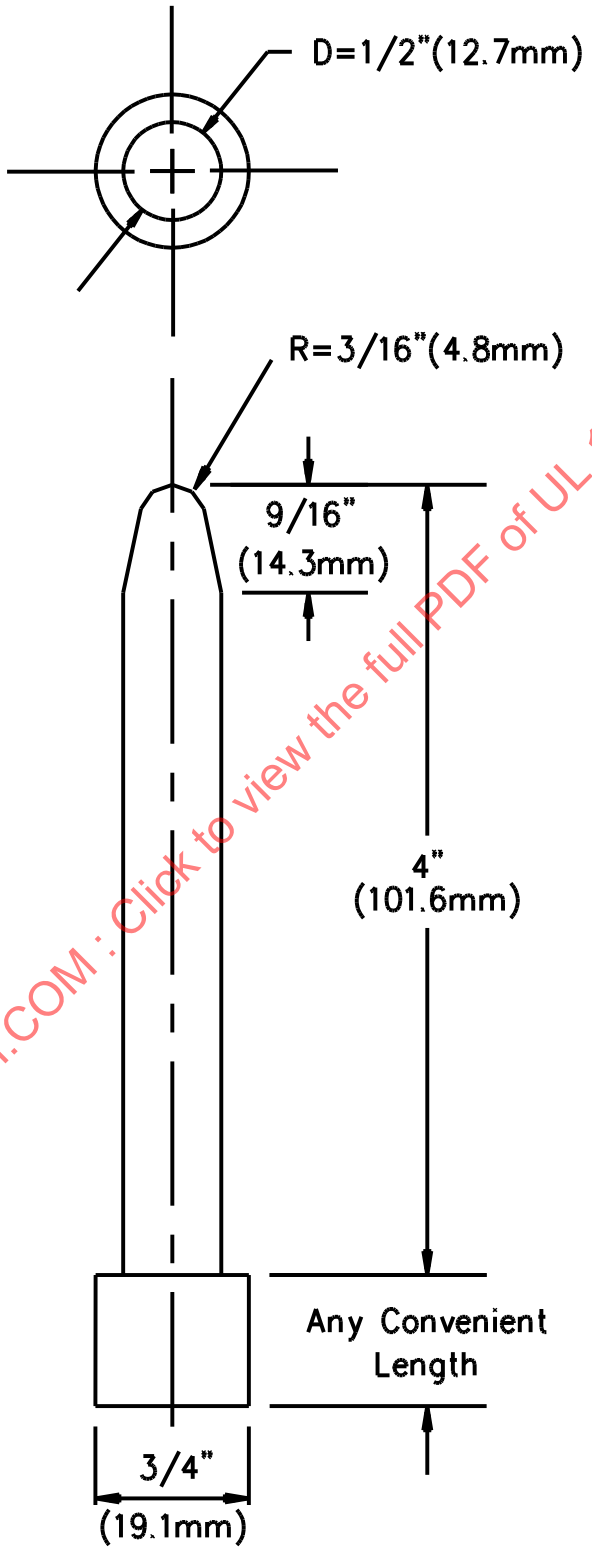


Figure 15.3

Straight probe with rounded tip

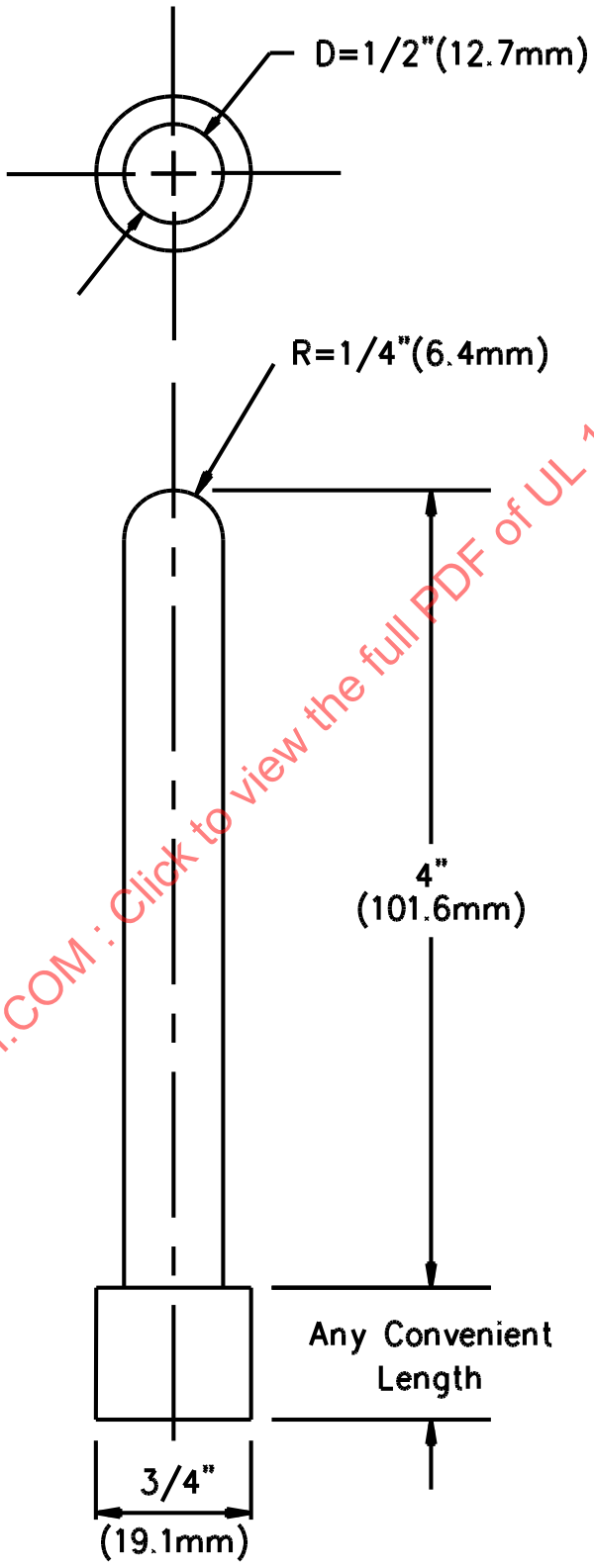
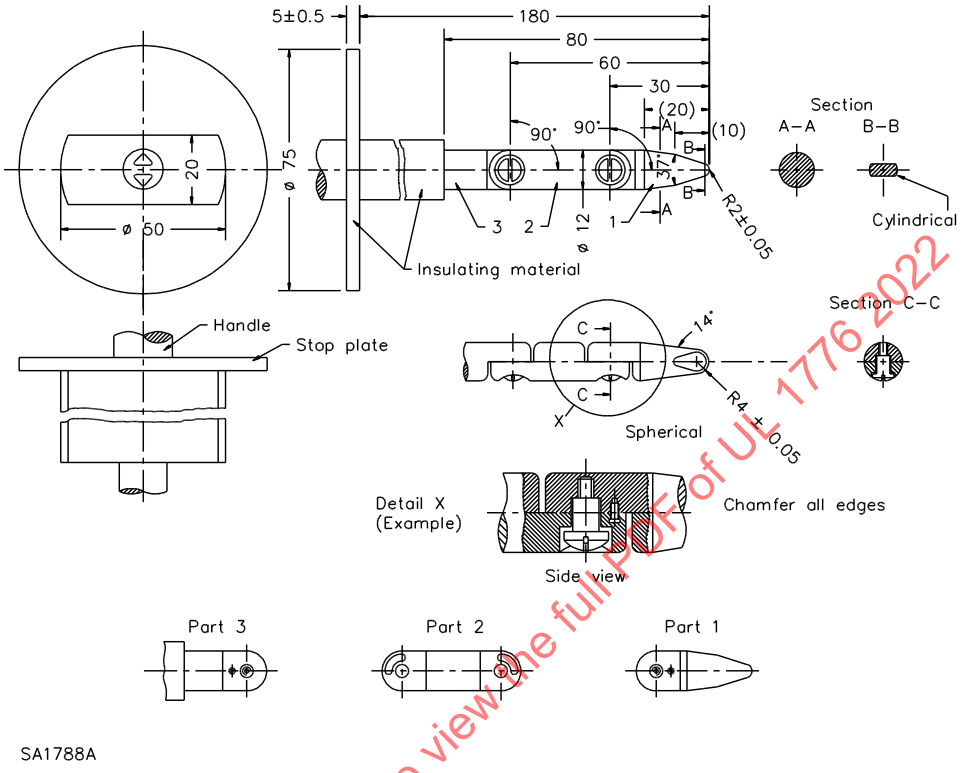


Figure 15.4

International electrotechnical commission (IEC) articulate accessibility probe with stop plate

(All dimensions in millimeters)



(Figure 15.4 Courtesy of IEC)

15.2 The probes mentioned in 15.1 and illustrated in Figure 15.1 – Figure 15.4 are to be applied to any depth that the opening will permit, and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probe illustrated in Figure 15.1 and Figure 15.4 shall be applied in any possible configuration; and, if necessary, the configuration is to be changed after insertion through the opening.

15.3 The probes mentioned in 15.2 and 15.4 are to 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 are to be applied with the minimum force necessary to determine accessibility.

15.4 With reference to the requirements in 15.1, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

15.5 With reference to the requirements in 15.1,

a) An indirectly accessible motor is a motor:

1) That is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without using a tool, or

2) That is located at such a height or is otherwise guarded or enclosed so that it is not contacted;

b) A directly accessible motor is a motor

1) That can be contacted without opening or removing any part, or

2) That is located so as to be accessible to contact.

15.6 During the examination of a product to determine whether it complies with the requirements in 15.1, a part of the enclosure that may be opened or removed by the user without a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

15.7 With reference to the requirements in 15.1, insulated brush caps are not required to be additionally enclosed.

16 Supply Connections

16.1 Cord-connected products

16.1.1 A product intended to be connected to the power-supply circuit by means of a flexible cord shall be provided with a flexible cord and an attachment plug for connection to the supply circuit.

Exception: A three phase product with a voltage rating exceeding 150 volts to ground, may be provided without an attachment plug if the markings in 113.5.4are provided.

16.1.2 The flexible cord shall have a voltage rating not less than the rated voltage of the product, and shall have an ampere rating that is not less than the current rating of the product.

16.1.3 The flexible cord shall be a Type SJ, SJE, SJO, SJT, SJTO, SJO, SJOO, SJEO, SJEOO, or SJTOO for a portable product employing a motor rated 2 horsepower (1492 W) or less. Portable products employing a motor rated more than 2 horsepower and stationary products shall employ Type S, ST, STO, SOO, SO, SE, SEO, SEOO, or STOO flexible cord.

16.1.4 The flexible cord employed on a product that may be used outdoors shall be marked “W” (for example, SJOW). The flexible cord shall not be prohibited from being additionally marked "Water Resistant".

16.1.5 The flexible cord shall be attached to the product.

16.1.6 For a portable product, the flexible cord shall be at least 35 feet (10.67 m) long. For stationary products, the flexible cord shall be at least 3 feet (0.91 m) long and not longer than 4 feet (1.21 m). The measurement of the length of the flexible cord is to include the attachment plug.

16.1.7 The attachment plug shall have an ampere rating not less than the rated current of the product, or the input current under maximum normal load conditions, whichever is greater, and a nominal voltage rating equal to the rated voltage of the product.

16.1.8 A single phase grounded or double-insulated product that is rated 120 volts and provided with a 15 amp or 20 amp attachment plug shall be provided with a Class A ground-fault circuit-interrupter (GFCI) for personnel protection as an integral part of the power-supply cord attachment plug; or power-supply cord within 12 inches (305 mm) of the attachment plug face. The GFCI shall be marked “Rainproof” or “Suitable for Wet Locations” and investigated in accordance with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

All other single phase grounded or double-insulated products rated 150 volts or less to ground and 60 amps or less, shall comply with 16.1.8A.

16.1.8A A single phase (other than those products rated in 16.1.8) or three phase grounded or double-insulated product that is rated 150 volts or less to ground and 60 amps or less, shall be provided with a Class A ground-fault circuit-interrupter (GFCI) for personnel protection. The GFCI shall be readily accessible and located in one or more of the following locations:

(1) Within the branch circuit overcurrent device;

(2) A device or outlet within the supply circuit;

(3) An integral part of the attachment plug;

(4) Within the supply cord not more than 300 mm (12 in.) from the attachment plug; or

(5) Factory installed within the appliance.

For products provided with an integral GFCI (Items 3, 4, or 5 above), the GFCI shall be investigated in accordance with the Standard for Ground-Fault Circuit-Interrupters, UL 943. For GFCIs that are integral to the plug or the supply cord, the GFCI shall be marked “Rainproof” or “Suitable for Wet Locations”.

16.1.9 A three- to two-wire, grounding-type adapter shall not be provided with the product.

16.1.10 Strain relief shall be provided so that mechanical stress on a flexible cord will not be transmitted to terminals, splices, or interior wiring. See Strain-Relief Test, Section 88.

16.1.11 Means shall be provided to prevent a flexible cord from being pushed into the product through a cord-entry hole if such displacement may subject the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is acceptable, or may reduce a spacing, such as a metal strain-relief clamp, below the minimum acceptable value.

16.1.12 The flexible cord shall be restrained from any rotation that can cause movement of the internal portion of the cord at splices or terminals.

16.1.13 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be reliably secured in place, and shall have a smooth, rounded surface against which the cord may bear.

16.1.14 A cord hole in wood, porcelain, phenolic composition, or other nonconducting material and having a smooth, rounded surface is considered to be equivalent to a bushing.

16.1.15 A vulcanized fiber bushing shall not be less than 3/64 inch (1.2 mm) thick and formed and secured in place so that it will not be adversely affected by conditions of ordinary moisture.

16.1.16 A separate soft-rubber, neoprene, or polyvinyl chloride bushing shall not be employed in a product.

Exception: This requirement does not apply to a bushing if the edges of the hole in which the bushing is mounted are smooth and free from burrs, fins, and similar roughness.

16.1.17 At any point in a product, a bushing of the same material as, and molded integrally with, the supply cord is acceptable if the built-up section is not less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure.

16.2 Permanently connected products

16.2.1 A product intended to be fastened in place and a product intended for permanent connection to the power supply shall have provision for connection of one of the wiring systems that would be intended for the product.

16.2.2 A wiring box or compartment in which power-supply connections to a permanently connected product are to be made shall be provided and shall be located so that the connections may be readily inspected after the product is installed as intended.

16.2.3 A wiring or splice compartment shall be complete and shall enclose all field-wiring terminals and all splices to be made in the field unless the product enclosure is otherwise complete – that is, unless all sides and a complete bottom are provided when the product is shipped from the factory. Ventilating openings shall not be located in the bottom or sides of the wiring compartment.

16.2.4 A wiring compartment shall be located so that internal wiring and components are not damaged when the field-installed connections are made or inspected.

16.2.5 A wiring compartment intended for connection of a supply raceway shall be attached to the product so as to be prevented from turning.

16.2.6 If it is intended that supply connections be made directly to a motor, the wiring compartment on the motor shall comply with the requirements for terminal compartments in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

16.2.7 Conduit openings or knockouts shall be provided for all field-wiring connections and shall be at least 7/8 inch (22.2 mm) in diameter.

16.2.8 A product exposed to the effects of weathering shall be provided with threaded openings unless the location of the openings:

a) Are wholly below the lowest uninsulated live part within the enclosure, or

b) Prevents drainage into the enclosure along the outside surface of a field-supplied wireway when subjected to the tests specified in 84.5 and 84.6, as applicable. A threaded opening shall comply with the applicable requirements in the Standard for Metallic Outlet Boxes, UL 514A.

16.2.9 A product as described in 16.2.2 shall be provided with wiring terminals for the connection of conductors having an ampacity rated for the product; or the product shall be provided with leads for such connection.

16.2.10 Wiring terminals for the supply conductors shall be provided with a pressure wire connector securely fastened in place – for example, firmly bolted or held by a screw.

Exception: A wire binding screw or stud-and-nut combination may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in place.

16.2.11 A wire-binding screw or stud-and-nut combination as mentioned in the exception to 16.2.10 shall not be smaller than No. 10.

Exception No. 1: A No. 8 screw or stud-and-nut combination may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

Exception No. 2: A No. 6 screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.8 mm^2) conductor in a low-voltage circuit.

16.2.12 A wiring terminal shall be prevented from turning.

16.2.13 The free length of a lead inside a wiring compartment shall be 6 inches (152 mm) or more if the lead is intended for field connection to an external circuit.

16.2.14 According to the National Electrical Code, ANSI/NFPA 70, 14 AWG (2.1 mm^2) is the smallest conductor that may be used for branch-circuit wiring, and therefore is the smallest conductor that may be anticipated at a terminal for connection of a power-supply wire.

16.2.15 A wire-binding screw shall thread into metal.

16.2.16 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick and shall not have less than two full threads in the metal.

Exception: An alloy plate may be not less than 0.030 inch (0.76 mm) thick if the tapped threads have the necessary mechanical strength.

16.2.17 A terminal plate formed from stock having the thickness specified in 16.2.16 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

16.2.18 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size specified in 16.2.9 under the head of the screw or washer.

16.2.19 A permanently connected product rated 125 or 125/250 volts (3-wire) or less shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit if the product employs, a lampholder of the Edison-screw-shell type, a single-pole switch, or an overcurrent-protective device other than an automatic control without a marked off position.

16.2.20 A terminal intended for the connection of a grounded supply conductor shall be of or plated with metal that is substantially white in color and shall be readily distinguishable from the other terminals, or proper identification of that terminal shall be clearly shown in some other manner.

16.2.21 A lead intended for the connection of a grounded power-supply conductor shall be finished white or grey color and shall be readily distinguishable from the other leads.

16.2.22 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is slotted or hexagonal, or both. The wire-binding screw or pressure wire connector shall be located so that it is unlikely to be removed during any servicing of the product. See 112.3.3.

16.2.23 The surface of an insulated lead intended for the connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified. The lead shall be connected to the product such that it is not likely to be removed during any servicing of the product.

17 Current-Carrying Parts

17.1 A current-carrying part shall be of silver, copper, copper alloy, stainless steel, 8000 series aluminum, or similar metal. See 19.3.4.

17.2 Ordinary iron or steel shall not be used as a current-carrying part.

Exception: Ordinary iron or steel provided with a corrosion-resistant coating may be used for a current-carrying part if acceptable and in accordance with its recognized ratings and other limitations of use.

18 Insulating Material

18.1 Material for mounting an uninsulated live part shall be porcelain, phenolic composition, or equivalent material.

18.2 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock.

18.3 Thermoplastic material used for mounting an uninsulated live part or as electrical insulation shall comply with the requirements for direct support materials described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

18.4 A small molded part, such as a brush cap, shall be constructed to have the necessary mechanical strength and rigidity to withstand the stresses of actual service. A brush cap shall be secured or located so that it is protected from mechanical damage that may result during normal use.

19 Internal Wiring

19.1 Mechanical protection

19.1.1 Wiring and connections between parts of a product shall be protected or enclosed.

Exception: A length of flexible cord may be employed for external connections if flexibility is essential. Any exposed cord shall be of a type at least as serviceable as the power supply cord on the product unless located or protected so as to reduce the possibility of mechanical damage.

19.1.2 With reference to exposure of internal wiring through an opening in the enclosure of a product, the protection of such wiring required by 19.1.1 is considered to exist if, when judged as though it were film-coated wire, the wiring, including that employed for grounding purposes, would be acceptable according to 15.1 and 15.2. Internal wiring not so protected may be accepted if it is secured within the enclosure so that it is unlikely to be subjected to stress or mechanical damage.

19.1.3 Internal wiring and components shall be protected from damage when field connections such as wiring, water, drains, and similar field connections, are made to the product.

19.1.4 Wires within an enclosure, a compartment, a raceway, or similar enclosed space shall be routed or otherwise protected so that damage to conductor insulation cannot result from contact with any rough, sharp, or moving part.

19.1.5 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure of a product shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces upon which the wires may bear.

19.1.6 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of a product.

19.1.7 A flexible cord used for external interconnection as mentioned in the exception to 19.1.1 shall be provided with strain relief and bushings in accordance with the requirements in 16.1.10 – 16.1.17, and Section 88, Strain Relief Test, unless the construction is such that the cord will be protected from stress and motion.

19.1.8 Internal wiring shall consist of wires of a type or types that are acceptable for the application, when considered with respect to the temperature and voltage to which the wiring is likely to be subjected and with respect to its exposure to oil, grease, cleaning solutions, or other conditions of service.

19.1.9 Thermoplastic-insulated wire and neoprene-insulated wire employed for internal wiring shall be standard building wire or appliance wiring material, and shall be in accordance with Table 19.1.

Exception: Appliance-wiring material having insulation not less than 1/64 inch (0.4 mm) thick and without a braid or jacket is acceptable in a circuit operating at not more than the rated voltage of the wire if the wire is within an individual, completely enclosed electronic chassis that need not be opened for normal field adjustment.

Table 19.1
Characteristics of internal wiring

Insulation	Nominal thickness of insulation, inch	Braid or jacket required	Nominal thickness of braid or jacket, inch
Thermoplastic or neoprene[a]	1/32 (0.8 mm)	No	–
	1/64 (0.4 mm)	Yes	1/64 (0.4 mm)
Rubber[b]	1/32 (0.8 mm)	Yes	1/64 (0.4 mm)

[a] See 19.1.9

[b] For heat-resistant rubber – other than a silicone type – the insulation thickness shall not be less than 3/64 inch (1.1 mm) and no braid is required.

19.1.10 *Deleted*

19.2 Wiring in products exposed to the effects of weathering

19.2.1 Type RW, RHW, TW, THW, XHHW, MTW, or THWN wires having equivalent moisture-resistant properties of those wires specified in Table 19.1 are acceptable for the wiring between electrical component enclosures when they are enclosed in rigid or flexible-steel conduit or electrical metallic tubing, or in moisture-resistant nonmetallic sheathed cable.

19.2.2 Wiring material of the type specified in 19.1.9 is acceptable when installed in either rigid conduit or electrical metallic tubing with raintight fittings or when installed in liquid-tight flexible metal conduit with acceptable fittings.

19.2.3 Each bushings shall be constructed of material that does not absorb moisture.

19.2.4 All wires not rated for use in wet locations, and all cords, shall be routed and supported so that they will not be immersed in water.

19.3 Splices and connections

19.3.1 Each splice and connection shall be mechanically secure and shall provide reliable electrical contact. A soldered connection shall be mechanically secured before being soldered.

19.3.2 The requirement in 19.3.1 will necessitate the use of lock washers or other equivalent means to prevent wire-binding screws and nuts from becoming loosened.

19.3.3 A splice shall be provided with insulation equivalent to that of the wires involved. Insulation consisting of two layers of friction tape, two layers of thermoplastic tape, or of one layer of friction tape on top of one layer of rubber tape, is acceptable on a splice if the voltage involved is less than 250 volts. In determining if splice insulation consisting of coated-fabric, thermoplastic or other type of tubing is acceptable, consideration is to be given to its dielectric properties, heat- and moisture-resistance characteristics, and similar characteristics and properties. Thermoplastic tape wrapped over a sharp edge is not acceptable.

19.3.4 Aluminum conductors, insulated or uninsulated, shall be terminated by a method acceptable for the combination of metals involved at the point of connection.

19.3.5 With reference to the requirements in 19.3.4, a wire-binding screw or a pressure wire connector used as a terminating device shall be acceptable for use with aluminum under the conditions involved – for example, temperature, heat cycling and vibration.

19.3.6 If stranded internal wiring is connected to a wire-binding screw, loose strands of wire shall be prevented from contacting other uninsulated live parts that are not always of the same polarity as the wire, and dead metal parts. This may be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other reliable means.

19.4 Separation of circuits

19.4.1 Conductors of circuits operating at different potentials shall be reliably separated from each other unless they are each provided with insulation acceptable for the highest potential involved.

19.4.2 An insulated conductor shall be reliably positioned so that it cannot contact an uninsulated live part of a circuit operating at a different potential.

19.5 Separation of wiring and fuel lines

19.5.1 Electrical wiring shall not be tied to a fuel line and shall be routed so that it cannot inadvertently contact a fuel line.

20 Capacitors

20.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line, such as a capacitor for radio-interference elimination or power-factor correction, shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will prevent the emission of flame or molten material resulting from malfunction or breakdown of the capacitor. The container shall be of metal providing strength and protection not less than that of uncoated steel 0.020 inch (0.51 mm) thick. Sheet metal shall not be less than 0.026 inch (0.66 mm) thick.

Exception: The individual container of a capacitor may be of sheet metal less than 0.020 inch (0.51 mm) thick or may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the product and provided that such housing is acceptable for the enclosure of live parts.

20.2 A filter or other across-the-line capacitor shall comply with the Standard for Capacitors, UL 810.

20.3 If a capacitor that is not a part of a capacitor motor or a capacitor-start motor is connected in a product that is intended to be automatically or remotely controlled so that malfunction or breakdown of the capacitor would result in a risk of fire, electric shock, or injury to persons, thermal or overcurrent protection shall be provided in the product to prevent such a condition.

20.4 A capacitor connected from one side of the line to the frame or enclosure of a product shall have a capacitance rating of not more than 0.10 microfarad. See 20.2.

20.5 A product that is intended to be controlled by or operated in conjunction with a capacitor or a capacitor/transformer unit shall be supplied with such capacitor or unit.

20.6 Under both normal and abnormal conditions of use, a capacitor employing a dielectric medium more combustible than askarel shall not cause a risk of fire or electric shock; and shall be constructed to reduce the risk of expelling the dielectric medium. See 30.11.

20.7 A capacitor complying with the requirements for protected oil-filled capacitors, Sections 18 – 21 of the Standard for Capacitors, UL 810, is considered to be constructed to reduce the risk of expelling the dielectric medium.

21 Grounding

21.1 A product shall have provision for grounding. The following are acceptable means for grounding:

a) For a product intended to be permanently connected by a metal-enclosed wiring system, a knockout or equivalent opening in the metal enclosure of the product.

b) For a product intended to be permanently connected by a nonmetal-enclosed wiring system, such as nonmetallic-sheathed cable, an equipment grounding terminal or lead.

c) For a cord-connected product, an equipment-grounding conductor in the cord. The surface of the insulation of a grounding conductor of a flexible cord shall be green with or without one or more yellow stripes.

Exception: A cord-connected product intended to be used on a circuit operating at not more than 150 volts to ground may be provided with a system of double insulation in lieu of a means for grounding.

21.2 All exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact during any servicing operation including maintenance and repair, that are likely to become energized shall be reliably connected (bonded) to the means for grounding.

21.3 A bonding conductor of ferrous metal shall be protected against corrosion by painting, plating, or the equivalent.

21.4 The grounding conductor of a power-supply cord and any internal wiring connection used for grounding shall be secured such that the connection is not likely to be unintentionally disconnected during any servicing operation. Servicing as mentioned here includes repair of the product by a qualified service person.

21.5 Solder alone shall not be used for securing a grounding conductor.

21.6 The grounding conductor of a cord-connected product shall be connected to the grounding member of an attachment plug. The grounding member shall be fixed.

21.7 A separable connection, such as that provided by an attachment plug and a mating connector or receptacle, shall be such that the equipment-grounding connection is made before connection to and broken after disconnection from the supply conductors.

Exception: This requirement does not apply to interlocked plugs, receptacles, and connectors that are not energized when the equipment-grounding connection is made or broken.

21.8 For a product provided with means for separate connection to more than one power supply, each such connection shall be provided with a means for grounding.

21.9 Bonding shall be by a positive means, such as by clamping, riveting, brazing, welding, or making a bolted or screwed connection. The bonding connection shall penetrate nonconductive coatings, such as paint.

21.10 A bolted or screwed connection that incorporates a star washer or serrations under a screwhead is acceptable for penetrating nonconductive coatings.

21.11 If the bonding means depends upon screw threads, two or more screws shall be used or a single screw shall have at least two full threads engaging metal.

21.12 A connection that depends upon the clamping action exerted by rubber or similar material in a resilient mount shall comply with the requirements for resilient rubber mountings in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1. The effect of assembling and disassembling such a connection (such as for maintenance) shall also be considered with particular emphasis on the likelihood of the clamping device being reassembled in its intended fashion.

21.13 The size of a copper or aluminum conductor employed for bonding shall be based on the rating of the branch-circuit overcurrent device by which the product will be protected. The size of the conductor shall be as specified in Table 21.1.

Exception No. 1: For a cord-connected product, the bonding conductors may be the same size as the power supply cord.

Exception No. 2: A bonding conductor to a motor or other electrical component may be the same size as the leads of the component.

Exception No. 3: A conductor, such as a clamp or strap, may be employed provided that its cross-sectional conducting area is not less than the wire specified.

Exception No. 4: A smaller conductor may be employed if it complies with the bonding conductor tests in Section 82.

Table 21.1
Size of bonding wire conductors

Rating of overcurrent protective device, amperes	Size of bonding conductor	
	Copper wire, AWG	Aluminum or copper-clad aluminum wire, AWG
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
400	3	1
600	1	2/0

21.14 If more than one size branch-circuit overcurrent device is involved, the size of the bonding conductor shall be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor. For example, if a motor is individually protected by a branch-circuit overcurrent device smaller than other overcurrent devices used with the equipment, a bonding conductor for that motor shall be sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

21.15 The secondary circuit supplied by a transformer with a primary operating at more than 150 volts to ground, including Class 1, 2, and 3 circuits, shall be grounded.

22 Heating Elements

22.1 The voltage rating of a heating element employed in a product shall not be less than that specified in Table 22.1.

Table 22.1
Rating of heating element

Nominal voltage of circuit	Minimum rating of heating element, volts
120	110
208	208
240	220
277	277
480	430
More than 480	Rating of circuit

22.2 Each sheathed heating element shall comply with the requirements in the Standard for Sheathed Heating Elements, UL 1030.

22.3 Each heating element shall be supported in a substantial and reliable manner, and shall be protected against mechanical damage and contact with outside objects.

23 Water Heaters

23.1 An electric water heater shall comply with the applicable requirements in the Standard for Electric Booster and Commercial Storage Tank Water Heaters, UL 1453, or the Standard for Household Electric Storage Tank Water Heaters, UL 174.

24 Lampholders

24.1 The screw shell of an Edison-base lampholder in a permanently connected product, or a product equipped with a polarized attachment plug shall be connected to the terminal or lead that is intended to be connected to the grounded conductor of the power-supply circuit.

25 Motors

25.1 General

25.1.1 Each motor shall be acceptable for the application, and shall be capable of handling the maximum normal load of the product as described in 67.3.1 and 67.3.2 without creating a risk of fire, electric shock, or injury to persons.

25.1.2 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly shall be retained to the degree necessary to keep accessible dead metal parts from becoming energized, and live parts from becoming accessible.

25.2 Overload protection

25.2.1 A product shall incorporate thermal or overload protection in accordance with 25.2.2 if it is permanently connected, continuous-duty, and manually started, employing a motor rated 1 horsepower (746 W output) or less, remotely or automatically controlled, or coin operated.

25.2.2 Motor-overload protection required for a product shall consist of one of the following:

a) Thermal protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111.

Exception No. 1: A motor intended to move air only by means of an air-moving fan that is integrally attached, keyed, or otherwise fixed to the motor shaft is not required to have running-overload protection.

Exception No. 2: A shaded-pole motor with a 2:1 or smaller ratio between locked-rotor and no-load currents and a 1-ampere or smaller difference between no-load and locked-rotor currents is considered to have acceptable overload protection if it is protected against locked-rotor conditions only.

b) Impedance protection complying with the requirements in the Standard for Overheating Protection for Motors, UL 2111, when the motor is tested as used in the product under stalled rotor conditions.

c) Other protection that is shown by test to be equivalent to the product mentioned in (a).

25.2.3 If a requirement in this standard refers to the horsepower rating of a motor and the motor is not rated in horsepower, use is to be made of the appropriate table of the National Electrical Code, ANSI/NFPA 70, that gives the relationship between horsepower and full-load currents for motors. For a universal motor, the table applying to a single-phase, alternating-current motor is to be used if the product is marked for use on alternating current only; otherwise the table applying to direct-current motors is to be used.

25.2.4 For a multispeed motor of any of the types mentioned in 25.2.1 that employs a separate overload protective device to provide running overload protection, the requirement in 25.2.1 applies at all speeds at which the motor is intended to operate.

25.2.5 The motor of a product with load characteristics likely to result in an overload or stalled condition that will not be evident to the user shall incorporate thermal or overload protection in accordance with the requirements in 25.2.2.

25.2.6 The functioning of a motor-protective device provided as part of a product, whether such a device is required or not, shall not result in a risk of fire, electric shock, or injury to persons.

25.2.7 An overload device employed for running overload protection, other than one that is inherent in a motor, shall be located in at least one ungrounded conductor of a single-phase supply system and in each ungrounded conductor of a 3-phase supply system.

25.2.8 Fuses employed for motor-running overload protection shall be located in each ungrounded conductor; and in each of the phases of a 3-phase, 3-wire, alternating-current motor.

25.2.9 A circuit breaker shall be connected to open all ungrounded conductors of the circuit. Multipole circuit breakers shall be the common trip type.

Exception: Single-pole circuit breakers with handle ties, the combination of which complies with the applicable requirements in the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489, may be used as the protection for each ungrounded conductor supplying line-to-line connected loads of a product rated for connection to a grounded system:

a) Single-phase circuit,

b) 3-wire direct-current circuit, or

c) Circuit that is connected to a 4-wire 3-phase, or 5-wire 2-phase system with a grounded neutral.

25.2.10 With reference to 25.2.2(c), an overload-protective device complying with the National Electrical Code, ANSI/NFPA 70, is considered to be an overload device that is responsive to motor current and is rated or set as specified in column A of Table 25.1. If the rating of the motor-running overload protection determined in accordance with the foregoing does not correspond to a standard size or rating of a fuse, nonadjustable circuit breaker, thermal cutout, thermal relay, or heating element of a thermal-trip motor switch, the next higher size, rating, or setting may be used, but may not be more than that specified in column B of Table 25.1. For a multispeed motor, each winding connection is to be considered.

Table 25.1
Maximum rating or setting of overload-protective device

Type of motor	Ampere rating of device as a percentage of motor full-load current rating[a]	
	A	B
Motor with marked service factor of 1.15 or more	125	140
Motor with marked temperature rise of 40°C (72°) or less	125	140
Any other motor	115	130

[a] See 25.2.10.

25.2.11 Motor-overload protection in which contacts control a relay coil in a motor starter shall comply with the requirements in 25.2.2.

26 Overload- or Thermal-Protective Devices

26.1 Each overload- or thermal-protective device shall have a current and voltage rating not less than the load that it controls.

26.2 If the current rating of a product is more than 40 amperes, and there are subdivided circuits within the product feeding two or more power-consuming components – motors, motor-control circuits, electric heating elements – connected in parallel with each other across any pair of main-supply terminals or leads, overcurrent protection shall be provided as a part of the product for the conductors of each terminal circuit.

Exception: Additional overcurrent protection is not required as a part of the product for the conductors of the subdivided circuits described below:

a) For each separate motor or heating-element circuit supplied by insulated conductors having an ampacity at least one-third that of the protective device in the branch circuit to which the product will properly be connected.

b) For each separate motor-control circuit supplied by insulated conductors having an ampacity at least one-fifth that of the protective device in the branch circuit to which the product will properly be connected.

26.3 A transformer shall be protected by overcurrent protection:

a) Rated 20 amperes or less,

b) Set at not more than 125 percent of the primary current when the primary only is protected, or

c) Set at not more than 250 percent of the primary current and 125 percent of the secondary current when both primary and secondary circuits are protected.

Exception: The overcurrent protection need not be provided as part of a pressure washer if the overcurrent protection of the branch circuit to which the product will be connected will provide equal or better protection.

26.4 A product that employs resistance-type heating elements rated more than 48 amperes shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

26.5 The overcurrent protective devices required in 26.4 shall be provided as an integral part of the product.

26.6 A protective device that requires resetting or replacement after it opens shall be readily accessible.

26.7 A protective device shall be wholly inaccessible from outside the product without opening a door or cover.

Exception: The operating handle of a circuit breaker, the operating button of a manually operable motor protector, and similar parts may project outside the product enclosure.

26.8 A fuseholder of a household or similar type product shall be constructed and installed so that no uninsulated live part will be exposed to contact by persons removing or replacing fuses.

26.9 The screw shell of a plug-type fuseholder shall be connected on the load side of the circuit.

27 Receptacles

27.1 A portable product shall not be provided with a general-use receptacle.

27.2 A 15- or 20-ampere general-use attachment-plug receptacle shall be of the grounding type.

27.3 Each circuit having an attachment-plug receptacle intended for general use shall have overcurrent protection of not more than 20 amperes provided as a part of the product if the overcurrent protection of the branch circuit to which the product will properly be connected exceeds that acceptable for the receptacles. The overcurrent protection provided shall be of the time-delay type.

27.4 A 120-volt, single-phase, 15- or 20-ampere receptacle outlet installed in a cord-and-plug connected fixed product intended for outdoor use shall be electrically-connected to the GFCI provided with the product, or be provided with Class A ground-fault circuit-interrupter (GFCI) for personnel protection as an integral part of the receptacle.

27.5 A fuseholder provided in accordance with 27.3 shall be of Type S construction or shall be of the Edison-base type with a factory-installed nonremovable adapter of Type S construction.

27.6 The face of a receptacle shall:

a) Be flush with or project beyond a nonconductive surrounding surface, or

b) Project at least 0.015 inch (0.38 mm) beyond a conductive surrounding surface.

28 Switches and Controls

28.1 A switch or other control device shall have a current and voltage rating not less than that of the load that it controls.

28.2 With reference to the requirement in 28.1, the current rating of a switch that controls an inductive load other than a motor, such as a transformer or an electric-discharge-lamp ballast, shall not be less than twice the rated full-load current of the transformer or ballast unless the switch has been investigated and found acceptable for the application.

28.3 In a permanently connected product rated 125 or 125/250 volts (3-wire) or less, no switch or overcurrent-protective device of the single-pole type other than an automatic control without a marked off

position shall be electrically connected to a terminal or lead intended for connection to the grounded conductor of the supply circuit.

28.4 A manually operated motor-control switch shall be provided in a cord-connected product that employs a motor rated more than 1/3 horsepower (250 W output).

28.5 A switch that controls a medium-base lampholder of other than a pilot or indicating light shall be acceptable for use with tungsten-filament lamps.

28.6 A product shall not employ a through-cord type switch.

29 Automatic Temperature Controls

29.1 An auxiliary control device in a product shall disconnect all heating elements that it controls from all ungrounded conductors of the supply circuit.

29.2 An auxiliary control is considered to be one that is intended primarily for time, temperature, pressure regulation, or similar functions under the conditions of intended operation, and not to reduce the risk of overload or excess-temperature conditions resulting from abnormal operation.

29.3 A temperature control – temperature-regulating, -limiting, or combination temperature-regulating and -limiting – shall comply with the requirements for temperature controls in Section 87 and with the requirements for limit controls in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

29.4 A temperature-regulating control is one by which the temperature is regulated and that, therefore, functions more or less frequently during intended operation of the product.

29.5 A temperature-limiting control is one that serves only to prevent abnormal temperatures and does not function during intended operation of the product.

29.6 A contactor or other device controlled by a temperature control shall comply with the endurance requirements applicable to the temperature control.

30 Spacings

30.1 Other than at field wiring terminals, the spacing between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part that is exposed to contact by persons or that may be grounded shall not be less than the value specified in:

a) Table 30.1 for a motor circuit, and

b) Table 30.2 for circuits without a motor.

Exception No. 1: The inherent spacings of a component of the product, such as a snap switch, are judged on the basis of the requirements for the component in question.

Exception No. 2: If an isolated dead metal part is interposed between or is in close proximity to live parts of opposite polarity, to a live part and an exposed dead metal part, or to a live part and a dead metal part that may be grounded, the spacing may be not less than 3/64 inch (1.2 mm) between the isolated dead metal part and any one of the other parts previously mentioned, provided the total spacing between the isolated dead metal part and the two other parts is not less than the value specified in Table 30.1.

Table 30.1
Spacings in motor circuits at other than field-wiring terminals

Potential involved, volts	Diameter of motor used in appliance[a]							
	7 inches (178 mm) or less				More than 7 inches			
	Over surface,		Through air,		Over surface		Through air,	
	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
0 – 125	3/32	(2.4)[b]	3/32	(2.4)[b]	1/4	(6.4)[c]	1/8	(3.2)[c]
126 – 250	3/32	(2.4)	3/32	(2.4)	1/4	(6.4)[c]	1/4	(6.4)[c]
251 – 600	1/2	(12.7)[c]	3/8	(9.5)[c]	1/2	(12.7)	3/8	(9.5)[c]

[a] The diameter of a motor is the diameter of the circle circumscribing the stator frame measured in the plane of the laminations, excluding lugs, fins boxes, and similar parts, used solely for motor mounting, cooling, assembly, or connection.

[b] For a motor rated 1/3 horsepower (250 W output) or less, these spacings may not be less than 1/16 inch (1.6 mm).

[c] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 inch (2.4 mm) over surface and through air between film-coated wire, rigidly supported and held in place on a coil, and a dead metal part is acceptable.

Table 30.2
Spacings other than at field-wiring terminals, in a circuit without a motor

Potential involved, volts	Minimum through air or over surface spacings, inch (mm)	
0 – 125	1/16	(1.6)
126 – 250	3/32	(2.4)[a]
251 – 600	1/2	(12.7)

[a] Spacings not less than 1/16 inch are acceptable at a heating element.

30.2 If an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces, or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the required minimum spacing will be maintained.

30.3 In a circuit incorporating two or more motors of different sizes, the spacings in the circuit are to be judged on the basis of the size of the largest motor in the circuit.

30.4 The spacings in a motor shall comply with the spacing requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

30.5 An insulating lining or barrier of vulcanized fiber or similar materials employed where spacing would otherwise be insufficient shall not be less than 1/32 inch (0.8 mm) thick, and shall be so located or of such material that it will not be adversely affected by arcing, except that vulcanized fiber not less than 1/64 inch (0.4 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Exception: Thinner insulating material may be used, if upon investigation, it is found to be acceptable for the application.

30.6 All uninsulated live parts connected to different line- or low-voltage circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirements in 30.1 and 30.7 and shall be judged on the basis of the highest voltage involved.

30.7 The spacing between field wiring terminals of opposite polarity, and the spacing between a wiring terminal and any other uninsulated metal part – dead or live – not of the same polarity, shall not be less than that specified in Table 30.3.

Table 30.3
Spacings at field-wiring terminals

Potential involved, volts	Minimum spacings, inch (mm)					
	Between wiring terminals, through air or over surface		Between terminals and other uninsulated metal parts not always of the same polarity[a]			
			Over surface		Through air	
250 or less	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
More than 250	1/2	(12.7)[b]	1/2	(12.7)[b]	3/8	(9.5)

[a] Applies to the sum of the spacings involved where an isolated dead metal part is interposed.

[b] A spacing of not less than 3/8 inch, through air and over surface, is acceptable at wiring terminals in a wiring compartment or terminal box if the compartment or box is integral with a motor.

30.8 At terminal screws and studs to which connection may be made in the field by means of the wire connectors, eyelets, and similar parts, as described in 16.2.11, spacings shall not be less than those specified in Table 30.1 when such connectors, eyelets, and similar parts, are in such position that minimum spacings – opposite polarity and to dead metal – exist.

30.9 The spacings in a low-voltage safety control shall comply with the requirements in 30.1 – 30.8 and Table 30.1 – Table 30.3.

30.10 At other than safety controls, the spacing between uninsulated live parts of opposite polarity and between such parts and dead metal that may be grounded in service is not specified for parts of circuits which are defined as low-voltage in 2.2.10.

30.11 For a capacitor employing a liquid dielectric medium more combustible than askarel and provided with an expansion mechanism to reduce the risk of expelling the dielectric medium, the spacing from a terminal of the capacitor including an assembled wire connector to:

a) An electrically isolated part or a part constructed of a nonconductive material shall be at least 1/2 inch (12.7 mm).

b) An uninsulated live part of opposite polarity or an uninsulated dead metal part that is either accessible or grounded shall be as specified in Table 30.4.

Table 30.4
Spacings for protected capacitors

Potential involved, volts	Minimum spacings[a]			
	Expansion		Electrical[b]	
	inch	(mm)	inch	(mm)
30 to 300	1/2	12.7	1/16	1.6
Over 300 to 600	1/2	12.7	1/8	3.2

[a] The minimum spacing required is the sum of the applicable expansion and electrical spacing values.

[b] This value is zero for a terminal including an assembled wire connector that is acceptably insulated for the highest voltage to which it may be subjected.

MECHANICAL SYSTEMS AND DEVICES – ENGINE DRIVEN PRODUCTS

31 Fuel Systems – Gasoline or Diesel

31.1 General

31.1.1 A fuel confining part having internal threads made of drawn brass or machined from brass rod shall be capable of withstanding, without cracking, the 10-Day Moist Ammonia-Air Stress Cracking Test specified in 106.3.

31.1.2 An engine-driven/flame heated unit shall have the gasoline fuel tank and supply system located so that they do not provide an air-vapor mixture exceeding the lower flammable limit in areas of possible ignition.

31.2 Fuel tanks

31.2.1 A fuel tank shall be constructed of material equivalent in strength, rigidity, and resistance to fire as mild steel having a minimum thickness of 0.024 inch (0.61 mm) for a fuel tank having a capacity of 1 gallon (3.8 L) or less, and 0.032 inch (0.81 mm) for a fuel tank having a capacity greater than 1 gallon.

31.2.2 A metal fuel tank of less than 0.032 inch (0.81 mm) thick shall be made of terneplate steel, aluminized steel, or galvanized steel or shall be provided with an inorganic coating on the inside and outside surfaces that provides equivalent protection against corrosion. See 31.2.3.

31.2.3 A metal fuel tank may be made of materials other than those mentioned in 31.2.2 provided the materials are galvanically compatible and are provided with protection against corrosion equivalent to the protection provided by the metals mentioned in 31.2.2. If the corrosion resistance properties of the metal are not known, a representative product shall be subjected to the salt-spray test described in 104.2.

31.2.4 A nonmetallic fuel tank, and a fuel tank constructed of nonmetallic and metallic materials in combination shall be resistant to the effects of Reference Fuel C [ASTM D471-79(1991)], heat aging, low temperature, and ultraviolet light if the nonmetallic surface is exposed to ultraviolet light during intended use. Resistance to the effects of these items are to be determined by the appropriate requirements in 104.3.1 – 104.6.3. See 31.2.5.

31.2.5 If a nonmetallic tank is provided with an exterior coating of paint for protection against ultraviolet light exposure, the acceptability of the paint for this purpose is to be determined by an investigation. Factors to be considered in the investigation are:

a) Effectiveness of the paint in providing protection against ultraviolet light,

b) Permanence and adherence of the paint in service, and

c) Adverse affect of the paint on the plastic.

31.2.6 Strengthening ribs or depressions in ferrous-metal fuel tanks that may trap water on the tank top shall not be more than 1/16 inch (1.6 mm) deep.

31.2.7 A fuel tank shall permit filling from a safety can that complies with the requirements in the Standard for Metal Safety Cans, UL 30, or the equivalent.

31.2.8 The inside diameter of a fill opening of a fuel tank shall be at least 0.72 inch (18 mm).

31.2.9 If a tank is within or contiguous to the engine compartment, the tank location and the facilities for filling shall be such that spillage or leakage will drain to the ground or product support surface and not onto the engine or electrical- or exhaust-system parts. Spillage tests are to be conducted, if necessary, to determine compliance with this requirement.

31.2.10 A fuel tank having a capacity greater than 1 gallon (3.8 L) and used in a gravity feed system shall incorporate an automatically operated positive shutoff in the fuel line. This positive shutoff may be a part of the carburetor, fuel pump, or similar component, or may be a separate fuel solenoid valve, and shall prevent fuel at 3 psig (20.7 kPa) or less from flooding the carburetor and spilling on the ground or product support surface when the engine is not operating.

31.2.11 A fuel tank having 1 gallon (3.8 L) or less capacity and using a gravity feed system shall incorporate either a manual-shutoff valve or an automatic-shutoff device as described in 31.2.10

31.3 Fuel pump

31.3.1 External fuel-confining parts of an electrically or mechanically operated fuel pump shall be of metal. Failure of operating parts shall not result in external leakage of fuel.

31.3.2 Each electrically operated fuel pump shall comply with the requirements for such pumps, see 3.1.

31.4 Fuel lines and fittings

31.4.1 A rigid fuel line shall be steel or seamless annealed copper tubing or the equivalent. Steel tubing shall have a corrosion-resistant exterior coating equivalent to that afforded by paint. See Table 45.2 for the minimum acceptable thickness of aluminum, copper, and steel tubing.

31.4.2 A flexible fuel line shall comply with the requirements in the Standard for Fuel and Oil Hose, ANSI/SAE J30, or the performance requirements for determining resistance to ASTM Reference Fuel C, heat aging, low temperature, and ultraviolet light as specified in the requirements in 104.3.1 – 104.6.3.

Exception: The burst pressure of a fuel line need not be more than 100 psig (689 kPa) if used in a pressure system, or 10 psig (69 kPa) if used in a gravity or suction system.

31.4.3 Nonmetallic tubing or hose shall comply with the requirements for the pull test in 106.1.1.

31.4.4 Metallic fuel-line tubing fittings shall be of the type complying with the Standard for Automotive Fittings, ANSI/SAE J512-NOV79, or the Standard for Fittings for Flared Copper Tubes, ANSI B16.26-1975, or the applicable requirements in the Standard for Tube Fittings for Flammable and Combustible Fluids, Refrigeration Services and Marine Use, UL 109, or the equivalent.

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

31.4.6 External fuel-confining parts of a filter, except a gasket or seal, shall be of metal.

Exception No. 1: Glass filter bowls may be used if they are located within a compartment or equivalently protected.

Exception No. 2: Filter bowls of other materials may be used if investigated and found acceptable for the normal use of the product.

31.4.7 Fuel lines shall be supported to reduce chafing and to maintain at least a 2-inch (51-mm) clearance from bare exhaust components.

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

31.5 Carburetors

31.5.1 A side or updraft carburetor shall be located so that overflow of gasoline due to excess choking will flow to ground or support surface and not contact electrical parts and exhaust system, or collect in an engine compartment. Nonmetallic drain hose, if used, shall comply with the fuel resistance, oil resistance, and dry-heat resistance tests of the Standard for Fuel and Oil Hose, ANSI/SAE J30, or the equivalent.

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

31.5.3 Each combustion air intake shall be provided with a backfire deflector (air cleaner) that complies with the requirements specified in the Backfire-Deflector Test, Section 107.

32 Fuel Systems – LP-Gas

32.1 General

32.1.1 An LP-Gas fuel system provided as part of the product shall be complete and installed at the factory, except as indicated in 32.1.2 and 32.1.3.

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

32.1.3 A product may be arranged for LP-Gas fuel but intended for use with a remotely mounted tank not provided as part of the product. Requirements for fuel containers do not apply to products of this type.

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

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

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

32.1.7 Valves and connections on LP-Gas containers shall be protected to reduce the likelihood of damage due to unintentional contact with stationary objects. Valves shall be protected to reduce the likelihood of damage due to collision, overturning, or similar occurrence. Parts of the product may be used to provide such protection to valves and fittings.

32.1.8 All fuel-system components shall be fastened to the product to reduce the likelihood of loosening due to vibration.

32.2 Containers

32.2.1 A fuel container shall be a pressure vessel constructed, tested, and marked in accordance with the ASME Unfired Pressure Vessel Code, or the Specifications of the Department of Transportation (DOT) for LP-Gas Containers.

32.2.2 A fuel container may be fixed to or removable from the product.

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

32.2.4 Each fuel container shall be located to reduce the possibility of damage to the container or its fittings. The fittings of a removable container shall be protected to reduce the possibility of damage during removal, filling, and replacement.

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

32.2.6 Instructions for installation shall indicate that a fuel container shall be installed with as much ground clearance as practical, but never less than the minimum ground clearance of the product in the area of the fuel container. This minimum clearance shall be measured to the bottom of the container or to the lowest fitting.

32.2.7 A fuel container shall be secured in place so as to comply with the requirements in the LP-Gas Container Securement Tests, Section 103.

32.2.8 A removable fuel container shall be constructed to engage a substantial positioning pin or an equivalent means for proper positioning of the container when reinstalled.

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

32.2.10 The use of a quick-closing coupling (a type closing in both directions when uncoupled) in the fuel line shall be considered as complying with the requirements of 32.2.9.

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

32.2.12 A fuel container from which vapor only is to be withdrawn shall be installed and equipped with connections arranged to reduce the risk of unintentional withdrawal of liquid.

32.2.13 A fuel container shall be shielded, if necessary, against direct heat radiation from the product to limit fuel temperatures in accordance with Table 67.1.

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

32.2.15 If an excess-flow or a back-pressure check valve, or both, are provided, they shall be located inside the container.

32.2.16 If a separate filling connection is provided it shall be fitted with a double back-pressure check valve, or a hand-operated shutoff valve and a back-pressure check valve.

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

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

32.2.19 An excess-flow or back flow check valve shall be provided in each container connection having an opening for the flow of gas in excess of a No. 54 drill size, 0.055 inch (1.4 mm); except a connection for a safety-relief valve.

32.3 Gauges

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

32.3.2 A fixed-tube gauge shall be employed on each fuel container.

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

32.3.3 The length of a fixed tube shall be such that, when the lower end touches the surface of the liquid in the container, the volume of the contents will not exceed 80 percent of the total container volume. This requirement applies to a removable container regardless of whether the container is being filled in the horizontal or vertical position.

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

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

32.4 Fuel lines and fittings

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

32.4.2 Steel and copper tubing shall have a wall thickness as specified in Table 45.2. Steel tubing shall have a corrosion-resistant exterior coating. Paint is considered to be an acceptable corrosion-resistant coating. Copper tubing shall be annealed. Aluminum tubing shall not be used.

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

32.4.4 Tubing fittings shall comply with the applicable requirements in the Standard for Tube Fittings for Flammable and Combustible Fluids, Refrigeration Service and Marine Use, UL 109.

32.4.5 Hose assemblies shall comply with the applicable requirements in the Standard for Pigtails and Flexible Hose Connectors for LP-Gas, UL 569.

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

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

32.4.8 Flexible hose passing through sheet metal shall be installed to reduce the likelihood of hose abrasion, such as by use of clamps and grommets.

32.4.9 All pipe threaded fuel-system fittings, including container fittings, shall be assembled using a pipe joint sealing compound intended for use with LP-Gas.

32.5 Vaporizers

32.5.1 Each vaporizer shall have a valve or plug located at or near the lowest portion of the section occupied by the water or other heating medium that will permit substantially complete draining of the vaporizer. The cooling system drain may serve this purpose if effective.

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

32.5.3 Vaporizers shall not be equipped with fusible plugs.

32.6 Safety-control and relief devices

32.6.1 A spring loaded internal-type safety-relief valve with proper start-to-discharge setting and flow capacity, as specified in 32.6.2 – 32.6.5, shall be provided on the fuel container.

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

32.6.3 A safety-relief valve on an ASME container shall be marked with its discharge capacity in cubic feet (cubic meters) per minute of air in accordance with Table 32.1.

Table 32.1
Safety-relief valve capacity

Container surface area,		Minimum flow rate of air	
ft^2	(m^2)	CFM	(M^3/m)
20 or less	1.86 or less	626	17.73
25	2.32	751	21.27
30	2.79	872	24.69
35	3.25	990	28.03
40	3.72	1100	31.15

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

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

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

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

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

32.6.9 An automatic switch, such as an oil-pressure switch or vacuum switch, provided to control the automatic-shutoff valve shall be rated for the load controlled and shall be constructed for the intended use.

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

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

32.7 Nonmetallic parts

32.7.1 A synthetic-rubber part shall comply with the requirements for Tests on Gaskets, Seals, and Parts, Section 70.

32.8 Exhaust System

32.8.1 A muffler provided as part of the engine system of the product shall have spark arresting capabilities and shall be qualified and rated by the U. S. Department of Agriculture Forest Service as a spark arrester for internal combustion engines (USDA-Forest Service Standard 5100-12). The muffler may be integrally installed as part of the product or provided as a separate piece for field installation in accordance with the manufacturer's instructions.

32.8.2 The muffler shall be located or shielded to reduce the risk of injury from unintentional contact with hot parts in accordance with the temperature limits specified in Table 67.1.

32.8.3 Exhaust components formed of ferrous sheet, pipe, or tubing materials intended to be routed within the confines of an enclosure for the engine assembly shall be formed of a material that provides strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel at least 0.032 inch (0.81 mm) thick.

32.8.4 The engine exhaust shall be located and directed so as to reduce the risk of injury to persons.

32.9 Battery compartment

32.9.1 If a separate lead-acid storage battery is intended to be provided with, or as part of, the engine assembly, means shall be provided to secure it in a position to prevent contact with conducting materials in the area and it shall be located to permit ready access to the cell openings for servicing.

32.9.2 If provision is made for battery positioning within a separate compartment, the compartment shall have ventilation directly to the exterior. The ventilation shall consist of at least 2 square inches (13 cm^2) of open area near the top of the compartment and 2 square inches of open area near the bottom of the compartment.

32.9.3 There shall be no sparking or arc producing devices (switches, relays, and similar devices) located within the battery compartment or closer than 12 inches (305 mm) to the battery when in an open or unshielded product.

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

MECHANICAL SYSTEMS AND DEVICES – FUEL FIRED PRODUCTS

33 General

33.1 Ignition assembly

33.1.1 The igniter, pilot burner, and pilot flame-sensing device shall be constructed and supported so that each will be fixed in its proper position.

33.1.2 The means for ignition shall be located so as to reduce the possibility of the collection of carbon and other material, or the dislocation, distortion, or burning of parts when the burner is tested in accordance with the requirements specified in Sections 93 – 95, Ignition Tests.

33.1.3 The construction of a burner assembly shall be such that the igniter assembly may be readily withdrawn from and replaced in the burner assembly during servicing of the igniter assembly and burner assembly without resulting in:

a) Reduction of the clearances between bare current-carrying parts, electrodes, and grounded metal parts.

b) Changes in the air gap at electrode tips.

c) Reduction of the spacings between the high-potential cables and grounded metal parts.

d) Changes in the position of the igniter or pilot relative to the area at which ignition is to be initiated.

33.2 Gas-fired burners

33.2.1 A gas-fired product provided with an electric-ignition system shall, for each individual combustion chamber, ignite the pilot of a gas burner assembly having an input of more than 400,000 Btu per hour (117.2 kW), per individual combustion chamber, or the pilot or main burner of a gas burner having an input of 400,000 Btu per hour or less.

33.2.2 The ignition system shall be activated before the delivery of fuel to the ignition zone and shall remain active during the main burner flame-establishing period. If means for ignition is cut off at the

termination of the main burner flame-establishing period, the ignition (igniter, pilot, and any pilot igniter) shall remain off for the duration of that firing cycle and for the purge period required upon attempting the next firing cycle.

33.3 Oil-fired burners

33.3.1 The ignition system of an automatically-lighted burner shall be activated before or simultaneously with the delivery of fuel to the ignition zone and shall remain active during the trial-for-ignition period. If ignition is cut off at the termination of the trial-for-ignition period, the ignition shall remain off for the duration of that firing cycle unless the ignition is fully restored within 0.8 second upon unintentional extinguishment of the main burner flame.

34 Burner Assemblies

34.1 General

34.1.1 A burner shall be provided as a separate assembly that is then attached to the cleaning machine at the factory or is shipped with the cleaning machine for field assembly (see 7.4), or incorporated into the overall assembly of the cleaning machine. If the burner is provided as a separate assembly, it shall include all the essential parts necessary for its intended function when installed as intended. The burner assembly may be shipped as two or more subassemblies in accordance with 34.1.3.

34.1.2 A separately provided burner assembly, if not assembled by the manufacturer as a unit assembly, shall be arranged in as few subassemblies as practicable. Each subassembly shall be capable of being incorporated into the final assembly without alteration, cutting, threading, welding, or similar tasks by the installer. Two or more subassemblies, that must bear a definite relationship to each other for the intended operation of the product, shall be arranged and constructed to permit them to be incorporated into the complete assembly, without need for alteration or alignment, only in the correct relationship with each other.

34.1.3 The various parts of a burner whether provided as a separate assembly or incorporated into the overall assembly of the cleaning machine shall be constructed and assembled in accordance with the requirements specified in 34.1.4 – 34.3.18 in a manner that provides acceptable strength, rigidity, and durability.

34.1.4 Burner piping components such as the main automatic gas-shutoff valve, main manual gas-shutoff valve, pressure regulator, and similar components, may be furnished as separate parts provided that they can be joined in the field with standard piping. The standard piping may be furnished, cut, and threaded by the field installer.

34.1.5 The burner shall provide a uniform and definite supply of fuel and air for combustion when installed and adjusted in accordance with the manufacturer's installation instructions. The means for regulating the supply of air and fuel shall be arranged so that the adjustments may be fixed or restricted in a manner to reduce the possibility of unintentional changes in settings.

34.1.6 All parts requiring adjustment or manipulation by the user in the course of operation of the burner shall be accessible and easily moved. Any part that may normally come in contact with the operator's hand during usage shall be free from sharp edges or projections and projecting sharp screw ends.

34.1.7 An adjustable or movable part shall be provided with a locking device to reduce the possibility of unintentional shifting.

34.1.8 Each burner assembly part, control, and safety device requiring normal care shall be accessible. Parts in an assembly removed for normal care shall be arranged such that their restoration following

removal will not necessitate their realignment to secure their proper relationship with other parts of the assembly. Other than ordinary tools that may be required for normal care to be done by the operator shall be supplied with the burner assembly.

34.1.9 Each burner assembly or subassembly shall incorporate provisions for support, adjustment, and attachment to the product or to the foundation on which it rests so that it can be installed so as to prevent its twisting, sliding, or dropping out of the correct position.

34.1.10 A burner of the swing type shall be provided with means for locking the burner in the firing position and, for an automatically-lighted burner, to prevent it from discharging fuel when in other than the firing position.

34.1.11 Screws or bolts used to attach parts that are detached for servicing of the burner shall withstand the torques specified in Table 34.1 after removal and replacement.

34.1.12 The base or frame on which burner parts are mounted shall be made of noncombustible material.

34.1.13 Each base or frame shall incorporate provisions for installing the assembly, and shall include securing and adjusting means for leveling and alignment if such operations are necessary.

Table 34.1
Torque requirements for screws or bolts

American standard screw size		Torque		I.S.O. screw size	Torque	
No.	mm	Lbf-In	N·m	mm	N·m	Lbf-In
–	–	–	–	4	1.6	14
8	4.2	18	2.0	4.5	2.6	23
10	4.8	30	3.4	5	4.2	37
Inch	mm					
1/4	6.4	100	11.3	6	8.7	77
–	–	–	–	7	15.0	133
5/16	7.9	200	22.6	8	23.5	208
–	–	–	–	9	33.6	297
3/8	9.5	350	39.6	10	45.2	400
7/16	11.1	575	65.0	12	81.0	715
1/2	12.7	850	96.0	14	128.0	1130
9/16	14.3	1200	136.0	–	–	–
5/8	15.9	1600	181.0	16	185.0	1640

34.1.14 Each fan housing and air duct shall be made of noncombustible or equivalent material and shall have the strength and durability to not be damaged during the tests specified in Sections 65 – 68 and 92 – 99.

34.2 Gas-fired assemblies

34.2.1 Bolt holes in a gas-fired burner assembly shall not intersect gasways unless provision is made to provide gas tightness.

34.2.2 Burner heads, mixer heads, and mixer tubes shall be of metals having a melting point (solidus temperature) greater than 788°C (1450°F).

34.2.3 A ribbon burner shall be so constructed that the ribbon assembly can be removed, cleaned, and replaced without the need for other than ordinary tools.

34.2.4 The burner orifice and orifice holder shall be made of a material having a melting point (solidus temperature) of not less than 788°C (1450°F) for use with manufactured and mixed gases and not less than 593°C (1100°F) for natural gas, LP-Gas, and LP-Gas-air mixtures.

34.2.5 Main burner gas orifice spuds shall be threaded into their holders with at least 3-1/2 full threads.

34.2.6 The exterior portion of a firing head within 6 inches (152 mm), measured parallel to its axis, from the firing end and all parts normally in contact with masonry, shall be made of iron or steel or acceptable refractory. Interior parts shall be made of materials acceptable for the purpose.

34.2.7 Flame spreaders and flame-spreader supports used with upshot-type burners shall be constructed so that they cannot be incorrectly fitted together, or they shall be marked to indicate the correct method of assembly if it is necessary to remove the flame spreader for service or assembly. A flame spreader shall not be threaded to its support unless the support is readily removable.

34.2.8 Flame-spreader supports used with upshot-type burners shall be constructed so that the flame spreader can be supported only at the correct distance above the burner.

34.2.9 Burners shall be provided with means to prevent disintegrated ceramic flame-spreader material from falling into the burner ports. They shall also be constructed so that disintegration of the ceramic will not cause an adverse change in the operating characteristics of the burner.

34.2.10 Joints in the pressure zone or in the burner head of a burner assembly shall be gastight and shall not depend for mechanical strength nor primarily for tightness on cement or other sealing material, except for joints forming part of the port area. Joints shall be bolted, screwed, machined, welded, brazed, or of equivalent construction.

34.3 Oil-fired assemblies

34.3.1 Fuel-confining parts or operating parts of an oil-fired burner assembly shall not sag, distort, melt, oxidize, show leakage of fuel, or prevent a safety device from functioning during any of the tests specified in Sections 65 – 68 and 92 – 99.

Exception: See 34.3.3.

34.3.2 A material shall have a melting point (solidus temperature) of not less than 510°C (950°F) and a tensile strength not less than 10,000 psig (69 MPa) at 204°C (400°F).

Exception: See 34.3.3.

34.3.3 Fuel-confining parts not complying with 34.3.1 and 34.3.2 may be employed if a fusible-link valve or the equivalent is included in the burner system so as to shut off the fuel supply in the event of excessive temperature or fire in the vicinity of such parts.

34.3.4 A burner part intended for the handling of fuel under pressure shall withstand, without rupture, a hydrostatic pressure equivalent to five times the maximum working pressure.

34.3.5 Soft solder shall not be used on any fuel-handling parts if melting of the solder may allow leakage of fuel. Soft-soldered joints shall be made mechanically secure before soldering.

34.3.6 A burner shall function so as to reduce the generation of unburned vapors, and shall not include chambers or pockets in which unburned vapors may accumulate. An oil-conveying pipe or passage shall not be exposed to such temperatures as may result in carbonization or clogging when the burner is tested in accordance with the requirements specified in Sections 65 – 68 and 92 – 99.

34.3.7 If the abnormal discharge of oil is prevented by the establishment and maintenance of a definite maximum level of oil in the burner, the parts required to maintain that oil level shall be assembled and fixed upon a common base in the correct relationship with one another by the burner manufacturer. The minimum distance between the intended maximum normal oil level in the burner and the level of the lowest point at which overflow may occur shall be not less than 3/4 inch (19.1 mm).

34.3.8 A firing assembly, atomizer and nozzle assembly, and similar assemblies, intended to be removed and replaced for servicing shall be constructed so that, upon replacement, the assembly will self-restore the atomizer or nozzle to its correct position.

34.3.9 A small orifice or other opening in an oil supply system shall be protected by a strainer as described in 34.3.10 – 34.3.14.

34.3.10 Each strainer shall comply with the requirements in the Standard for Strainers for Flammable Fluids and Anhydrous Ammonia, UL 331.

34.3.11 The larger dimension of the largest opening of a strainer element shall not be greater than 90 percent of the smaller dimension of the smallest fixed opening protected by the strainer.

34.3.12 For the purpose of these requirements, a metering valve, a float valve, and an automatic-safety valve shall be considered as a fixed opening, having a diameter of 0.03125 (1/32) inch (0.79 mm) when No. 1 and 2 oils are used, and 0.0625 (1/16) inch (1.59 mm) when No. 4, 5 and 6 oils are used.

34.3.13 A primary strainer shall be based on the maximum firing rate of the burner and the heaviest grade of fuel for which the burner is intended.

34.3.14 Pipe or other fuel conduit used to connect a float valve, metering valve, or safety valve to the protecting strainer shall be free of dirt and scale at the time of assembly.

34.3.15 A fan housing in which oil leaking from any oil-handling part of the assembly may accumulate (for example, an inverted fan housing on a gun-type burner) shall be provided with an open drain.

34.3.16 An air tube of a gun-type oil burner shall prevent the accumulation of oil in it. Any drippage from the nozzle shall drain to the fire box. A drain shall be located to reduce the risk of blockage by refractory or cement.

34.3.17 The exterior portion of a firing head within 6 inches (152 mm), measured parallel to its axis, from the firing end, and all parts that may be in contact with masonry when the burner is installed as intended, shall be made of iron or steel. Interior parts shall be made of materials complying with 34.3.1 – 34.3.5.

34.3.18 An outer shell of a blast tube or firing head, if made of sheet metal, shall have the necessary strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to sheet steel not less than 0.053 inch (1.35 mm) thick or Type 309 stainless steel not less than 0.026 inch (0.66 mm) thick.

35 Combination Gas-Oil Burner Assemblies

35.1 A combination burner assembly intended to burn only one fuel at a time shall be arranged so that the fuel not being fired will be shut off automatically when the burner assembly for that fuel is not in firing position or is not intended to be fired.

35.2 A combination burner assembly intended to burn only one fuel at a time, equipped to change automatically from one fuel to the other, shall be arranged so that the fuel being fired is shut off before the other fuel is delivered to the ignition zone. The ignition system for the fuel to be fired shall provide a predetermined ignition cycle that shall be initiated before the delivery of main burner fuel to the ignition zone.

35.3 A burner intended to burn both gas and oil simultaneously shall be regulated so that the total input to the burner does not exceed the maximum for which the burner is constructed.

36 Electric High-Tension Ignition System

36.1 Assembly

36.1.1 The requirements for electric high-tension ignition systems specified in 36.1.2 – 36.5.2 are based upon the use of ignition energy that is essentially sinusoidal. Other types of systems employing ignition energy that is not essentially sinusoidal may be considered. Among the factors taken into consideration in determining the acceptability of such systems are dielectric properties, electrical spacings, the true root-mean-square value and the peak voltage of the system, the average pulse power, time between pulses, duration of the pulses, and duty cycles.

36.1.2 A high-tension current-carrying part, such as a bus bar, electrode, or terminal, shall be enclosed or insulated to provide protection against the possibility of unintentional contact. See Section 15, Accessibility of Uninsulated Live Parts and Film Coated Wire.

36.1.3 If an adjustable air deflector or similar part is employed in the vicinity of bare conductors, the construction shall be such that the part may be securely fixed to maintain any spacing required to comply with 83.4.

36.2 Electrode and bus bars

36.2.1 Bare high-tension conductors shall be self-sustaining when in place.

36.2.2 An electrode or bus bar supporting an electrode shall be so constructed that it may be fixed in its intended position and maintain the intended gap.

36.2.3 A setscrew shall not bear directly against an insulator. The construction shall be such that an insulator is not likely to be damaged when tightening the securing means.

36.2.4 An electrode shall be prevented from rotating within its insulator, unless such rotation will not result in any change in spacing or alignment.

36.2.5 An electrode tip shall be of such material that burning of its point will not be evident while the burner is being tested in accordance with Sections 93 – 95. High-temperature alloy steel or equivalent material shall be used for the electrode tip.

36.2.6 An oil burner electrode slanting downward toward its insulator shall be provided with a drip loop, or the equivalent, to prevent oil running down the electrode from reaching the insulator.

36.3 Insulators

36.3.1 An insulator shall be:

a) Made of ceramic insulating material or the equivalent,

b) Impervious to oil and moisture, and

c) Cleanable by wiping.

36.3.2 An insulator shall provide the minimum distance specified in Table 36.1, as measured across the surface of the insulator, between the nearest point of an uninsulated current-carrying part and the nearest grounded metal surface.

Exception: An insulator included in a proved gas pilot assembly to be energized by a transformer having a secondary voltage of not more than 6000 volts need not comply with 36.3.2 and Table 36.1 if ignition is for combustible air-gas mixtures under pressures of not less than 1/4 inch water column (62 Pa) and handled only within or adjacent to a pilot tip or nozzle.

Table 36.1
Spacing over surface of insulators

Secondary voltage of ignition transformer	Minimum surface distance over insulation	
	inches	(mm)
Not more than 10,000	1-1/2	38.1
Not more than 15,000	2	50.8
NOTE – Except as indicated in 36.3.2, an insulator included in the assembly of a spark-ignited gas burner or gas pilot shall have an over surface spacing of not less than 1 inch (25.4 mm) if the secondary voltage of the ignition transformer is 6000 volts or less.		

36.3.3 An insulator shall be located so that no detrimental accumulations of carbon will form on its surfaces when the burner is tested in accordance with the requirements in Sections 93 – 95, Ignition Tests.

36.4 Leads

36.4.1 Ignition cable shall have a voltage rating equal to or greater than the rated secondary voltage of the ignition transformer. Each end of a high-tension lead shall be provided with a fixed loop, eyelet, or connector to facilitate the provision of electrical connection to the terminal. A high-tension lead or cable shall be run individually in a manner that does not require sharp bends.

36.4.2 An ignition cable that passes through a metal wall shall be protected by an insulating bushing of porcelain or molded phenolic having a wall thickness of at least 1/8 or 1/16 inch (3.2 and 1.6 mm), respectively, or by other insulating materials that provide equivalent protection.

36.5 Transformers

36.5.1 A transformer shall be mounted as closely as possible to the spark gap to provide leads of acceptable length. It shall not be located within 1 inch (25.4 mm) of the floor when the burner is installed in accordance with the manufacturer's installation instructions unless that portion of the case within 1 inch of the floor is waterproof.

36.5.2 A transformer high-tension insulator shall be spaced at least 1/8 inch (3.2 mm) from any adjacent metal part other than the transformer case.

37 Electric Hot-Wire Ignition System

37.1 An electric hot-wire ignition system shall:

a) Be acceptable for the application,

b) Have a voltage rating not less than the circuit in which it is employed, and

c) Comply with the requirements specified in 95.3.1 – 95.6.2.

37.2 The wiring between a transformer and an electric hot-wire igniter shall be of sufficient capacity for the current involved and shall be provided with insulation having a temperature rating and thickness consistent with its use. Bare terminals shall be enclosed.

38 Gas Pilots

38.1 General

38.1.1 A pilot burner not automatically lighted shall be placed so that it can be lighted manually without increasing the risk of fire or injury to persons.

38.1.2 A pilot burner, electric igniter, and pilot flame-sensing device shall be supported in such a manner that their position relative to each other and to the ports of the main burner or burners will remain fixed and means shall be provided to reduce the possibility of incorrect assembly or mounting of any pilot burner in relation to the burner being served.

38.1.3 Clearance shall be provided for removal and replacement of the pilot burner without kinking the pilot gas tubing.

38.1.4 Primary air openings and orifices shall be accessible for servicing.

38.1.5 Tips of continuous burning aerated pilot burners shall be made from AISI Type 416 stainless steel or material having at least equivalent heat and corrosion resistant characteristics. Nickel alloys of greater than 1.0 percent nickel shall not be used due to the possibility of catalytic cracking effect.

38.2 Gas-fired burners

38.2.1 A pilot provided for ignition of a main burner unit shall be proved. If multiple burners are operated as a unit, a sufficient number of pilots shall be used to accomplish proper ignition.

38.2.2 The gas-supply pressure to the pilot or a group of pilots shall be regulated separately of the main burner-gas regulator. The pilot-supply line shall be connected, or arranged to permit connection, upstream from all main burner valves and the main burner regulator.

Exception: A gas burner having an input rate of 400,000 Btu per hour (117 kW) or less to any individual combustion chamber may be provided with a single gas-appliance pressure-regulator to control the pressure of both pilot and main-burner gas, provided it is of the type acceptable for pilot and main burner load application.

38.2.3 If a pilot burner-supply line is taken from a horizontal line, the connection shall be made either at the side or top of the pipe. The pilot-supply line shall be connected upstream of all main burner valves and regulators.

38.3 Oil-fired burners

38.3.1 A pilot burner shall be located so that fuel oil will not accumulate on or in it when the burner is firing or when the burner fails to ignite.

38.3.2 The gas pilot shall be independently controlled by means of a manually operated pilot-shutoff valve.

39 Valves

39.1 General

39.1.1 The pressure rating of a valve shall be not less than the maximum operating pressure of the burner.

39.1.2 Safety-shutoff valves shall be constructed so that they can not be restrained or blocked in the open position. Such valves shall close upon being de-energized regardless of the position of an operating lever or reset handle.

39.1.3 An electrically operated safety-shutoff valve shall not depend on electricity to shut off the fuel supply.

39.1.4 A pressure-operated safety-shutoff valve shall close upon complete loss of pressure.

39.2 Automatic safety-shutoff valves – gas-fired burners

39.2.1 Each main burner supply line and each pilot supply line shall be equipped with at least one safety-shutoff valve that will close, independent of external force and with sufficient closing force to provide tight shutoff under intended operating conditions. If the maximum firing rate per combustion chamber exceeds 2,500,000 Btu per hour (733 kW), the main burner-supply line shall be equipped with:

a) Two safety-shutoff valves, in series, or one safety-shutoff valve of the type incorporating a valve seal overtravel interlock, when the maximum firing rate per combustion chamber exceeds 2,500,000 Btu per hour but is not more than 5,000,000 Btu per hour (1,465 kW), or

b) Two safety-shutoff valves in series, one of which is of the type incorporating a valve seal overtravel interlock when the maximum firing rate per combustion chamber exceeds 5,000,000 Btu per hour. Burners having a maximum firing rate per combustion chamber in excess of 12,500,000 Btu per hour (3,663 kW) and equipped to fire fuel gas having a specific gravity less than one shall also include a normally open 3/4-inch (19-mm) or larger electrically operated valve in a vent line located between the two safety-shutoff valves.

39.2.2 Safety-shutoff valves shall shut off after being de-energized within the time limits specified in Table 46.1.

39.2.3 A bypass to provide for minimum flame may be installed around a valve used to regulate fuel input only. A bypass shall not be installed around a safety-shutoff valve or a combination input control and safety-shutoff valve.

39.2.4 Means shall be provided to facilitate testing automatic valves for leakage when in the closed position.

39.3 Automatic safety – shutoff valves– oil-fired burners

39.3.1 An automatic safety valve shall shut off in not more than 5 seconds after being de-energized. It shall be constructed so that it may not be restrained or blocked in the open position.

39.3.2 A nozzle-shutoff valve of the automatic type shall close at a pressure above the minimum atomizing pressure of the burner.

39.4 Manual valves – gas-fired burners

39.4.1 Manually operated main-shutoff and pilot-shutoff valves in sizes larger than 2 inches (51 mm) or for pressures greater than 0.5 psig (3.4 kPa) shall be of the lubricated plug or ball type, with stops. Manually operated valves shall have the handle attached parallel to the gas flow when in the open position, shall be accessible, and shall be marked to indicate the on and off positions.

39.4.2 A manually operated main-burner-shutoff valve shall be installed in the line supplying all main burners of each gas device and shall be located upstream of main-burner-gas control and automatic safety-shutoff valves.

39.4.3 A manually operated pilot-shutoff valve shall be located in the gas supply line to a pilot burner or burners.

39.4.4 A manually operated main-burner-test valve (checking-gas cock) shall be provided downstream from the safety-shutoff valve for each main burner that is manually lighted. The test valve shall be interlocked with the safety-control circuit and arranged so that the main burner-safety shutoff-valve must be opened against their associated closed test valve.

39.5 Manual valves – oil-fired burners

39.5.1 A plug or rotating-disc type valve, employing the bearing surface of the plug or disc as the liquid seal to the exterior of the valve body, shall not be used in a fuel-oil line.

39.5.2 An air-bleeder valve provided in the oil supply line shall be of a self-closing type.

39.5.3 A pressure-regulating valve shall incorporate a means of shielding or locking the adjustment to discourage tampering by unauthorized persons after being set. The valve shall be constructed so that the maximum pressure of oil at the maximum valve setting will not exceed the intended maximum pressure for the burner.

39.6 Pressure-relief valves

39.6.1 A pressure-relief valve used in an oil-fired burner shall be connected into a fuel line in which pressure may build up in excess of that intended by the construction, because of the closing of any valve in the assembly of the burner or when the oil is heated by a preheater.

40 Pressure Regulators

40.1 A spring or weight loaded pressure regulator used in gas-fired burners shall have the springs or weights covered by a housing. A weight and lever type of regulator shall not be used.

40.2 The diaphragm housing of a gas-pressure regulator shall be constructed so that a vent pipe may be connected. See 112.3.4 for the marking requirements for vent-line connection.

40.3 A gas-pressure regulator shall be furnished on a gas-fired burner. The regulator shall be located upstream of all automatically operating valves and pressure detecting devices. This regulator may be an integral part of a gas valve assembly or a separate unit.

41 Heating Surfaces and Combustion Chambers

41.1 Heating surfaces shall be constructed of cast iron, sheet steel, or other acceptable material. Sheet steel, if used, shall have strength, rigidity, durability, resistance to corrosion, and other physical properties equivalent to AISI Type C1010 sheet steel that:

a) For a gas-fired burner is not less than 0.053 inch (1.30 mm) thick.

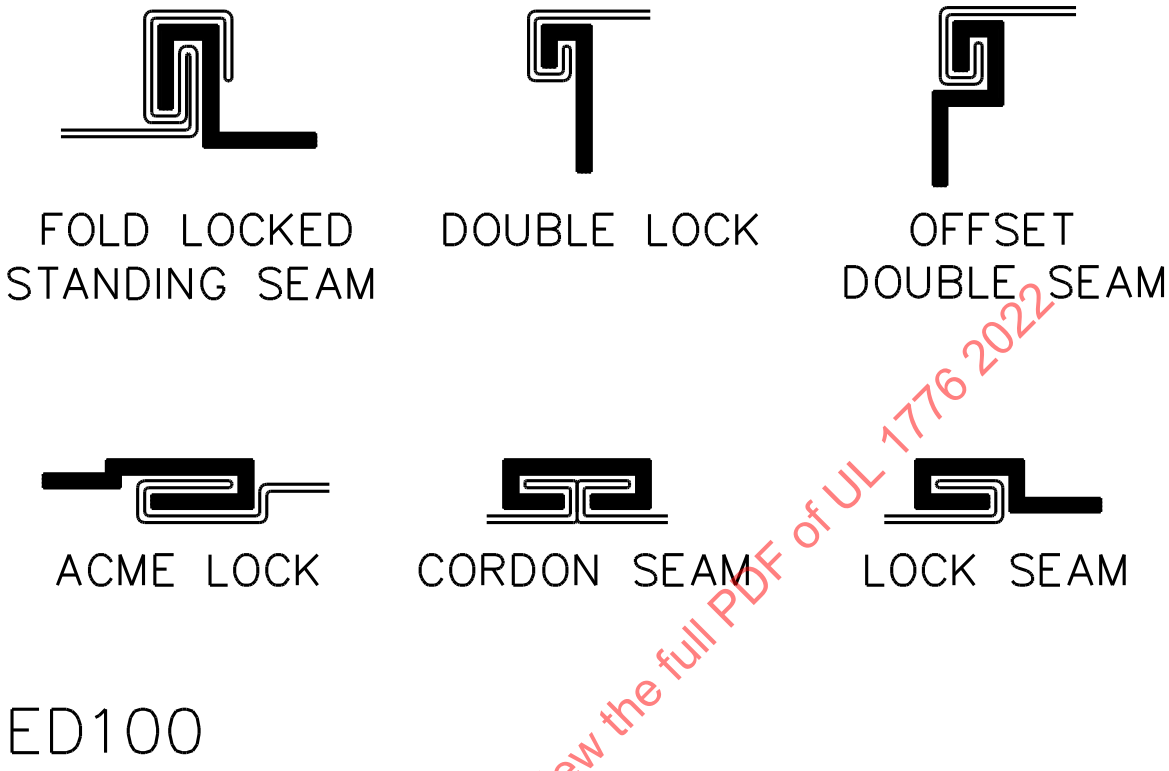
b) For an oil-fired burner is not less than 0.042 inch (1.07 mm) thick.

41.2 Combustion-chamber (fire box) lining, if used, shall be durable, securely held in place, and accessible for replacement with an equivalent material.

41.3 Joints in heating surfaces shall be welded, lock-seamed, machined, and bolted or riveted. The tightness of each joint shall be equivalent to that provided by lock-seaming and shall not depend solely on cement for tightness. A slip or lap joint shall not depend solely upon friction of the joint itself for strength. For some examples of an acceptable lock-seam, see Figure 41.1.

Figure 41.1

Types of acceptable lock-seams



42 Baffles

42.1 A baffle in a flue-gas passage or otherwise exposed to combustion products shall be fixed in position. A flue baffle shall be made of material having resistance to corrosion equivalent to AISI Type C1010 sheet steel not less than 0.042 inch (1.07 mm) thick, unless its deterioration will not cause excessive temperatures when the product is tested in accordance with Section 67.

42.2 Each flue baffle shall be removable for cleaning or shall be constructed so that it cannot be dislodged or distorted during cleaning. Flue baffles that are removable for cleaning shall be constructed so as to reduce the possibility that they may be replaced in an incorrect position.

43 Draft Control

43.1 An adjustable damper, if provided, shall be equipped with minimum and maximum operating stops. The minimum operating stop for the damper shall be located to obtain sufficient air for complete combustion at minimum burner input.

43.2 An automatically operated damper, if provided, shall maintain the intended damper opening at all times and be arranged to prevent starting of the burner unless the damper is in the intended position for starting.

43.3 An automatically operated flue damper, if provided, shall be counterbalanced to assume an open position in the event of breakage or failure of its operating means. Operating parts shall be located or shielded so that interference with their movement will not increase the risk of injury to persons in case of breakage.

43.4 A barometric-draft regulator or draft hood, if provided, shall not require installation in a false ceiling, in a different room, or in any manner that will permit a difference in pressure between the air in the vicinity external to the regulator or draft hood and the combustion-air supply.

43.5 *Deleted*

43.6 A draft hood, if provided, shall comply with the applicable construction requirements in the Standard for Draft Hoods, ANSI Z21.12.

43.7 An adjustable flue damper shall not be used in connection with a product equipped with a draft hood or draft regulator.

44 Venting

44.1 A flue collar or a flue-collector part shall have the rigidity, heat, and corrosion resistance at least equivalent to that of AISI (American Iron and Steel Institute) Type 1010 steel having a thickness as specified for heating surfaces. The collar shall extend externally through the casing a sufficient distance to permit secure attachment of the vent connector.

45 Fuel-Supply System

45.1 Oil tanks

45.1.1 A gravity tank intended to be included as part of the product shall have a capacity of not more than 60 ±3 gallons (227 ±11.3 L). A 5-percent tolerance is acceptable. The tank shall be constructed for permanent attachment to the product.

45.1.2 A tank shall be constructed of noncombustible material acceptable for the purpose. Materials other than those described in 45.1.3 – 45.1.10 are to be investigated to determine their acceptability for the purpose.

45.1.3 The thickness of uncoated sheet steel employed in tanks shall not be less than No. 18 MSG (1.07 mm). An acceptable finish shall be applied to uncoated surfaces of tanks to prevent rusting prior to use.

45.1.4 The thickness of aluminum-coated steel, galvanized steel, terne sheet, and corrosion resistant sheet metal employed in tanks shall not be less than that specified in Table 45.1. Coated sheet shall be free from blisters, flux, and uncoated spots visible to the unaided eye.

Table 45.1
Minimum thickness of sheet metal for fuel tanks

Actual capacity, gallons (L)	Minimum thickness, gauge no.
3 or less (11.4 or less)	26
3.1 – 6.0 (11.5 – 22.7)	24
6.1 – 10.5 (22.6 – 39.7)	22

45.1.5 The thickness of a zinc coating on sheet steel shall not be less than that on Grade G90 galvanized steel complying with the Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality, ASTM A526-90.

45.1.6 The coating of terne sheet shall not be less than 8 – 12 pounds (3.6 – 5.4 kg) per double base box [112 sheets, 20 by 28 inches (508 by 711 mm)].

45.1.7 The coating of aluminum-coated steel shall not be less than 0.5 ounce per square foot (152.8 g/m^2) of sheet.

45.1.8 A material with coating thicknesses other than as described in 45.1.5 – 45.1.7 may be investigated for equivalence to Grade G90 zinc-coated steel not less than 0.019 inch (0.48 mm) thick.

45.1.9 A material having each side differently coated may be used, provided the material complies with 45.1.8 on the side of the material that is in contact with oil. The outside of the fuel tank shall be provided with corrosion protection by painting or plating.

45.1.10 A tank made of uncoated sheet steel, aluminum-coated steel, and terne sheet shall be of full-drain construction. Full-drain construction is obtained by building a tank so that it is emptied through the fuel outlet at the bottom of the tank.

45.1.11 A tank not required to be of full-drain construction, and not so designed, shall allow the ready removal of any accumulation of water or sludge. For a gravity tank not over 18 inches (457 mm) deep, this may be accomplished by providing an accessible fill opening large enough to permit entrance of the average adult hand.

45.1.12 Each joint of a tank shall be lock-seamed, brazed, welded, or otherwise made mechanically secure. A joint not continuously brazed or welded shall be thoroughly sweated with solder or equivalent. Brazing or welding of coated sheets less than 0.042 inch (1.07 mm) thick shall not damage the coating of surfaces in contact with oil when the tank is full. All connections shall be made through solid threaded bosses or fittings mechanically secured to the tank.

45.1.13 An integral-gravity tank shall be provided with:

a) A liquid-level indicator that is readily observable when the tank is being filled, or

b) A fill opening of a shape and size permitting ready observation of the fuel level within the upper 2 inches (51 mm) of the lowest point of overflow while the tank is being filled.

45.1.14 A tank that employs a gauge glass or any other fuel-level indicator that, when damaged, may allow flooding at the burner or escape of fuel from the tank either when the tank is installed on the product as intended, or is in a position in which it may be stored or carried, shall be marked as specified in 112.1.20. If the indicator employs thermoplastic, gasket, or other seal materials, the tank shall be subjected to the Tests on Gaskets, Seals, and Parts, Section 70.

45.1.15 The top of the fill opening of a tank not equipped with a gauge complying with the requirement in 45.1.13 shall not be above the level at which fuel will overflow the tank.

45.1.16 A gravity tank shall permit ready filling by the user without increasing the likelihood of spillage of fuel.

45.1.17 A product equipped with a three-way valve to permit optional fuel feed from the integral tank or from a separate tank shall be arranged so that the valve cannot be positioned to permit oil to flow from one tank to the other, or permit oil to be delivered from both tanks simultaneously.

45.2 Fuel lines and piping

45.2.1 An opening threaded for pipe connection shall be threaded in accordance with the Standard for General Purpose (Inch) Pipe Threads, ANSI/ASME B1.20.1.

45.2.2 An opening for field attachment to pipe larger than nominal 3-inch ANSI/ASME B1.20.1 pipe size shall be provided with a flanged pipe connection complying with the Standard for Cast Iron Pipe Flanges and Flanged Fittings, ANSI B16.1.

45.2.3 A fitting, other than one complying with the appropriate American National Standard, shall comply with the applicable torque requirements specified in Table 105.1.

45.2.4 Iron or steel supply pipe employed on a product shall comply with the Standard for Wrought Steel and Wrought Iron Pipe, ANSI B36.10, Schedule 40. If brass or copper pipe is employed, it shall be dimensionally equivalent to iron pipe. Substantial malleable iron, steel, brass, or copper pipe fittings shall be used with pipe. Unions, where used, shall be the ground-joint type or the equivalent.

45.2.5 Ends of piping and tubing shall be reamed to remove obstructions or burrs.

45.2.6 Bent-supply piping shall:

a) Have the bends smoothly made without any appreciable reduction in the cross-sectional area,

b) Not be damaged by the bending process,

c) Be annealed if necessary to remove internal stresses, and

d) Be cleaned inside to remove loose particles.

45.2.7 The tubing and fittings shall not be exposed to temperatures greater than those specified in Table 67.1. Tubing shall be arranged to reduce the likelihood of mechanical damage, such as by closely following the contour of the product. Tubing connections shall be made by means of compression or flare type fittings with steel or brass nuts.

45.2.8 Seamless drawn aluminum or copper tubing and steel tubing of the seamless, brazed, or welded type employed in the fabrication of a factory-assembled product shall be not less than 1/4 inch nominal (approximately 6 mm) outside diameter and shall have a wall thickness not less than that specified in Table 45.2.

Table 45.2
Wall thickness for aluminum, copper, and steel tubing

Outside diameter		Minimum wall thickness, inches[a] (mm)			
inches	(mm)	Aluminum and copper		Steel	
1/8	(3.18)	0.029	(0.74)	0.028	(0.71)
3/16	(4.76)	0.029	(0.74)	0.028	(0.71)
1/4	(6.35)	0.029	(0.74)	0.028	(0.71)
5/16	(7.94)	0.029	(0.74)	0.028	(0.71)
3/8	(9.53)	0.032	(0.81)	0.028	(0.71)
7/16	(11.11)	0.032	(0.81)	0.028	(0.71)
1/2	(12.70)	0.035	(0.89)	0.028	(0.71)
9/16	(14.19)	0.038	(0.96)	–	–
5/8	(15.88)	0.038	(0.96)	0.035	(0.89)
3/4	(19.05)	0.045	(1.14)	0.035	(0.89)

Table 45.2 Continued on Next Page

Table 45.2 Continued

Outside diameter		Minimum wall thickness, inches[a] (mm)			
inches	(mm)	Aluminum and copper		Steel	
7/8	(22.23)	0.045	(1.14)	0.049	(1.24)
1	(25.40)	0.049	(1.24)	0.049	(1.24)
1-1/8	(28.58)	0.049	(1.24)	0.049	(1.24)
1-1/4	(31.75)	0.055	(1.40)	0.049	(1.24)
1-3/8	(34.93)	0.055	(1.40)	–	–
1-1/2	(38.10)	–	–	0.065	(1.65)

[a] Nominal wall thickness of tubing will have to be greater than the thickness indicated to maintain the minimum wall thickness.

45.2.9 Aluminum tubing shall not be exposed to condensate; pass through insulating material of other than neutral reaction, unless the tubing is protected from the insulation; be used in combination with dissimilar metals; or be used in machines that use propane in areas where it may contact propane.

45.2.10 Steel tubing having a wall thickness of 0.053 inch (1.35 mm) or less shall be constructed of corrosion-resistant material such as stainless steel or shall be painted, plated, dipped, coated, or otherwise treated to resist external corrosion.

45.2.11 Cadmium plating shall not be less than 0.0003 inch (0.008 mm) thick, and zinc plating shall not be less than 0.0005 inch (0.013 mm) thick, except on parts where threads constitute the major portion of the area, in which case the thickness of the cadmium or zinc plating shall be not less than 0.00015 inch (0.0038 mm).

45.2.12 Flexible-metallic hose shall not be used as a substitute for rigid piping or tubing as ordinarily employed. Its use shall be confined to applications in which rigid piping or tubing is impractical. It shall not be subjected to torsional, tensile, or bending stresses or to abrasion. It shall not be used in conjunction with safety devices or where bending is caused by automatic operation.

45.3 Gas-fired products

45.3.1 Tapped holes for gas valves, pilots, or other branch supply lines shall have at least 3-1/2 pipe threads.

45.3.2 Compounds used on threaded joints of gas piping shall be resistant to the action of liquefied petroleum gases. A fitting requiring the use of a gasket to obtain a gas-tight joint shall not be used.

45.3.3 If a vertical section of piping is supplied on the upstream side of the gas controls, a trap in this piping shall be supplied by the manufacturer. If a vertical section of piping is not supplied, the installation instructions shall require the installation of a trap at the inlet of the gas connection of the product.

45.3.4 Copper tubing or tubing with internal copper surfaces, used for conveying gases other than liquid petroleum gases, shall be internally tinned or equivalently treated to resist corrosion by sulfur compounds.

45.3.5 A 1/8-inch (3.2-mm) iron pipe size or larger plugged tapping, accessible for test gauge connection, shall be furnished downstream from the last main line gas control for measuring gas pressure at the burner.

45.4 Oil fired products

45.4.1 A coupling or union that is disconnected for service shall be located so that any oil dripping from the connection will not drip or run onto electrical parts.

46 Controls

46.1 General

46.1.1 A safety-control circuit shall be two-wire, one side grounded, having a nominal voltage of 120 volts. A safety control or protective device shall interrupt the ungrounded conductor.

Exception: This requirement does not apply to a supervised circuit within a safety control or to the extension of such circuit to a separate element of the control, such as a flame-sensing device.

46.1.2 A control circuit shall be constructed so that a safety control or protective device cannot be rendered ineffective by a short circuit to ground. Safety-control-circuit arrangements and voltages other than described in 46.1.1 shall provide equivalent protection.

46.1.3 A control circuit shall be arranged so that it may be connected to a power-supply branch circuit that can be fused at not more than the value appropriate for the rating of any control included in the circuit in accordance with the National Electrical Code, ANSI/NFPA 70.

46.1.4 All safety controls shall be accessible. Partial disassembly with ordinary hand tools, such as a screwdriver, is acceptable.

46.1.5 A safety control shall be supported in such a manner that it and its sensing element will remain in the intended position. It shall be possible to determine by observation or test whether or not each control is in its intended location.

46.1.6 A product shall not provide means to render any safety control ineffective or to allow firing of the burner without the protection of each of the required safety controls.

46.1.7 A burner not equipped to provide automatic restarting shall be arranged to require manual restart after any control functions to cause the fuel supply to be shut off and following restoration of an interrupted power supply.

46.1.8 A burner shall permit installation with a limit control to prevent excessive temperature in the product being fired.

46.1.9 The control circuit of a burner intended for use with a limit control, that functions to interrupt or reduce the delivery of fuel for combustion by opening an electrical circuit, shall be arranged to permit the limit control to be wired into the circuit so as to effect the direct opening of that circuit, whether the switching mechanism is integral with or remote from the sensing element.

46.1.10 The requirement in 46.1.9 is intended to prevent interposing in the limit-control circuit other controls, the failure of which may result in a condition the limit control is intended to prevent. For this purpose, a limit control may interrupt the pilot circuit of a magnetic-type motor controller that, in turn, directly opens the desired circuit when it is necessary to interrupt a single-phase circuit carrying a load greater than the capacity of available limit controls, or to interrupt a multiphase circuit.

46.1.11 A burner circuit shall be arranged to prevent feedback by a motor, capacitor, or similar device from energizing a fuel valve or ignition device.

46.1.12 Cabinet compartments housing gas piping and controls for a gas-fired burner shall be ventilated.

46.2 Combustion-air controls

46.2.1 An air shutter shall be adjustable to any intended setting and be provided with means that will reduce the likelihood of an unintentional change in the setting.

46.2.2 The air inlet arrangement shall supply sufficient air for complete combustion under the specified draft condition and at the maximum rate of firing when the burner is installed as intended. All the air required for complete combustion shall be introduced in a manner that will allow thorough mixing of the fuel and air in order to complete the combustion within the combustion zone.

46.2.3 An air shutter shall provide a smooth surface between the shutter and the matching face.

46.2.4 Sheet metal air shutters shall not be less than 0.0254 inch (0.65 mm) thick. If sheet metal air shutters are less than 0.0508 inch (1.29 mm) thick, they shall have the outer edge turned at right angles or be reinforced in an equivalent manner.

46.2.5 An air shutter shall be constructed to reduce the possibility of sticking or corroding in position. Screws or bolts used for attaching or adjustment shall be of corrosion-resistant material.

46.2.6 An adjustable part shall be guided to prevent its movement from its intended path during adjustment, and the means for adjusting the part shall be accessible for servicing.

46.2.7 A burner arranged to change the firing rate automatically shall automatically proportion the air supply with the fuel, if necessary, to produce stable combustion at all firing rates allowed by the automatic control.

46.2.8 Linkage for operating air and fuel controls shall maintain the intended fuel-air ratio and shall resist unintentional damage and disengagement.

46.2.9 A gas-burner assembly equipped with a forced or induced draft fan, or both, shall be constructed to obtain the intended combustion level or it shall shut off the fuel supply immediately upon failure of the air supply.

46.2.10 If air under pressure is mixed with the gas supply in a mixer and is automatically controlled, effective means shall be provided to prevent air from passing back into the gas line, or gas into the air supply. The gas and air supply shall be controlled to prevent gas from entering burners until the air supply is available and, in the event of air failure, to shut off the gas supply.

46.2.11 If air for combustion is supplied mechanically by a source from which the flow may be interrupted, provision shall be made to shut off the fuel supply to the main burner and pilot assembly upon failure of the air supply. A supervised secondary pilot as described by 46.5.8 need not include provision for fuel shut off on failure of the combustion air supply.

46.2.12 A gas burner shall be equipped to provide preignition purging in accordance with 46.2.13 and 46.2.16.

Exception: Preignition purging is not required if the burner is equipped with a continuous pilot and the assembly is arranged so that any and all gas from the burner ports will be lighted and burned without increasing the risk of fire or injury to persons.

46.2.13 A forced- or induced-draft gas burner assembly shall provide preignition purging for the combustion chamber, heat exchanger, and flue passages of the product to which the burner assembly is to be applied, immediately before ignition of an interrupted or intermittent pilot. Purging shall continue for a sufficient time to permit at least four air changes of this volume. Purging shall be at an air-flow rate not less than the equivalent of that provided for combustion at one-third rated high-fire input.

46.2.14 The following are considered to provide purging in accordance with 46.2.13.

a) A purge period of 30 seconds, during which time air flow at a rate equivalent to that provided for combustion at rated high-fire input of the burner assembly or product is obtained.

b) A purge period of 60 seconds, during which time air flow at a rate equivalent to that provided for combustion at one-half rated high-fire input of the burner assembly or product is obtained.

c) A purge period of 90 seconds, during which time air flow at a rate equivalent to that provided for combustion at one-third rated high-fire input of the burner assembly or product is obtained.

46.2.15 Purge periods less than those indicated in 46.2.14 for a product's burner assembly may be considered as providing purging in accordance with 46.2.13 if the quantity of purge air flow is found to be sufficient to provide at least four air changes of the product's combustion chamber, heat exchanger, and flue-passage volume.

46.2.16 An atmospheric or natural-draft gas burner equipped with an automatically operated air shutter or draft damper that is closed or positioned so as to restrict the passage of air when the burner is not firing shall provide means to open such air shutters or dampers to the high-fire position for at least 90 seconds immediately before each light-off cycle is initiated.

46.3 Operating controls

46.3.1 A high pressure cleaning machine shall be provided with a temperature or pressure-regulating control or a flow sensing device. For a machine that incorporates water heating means such controls or devices shall regulate the heat source to retain the water temperature between the intended setpoints.

46.4 Limit controls

46.4.1 A product shall be provided with a limit control if, under conditions of abnormal operation, a risk of fire, electric shock, or injury to persons exists. Limit controls shall be in addition to and set at a higher value than any operating control.

46.4.2 If the product is equipped with an operating control that only regulates the fuel input between high and low values, an additional operating-control set to shut off the fuel at a value below the set point of the limit control shall be provided.

46.4.3 The limit control for a product shall prevent pressure in excess of the intended working pressure or a water temperature of not more than the temperature of saturated steam at the intended working pressure.

46.4.4 Limit controls shall be marked in accordance with 112.1.25.

46.5 Primary-safety controls – gas-fired burners

46.5.1 Each burner assembly shall be provided with a primary-safety control that will de-energize the main burner safety-shutoff valve upon loss of flame at point of supervision.

46.5.2 The time interval between loss of flame and de-energizing of the safety-shutoff valves shall be as specified in Table 46.1.

Table 46.1
Rated timings for gas-fired products

Program	Maximum firing rate per combustion chamber in million Btu per hour		
	0.4 (117 kW) or less	Over 0.4, but 2.5 or less	Over 2.5 (733 kW)
	Timing in seconds		
Continuous ignition			
Flame-establishing period	120	120[f]	120[f]
Flame-failure response time	180	4	4
Flame-failure reignition time	0.8	0.8	0.8
Valve closing time	a	5	1
Intermittent ignition			
Flame-establishing period	90	15	10
Flame-failure response time	180	4	4
Flame-failure reignition time	0.8	0.8	0.8
Valve closing time	a	5	1
Interrupted ignition			
Ignition means flame-establishing period	90	15	10
Main burner flame-establishing period	90[b]	15[c]	10[c]
Flame-failure response time[d]	180	4	4
Flame-failure reignition time[e]	0.8	0.8	0.8
Valve closing time	a	5	1
Direct ignition			
Flame-establishing period	60	Not permitted	
Flame-failure response time	90		
Flame-failure reignition time	0.8		
Valve closing time	a		

[a] Included in flame-failure response time.

[b] Includes main gas valve opening time from initiation of gas flow.

[c] May be 30 seconds for burners, other than power burners, with a safety shutoff valve having a full opening time of not less than 25 seconds.

[d] Applicable to both pilot and main burner flame failure.

[e] Applicable to pilot flame-failure reignition only.

[f] Not acceptable on mechanical draft burners.

46.5.3 A burner assembly shall be equipped with an automatic gas-ignition system. This system shall be constructed to provide for ignition by means of one of the following:

a) For a product having an input of 400,000 Btu per hour (117 kW) or less for each combustion chamber, a direct ignition device; or

b) A proved igniter or pilot.

46.5.4 An ignition system as described in 46.5.3 (a) shall provide for automatic shutoff of main burner gas if the presence of the main burner flame is not proved.

46.5.5 An ignition system as described in 46.5.3 (b) shall provide for automatic shutoff of all gas if the presence of the ignition source is not proved.

46.5.6 An ignition system shall provide for automatic shutoff of the main burner gas without reenergizing the direct ignition device in the event of main burner flame outage during an operating cycle.

46.5.7 Pilot supervision by the primary-safety control shall be only at the point where the pilot flame will effectively ignite the gas at the main burner or burner group. The supervision shall be effective with the pilot burning with any flame capable of actuating the safety control.

46.5.8 If a pilot is not proved, the gas to the pilot shall be automatically shut off and safety shutdown established. In the event of pilot extinguishment the gas to such pilots shall be shut off within the time interval specified in 46.5.10. A pilot, independently supervised, having an hourly input of 5000 Btu per hour (1.47 kW) or less, intended to light a larger pilot that is supervised in accordance with 46.5.10, is acceptable.

46.5.9 If burner assemblies are constructed for multiple installation in single devices, the automatic safety-control mechanism of each burner assembly shall operate independently of the other, or equivalent features shall be provided so that in no case can any one burner operate so as to increase the risk of fire or injury to persons.

46.5.10 The time required to prove an expanded pilot, the pilot flame-establishing period for intermittent and interrupted pilots, and the main burner flame-establishing period shall be as specified in Table 46.1. See 46.5.11.

46.5.11 Supervision of the main burner flame only shall begin at the end of the main burner flame establishing period if:

a) The maximum firing rate per combustion chamber is more than 2,500,000 Btu per hour (733 kW) for a mechanical draft burner and 5,000,000 Btu per hour (1465 kW) for an atmospheric burner, or

b) The burner assembly is provided with interrupted pilot, or

c) The maximum firing rate per combustion chamber is more than 2,500,000 Btu per hour and modulating or high-low firing is employed. If the main burner flame is not proved, safety shutdown shall be established.

46.5.12 If the maximum firing rate per combustion chamber is more than 2,500,000 Btu per hour (733 kW), a burner assembly shall be equipped with low- and high-gas-pressure switches. The switches shall cause a safety shutdown in the event the gas pressure varies by ±50 percent of rated pressure down-stream of the main-burner regulator. The low-gas-pressure switch shall be located up-stream or down-stream of the safety-shutoff valve. The high-gas-pressure switch shall be located down-stream of the safety-shutoff valve.

46.6 Primary-safety controls – oil-fired burners

46.6.1 An oil burner shall be equipped by the burner manufacturer or the product manufacturer with a primary-safety control.

Exception: An oil burner need not be equipped with a primary-safety control provided all of the following conditions are met:

a) The machine is portable.

b) The fuel input does not exceed 4 gallons (15.1 L) per hour.

c) The burner employs continuous spark ignition.

d) The machine is provided with an integral fuel tank having a capacity of not more than 10 gallons (37.9 L).

e) The combustion chamber is constructed so that it can accept the entire capacity of the tank without spillage to the outside.

f) The discharge hose length does not exceed 60 feet (18.3 m).

46.6.2 A primary-safety control shall comply with the requirements in 46.6.3 and 46.6.4 and Table 46.2.

46.6.3 A burner having a firing rate of not more than 4 gallons per hour (15.1 L/hr), which upon ignition or flame failure collects or retains within a metal fire pot or receptacle furnished by the manufacturer as part of the burner assembly all of the oil delivered for combustion, may be equipped with an antiflooding device.

46.6.4 A primary safety control for a burner, except one equipped as specified in 46.6.3, shall be a safety combustion control having nominal safety timings as specified in Table 46.2. Except as permitted by note[b] to Table 46.2, a burner having a firing rate above 20 gallons per hour (76 L/hr) shall be equipped with a safety control providing for proved ignition. The pilot flame or ignition-establishing period shall be not more than 15 seconds. At the end of the main flame-establishing period, supervision of the main flame only shall begin.

Table 46.2
Safety control timing for oil-fired products

Maximum main flame hourly input gallons (L)	Ignition	Main flame establishing period[a,b], seconds	Flame-failure reaction time[c], seconds
3 (11.4) [approximately 400,000 Btu/hr (117 kW)] or less	Unproved igniter or pilot	90	90
20 (76) [approximately 3,000,000 Btu/hr (879 kW)] or less	Unproved igniter or pilot	15	4[d]
Over 20 (76)	Proved igniter or pilot required	10 or 15[f]	4[e]

NOTE – The nominal timing is the designed duration of the period determined at rated voltage of the control in a room temperature of 21.1°C (70°F). Allowable factory tolerance may be in addition thereto.

[a] The maximum input for determining the main-flame establishing period for a burner not equipped as indicated in (3) is to be the maximum input of the burner.

[b] The maximum input for determining the main-flame establishing period and for determining if a proved pilot or igniter is required for a burner equipped to start on low fire only is to be the input to the largest fire that can be initially ignited, provided the input to that fire cannot be increased until ignition of the low fire is established and proved.

[c] The flame-failure reaction timing is to be based on the burner's maximum input. The flame-failure reaction time is the interval between the occurrence of flame extinguishment and the time the safety shutoff device is de-energized. For burners having an hourly input of 400,000 Btu (117 kW) or less, the timing may be the interval measured from the time the sending device first detects loss of flame to the time the safety shutoff device is de-energized.

[d] A flame-failure reaction time of more than 4 seconds, but not more than 15 seconds, is acceptable if intermittent ignition is employed, or if the ignition system is reenergized in not more than 0.8 seconds after flame extinguishment occurs.

Table 46.2 Continued on Next Page

Table 46.2 Continued

Maximum main flame hourly input gallons (L)	Ignition	Main flame establishing period[a,b], seconds	Flame-failure reaction time[c], seconds
[e] The timings given for burners required to be equipped with a proved igniter or pilot may also be applied to burners firing 20 gph (76 L/hr) or less when such burners are equipped with proved ignition or pilot.			
[f] For burners equipped to burn a distillate fuel and burners equipped to burn a residual fuel the maximum main flame establishing periods are 10 and 15 seconds respectively. Where it can be demonstrated by tests that a burner equipped to burn a residual fuel needs a longer main flame establishing period so as to avoid nuisance shut down, such MFEP may be more than 15 but not more than 30 seconds provided not more than 15 seconds of unburned fuel is discharged during an attempt to establish main flame.			

PROTECTION AGAINST INJURY TO PERSONS

47 General

47.1 If the operation and maintenance of a product by the user involves a risk of injury to persons, means shall be provided to reduce the risk.

47.2 When judging a product with respect to the requirement in 47.1, consideration is to be given to reasonably foreseeable misuse of the product.

47.3 Unless the manufacturer recommends the use of two or more attachments at the same time, only one attachment at a time is to be evaluated with the product.

47.4 Whether a guard, a release, an interlock, or similar feature is required and whether such a device is adequate shall be determined from an investigation of the complete product, its operating characteristics, and the possibility of a 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 one component, but not more than one component at a time, unless one event contributes to another. If the investigation shows that breakdown or malfunction of a particular component can result in a risk of injury to persons, that component shall be investigated for reliability.

47.5 Specific constructions, tests, markings, guards, and similar features are detailed for some common constructions. Specific features not covered herein are to be examined and tested to determine whether they are acceptable for the purpose.

48 Sharp Edges

48.1 An enclosure, a frame, a guard, a handle, or similar feature shall not be sufficiently sharp to constitute a risk of injury to persons in normal maintenance and use.

48.2 Whenever referee measurements are necessary to determine that a part as mentioned in 48.1 is not sufficiently sharp to constitute a risk of injury to persons, the method described in the Standard for Test for Sharpness of Edges on Equipment, UL 1439, is to be employed.

49 Enclosures and Guards

49.1 The rotor of a motor or a pulley, belt, gear, fan, or other moving part that could cause injury to persons, shall be enclosed or guarded to reduce the likelihood of unintentional contact therewith.

49.2 For an opening having a minor dimension less than 1 inch (25.4 mm), such a part shall not be contacted by the probe illustrated in Figure 15.1. For an opening that has a minor dimension of 1 inch or more, such a part shall be spaced from the opening as specified in Table 15.1.

Exception: An opening in the integral enclosure of a motor that is not used in either a handheld machine or a hand-supported portion of an machine is acceptable if a moving part cannot be contacted by the probe illustrated in Figure 15.2.

49.3 During the examination of an appliance to determine whether it complies with the requirements in 49.1 and 49.2, a part of the enclosure that may be removed without the use of a tool (to attach an accessory, to make an operating adjustment or for other reasons) is to be opened or removed.

Exception: A part need not be opened or removed provided the machine is marked in accordance with 113.2.2.

49.4 An enclosure or guard over a rotating part shall:

a) Retain a part that, because of breakage or other reasons, may become loose or may separate from the rotating part; and

b) Retain a foreign object that may be struck and propelled by the rotating part.

50 Materials

50.1 The material of a part, such as an enclosure, frame, guard, or similar feature, the breakage of which may result in a risk of injury to persons, shall have such properties as to meet the demand of expected loading conditions.

50.2 The requirement in 50.1 applies to those portions of a part adjacent to moving parts considered to involve a risk of injury to persons.

50.3 A metal enclosure, frame, or guard shall comply with the applicable requirements for Frames and Enclosures, Section 11.

50.4 An enclosure, guard, or frame of polymeric material shall have a temperature index with impact resistance equal to or greater than the maximum temperature of the material as measured under normal operating conditions when tested in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

50.5 Nonmetallic enclosures or guards shall have a flammability rating of HB, minimum, as determined in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

50.6 In addition, an enclosure or guard of polymeric material shall comply with the ball impact and mold stress-relief distortion tests described in Section 71.

50.7 A nonmetallic enclosure or guard having a total area greater than 10 square feet (0.93 m^2) shall have a flame spread rating of 200 or less as determined by the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723.

50.8 A nonmetallic enclosure or guard that is a component of a machine intended for permanent installation outdoors or a portable machine intended for outdoor use (not marked to store indoors) and where the component is exposed to weathering shall comply with the light and water exposure test described in Section 71.

51 Rotating or Moving Members

51.1 A rotating or moving part that, if it should become disengaged, may create a risk of injury to persons shall be provided with a means to retain the part in place under conditions of use.

51.2 A rotating member, breakage of which may create a risk of injury to persons, shall be constructed so as to reduce the possibility of breakage, or the release or loosening of a part that could become a risk of injury to persons.

51.3 A machine employing a series motor is to be tested as described in 91.1 to determine that it complies with the requirement in 51.2. A part that may create a risk of injury shall not work loose.

52 Back-Flow Prevention

52.1 A washer intended to be connected to a potable water supply, and provided with an integral water supply tank that is accessible for adding cleaning agents, shall be constructed to prevent back-flow or back-siphonage of contaminated water. An air gap of at least 1 inch (25.4 mm) shall be provided between the fill fitting and the flood rim of the receptacle for a fitting having an effective opening not greater than 1/2 inch (12.7 mm). For a fill fitting having an effective area greater than 1/2 inch, the air gap shall be at least two times the diameter of the effective opening.

52.2 As an alternative to the fill fitting described in 52.1, an appropriate back-flow prevention device conforming to the requirements of the American Society of Sanitary Engineers may be used.

53 Parts Subject to Pressure

53.1 A pressure vessel that is covered by the scope of the ASME Boiler and Pressure Vessel (BPV) Codes shall be constructed and marked in accordance with the Code.

53.2 A product or component of a product subjected to hydraulic pressure during normal or abnormal use, including a mechanical shaft seal, hose, gasket, and the normal fluid flow path, shall comply with the requirements in the Hydrostatic Pressure and Strength Test, Section 69.

53.3 A product or component of a product subjected to air or vapor pressure, including the vapor pressure in a vessel containing only super-heated fluid, shall be subjected to additional evaluation to determine its suitability in the application.

54 Overpressure Protection

54.1 A pressure-relief device which inhibits a pressure increase that occurs as a result of the closing of a nozzle control device, or malfunction of a bypass or dump valve, shall be set and have a flow capacity such that pressure does not continue to increase after the discharge of the relief device.

Exception: A pressure-relief device is not required in an application when the construction of the appliance is such that it does not pose a potential risk of injury to users under abnormal pressure conditions. The integrity of the construction is to be determined by the test described in Section 69.

54.2 A pressure-relief device is considered to be a pressure-actuated valve or rupture member intended to relieve excessive pressures automatically. For a pressure vessel that falls under the scope of ASME Codes, the pressure-relief device shall be a safety relief valve. The start-to-discharge pressure settings of these devices shall be within 5 percent of each other when determined in accordance with 74.2.2. The manufacturer of the product pressure system shall calibrate 100 percent of relief devices.

Exception: Three rupture discs tested in accordance with 74.2.2, and subjected to the Manufacturer Production Line Rupture or Burst Disc Overpressure Protection Test, Section 111, meet the intent of the requirement.

54.3 There shall be no shutoff valve between the pressure-relief means and the parts that it is intended to protect.

54.4 A pressure-relief device shall:

a) Be installed so that it is readily accessible for inspection and repair, and cannot be readily rendered inoperative so that it will not perform its intended function; and

b) Have its discharge opening located and directed so that:

1) Operation of the device does not deposit moisture on bare live parts or on insulation or components detrimentally affected by moisture, and

2) The likelihood of scalding or pressure injecting persons is reduced.

54.5 A pressure-relief device having an adjustable setting is judged on the basis of the maximum setting unless the adjusting means is reliably sealed at a lower setting.

54.6 A pressure-regulating control switch depended upon to limit the pressure in a system shall comply with the applicable requirements in the Standard for Limit Controls, UL 353, or the applicable requirements for refrigeration limiting devices in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

54.7 A pressure-regulating control shall comply with the requirements in 74.1.1 and shall have a maximum pressure setting of not more than 90 percent of the rating of the pressure-relief device.

54.8 In addition to requirements in 54.1 – 54.7, a Type 4 pressure cleaning machine shall also comply with the requirements in Sections 54A – 54B.

54.9 Type 4 machines shall be rated for cold-water use only.

54A Overpressure Protection for Type 4 Machines

54A.1 The machine shall be provided with a pressure limiting device (safety control device) that keeps the maximum pressure from exceeding 115% of its maximum pressure rating.

54A.2 This pressure limiting device shall not be capable of being adjusted, turned-off, or defeated by the user.

54A.3 This device shall be so located on the machine that the risk of injury and risk of water injection is mitigated in the event of water discharge due to operation, failure or breakage of the pressure limiting device.

54B Pressure Gauge for Type 4 Machines

54B.1 The machine shall be provided with a pressure gauge indicating operating pressure of the liquid at the outlet. The gauge shall be readily visible to the user and the maximum operating pressure shall be marked on or near the gauge.

55 Risks of Pressure Injection and Cutting, and Recoil

55.1 A Type 1 cleaning machine may be of a continuous flow design or incorporate provision for manual shutoff of the fluid flow.

55.2 A Type 2 cleaning machine shall be provided with a manually-actuated control (deadman control) for release of the cleaning solution. The control actuator shall be biased to the off position and located or guarded to reduce the likelihood of unintentional operation. See Section 72.

55.3 A Type 2 cleaning machine shall be provided with a lance or wand having a trigger mechanism located at least 29.5 inches (750 mm) from the discharge nozzle.

Exception: The trigger mechanism may be located less than 29.5 inches from the discharge nozzle if it can be demonstrated that a shorter length does not present a risk of skin injection, as determined by compliance with Injection Test, Section 55A.

55.4 If the lance or wand is of a type that can be detached from the trigger mechanism, a Type 2 cleaning machine shall not be capable of discharging cleaning fluid with the part removed, or building up a discharge pressure greater than 100 psig (690 kPa) with the part removed.

55.5 A Types 3 and 4 cleaning machine shall comply with the requirements for a Type 2, except that the trigger mechanism on the lance or wand shall be located at least 4 feet (1.22 m) from the discharge nozzle.

Exception: The trigger mechanism for a Type 3 cleaning machine may be located less than 48 inches from the discharge nozzle if it can be demonstrated that a shorter length does not present a risk of skin injection, as determined by compliance with Injection Test, Section 55A. This exception does not apply to Type 4 cleaning machines.

55.5A A Type 4 cleaning machine shall comply with the requirements for a Type 3, except that the trigger mechanism on the lance or wand shall be provided with the means to lock the mechanism in the OFF position, and shall not be able to lock the trigger mechanism in the ON position.

55.6 For all types of machines, the cautionary marking relating to risk of injury to persons shall be included on the product and in the instruction manual as noted in Sections 112 and 115, respectively.

55.7 Nonmetallic hose used to connect the lance to a Type 3 or Type 4 cleaning machine shall be shrouded by a protective device for a distance of at least 2 feet (610 mm) from the nearest grasping area of the lance. The shroud shall interrupt and disperse the fluid flow in the event of hose rupture so as to prevent operator injury.

55.8 For a Type 4 cleaning machine, when the trigger mechanism is released one of the following shall occur:

a) No more liquid shall emerge from the nozzle (dry shut-off);

b) Any liquid emerging from the spraying device shall generate a reaction force no greater than the weight of the spraying device; or

c) The pump shall be switched off.

55.9 For a Type 4 cleaning machine, releasing the trigger mechanism shall not be hindered by recoil effects of shutting-off. The holding force to be applied manually on the trigger mechanism of the sprayer shall not exceed 13.5 pound-force (60 N).

55.10 For a Type 4 cleaning machine, the recoil forces exerted on the spraying device shall not exceed 56 pound-force (250 N) longitudinally. The recoil force shall not be released in under 1 second so as to permit reaction time for the user.

55A Injection Test

55A.1 As a result of the test described in 55A.1, there shall not be penetration of Tape No. 1 (outer layer). Indentation without penetration meets the intent of the requirement.

55A.2 The test is to be performed with the nozzle tip installed. The test is to be repeated for each nozzle tip, specified by the manufacturer in the operating instructions, and for both the forward and reverse positions of a reversible nozzle tip. For a removable nozzle, the test is to be additionally performed with the nozzle removed.

55A.3 The unit's controls, such as for flow rate or pressure, are to be at the maximum settings to represent the most severe conditions.

55A.4 Water containing a tracer dye, methylene blue for example, is to be used for the test liquid.

55A.5 The test fixture is to be a rigidly mounted wooden surface having a width and height that is greater than the minimum spray pattern of the nozzle tip. The following test tapes are to be applied to the test fixture:

a) Tape No. 3 (inner layer) – 1 inch (25.4 mm) wide and a length to accommodate the minimum spray pattern of the nozzle tip. The tape is to be adhesive backed, single-adhesive coated, vinyl foam tape, black in color, having the tape properties given in Table 55A.1,

b) Tape No. 2 (middle layer) – 1 inch (25.4 mm) wide and a length to accommodate the minimum spray pattern of the nozzle tip. The tape is to be double-adhesive coated, vinyl foam tape, white in color, having the tape properties given in Table 55A.1, and

c) Tape No. 1 (outer layer) – 1 inch (25.4 mm) wide and a length to accommodate the minimum spray pattern of the nozzle tip. The tape is to be single-adhesive coated, skived tetrafluorethylene tape, natural color, having the tape properties given in Table 55A.1.

Table 55A.1
Tape dimensions and properties (average values)

Tape property	Tape No. 3	Tape No. 2	Tape No. 1
Thickness	0.045 – 0.080 inch (1.14 – 2.03 mm)	0.025 – 0.040 inch (0.64 – 1.02 mm)	Total: 0.0045 inch (0.114 mm) Backing: 0.0025 – 0.0035 inch (0.064 – 0.089 mm)
Density	16 lbs/cubic foot (256 kg/cubic meter)	14 lbs/cubic foot (224 kg/cubic meter)	–
Tensile strength	110 lbs/inch^2 (758 kN/m^2)	55 lbs/inch^2 (379 kN/m^2)	16 lbs/inch^2 (110 kN/m^2)

Table 55A.1 Continued on Next Page

Table 55A.1 Continued

Tape property	Tape No. 3	Tape No. 2	Tape No. 1
	(ASTM D 412-97[a], Die A)	["T" Block, Jaw 12 inches/minute (305 mm/minute)]	(ASTM D 1000-93[b])
Elongation, percent	370 (ASTM D 412-97[a], Die A)	–	275 (ASTM D 1000-93[b])
Temperature Resistance (continuous)	175°F (80°C)	150°F (65°C)	356°F (180°C)
Compression Deflection at 25 percent (ASTM D 1056-91[c])	13 psi (90 kN/m^2)	–	–
Compression Modules at 25 percent	–	8.5 psi (59 kN/m^2)	–
Compression Set percent loss of original height:			
In accordance with ASTM D 1056-91[c]	3 percent	–	–
In accordance with ASTM D 1667-76(1990) [d]	–	3.9 percent	–

[a] Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers – Tension.

[b] Test Methods for Pressure-Sensitive Adhesive Coated Tapes for Electrical and Electronic Insulation.

[c] Specifications for Flexible Cellular Materials – Sponge or Expanded Rubber.

[d] Specifications for Flexible Cellular Materials – Vinyl Chloride Polymers and Copolymers (Closed – Cell Vinyl).

55A.6 The lance or wand is to be held with the nozzle tip in contact with Tape No. 1 (outer layer) of the test fixture without applying pressure. The unit is then to be operated at maximum pressure for 5 seconds.

56 Switches, Controls, and Interlocks

56.1 A product shall be constructed so as to reduce the possibility of unexpected operation of a part capable of causing injury to persons.

56.2 Each function of a multiple-function product is to be taken into consideration in determining whether the product complies with the requirement in 56.1.

56.3 A motor control switch, other than a momentary-contact switch, on the product shall have a plainly marked off position.

56.4 If unintentional operation of a control can result in a risk of injury to persons, the actuator of the control shall be located or guarded so that such operation is unlikely. The actuator of a control may be guarded by recessing, ribs, barriers, or similar obstruction.

56.5 The gun control on a Type 2 and 3 cleaning machine shall be equipped with an automatic or visible manual safety device which will preclude pulling of the trigger and release of the fluid until the safety device is manually released.

56.6 The actuator of an interlock switch shall be located so that unintentional operation is unlikely.

56.7 A device that automatically starts a product, such as a timer, an automatically reset overload-protective device, or similar device, shall not be employed unless it can be demonstrated that automatic starting will not result in a risk of injury to persons.

56.8 The requirement in 56.7 will necessitate the use of an interlock if moving parts, high pressure fluid, or similar materials could result in a risk of injury to persons upon automatic starting or restarting of a motor.

56.9 Operation of an interlock in normal use shall not inconvenience the operator so as to encourage deliberate defeat of the interlock.

56.10 An interlock shall be such that it cannot be defeated readily:

a) Without damaging the product,

b) Without making wiring connections or alterations,

c) By using readily available materials, or

d) By materials that could accumulate in normal use.

56.11 If an interlock is actuated by movement of a guard, the arrangement shall be such that the guard is in place when the interlock is in the position that permits operation of the part being guarded. With the guard removed, the interlock shall comply with the requirement in 56.6.

56.12 A floor- or ground-supported product that can travel or rotate to an extent that could result in a risk of injury to persons if left unattended shall be provided with a momentary contact switch that cannot be locked in the on position.

57 Strength of Support Handles

57.1 A support handle or similar means provided to support or carry a product shall comply with the requirements of the Test for Strength of Support Handles, Section 73.

58 Stability

58.1 A portable product shall comply with the requirements of the Stability Test, Section 101.

58.2 A product provided with casters or wheels shall have at least two locking casters or other means to restrict movement.

58.3 A product not intended to move from its de-energized position to perform its intended function but that may move from its de-energized position when operated – such as from vibration – shall be provided with locking wheels or other means to restrict movement.

58.4 The stability of a Type 4 machine with a mechanically held sprayers (not held by hand) shall be tested using any of the manufacturer provided nozzle and/or spray accessory which causes the highest recoil force. The machine shall not tip over, lift up or roll away due to the recoil forces.

59 Strength of Mounting

59.1 A product intended to be mounted on a wall or ceiling shall withstand a force of four times the weight of the product without malfunction of or damage to the mounting bracket, its securing means, or

that portion of the product to which it is attached. Provision shall be included to accommodate any excessive vibration of the product.

59.2 To determine whether a product complies with the requirement in 59.1, it is to be mounted in accordance with the installation instructions provided by the manufacturer – on a surface of the construction specified using the parts provided. If no surface construction is specified, 3/8-inch-thick plasterboard (dry wall) on nominal 2- by 4-inch (actual 1-5/8- by 3-5/8-inch– 41- by 92-mm) wood studs spaced on 16-inch (406-mm) centers is to be used as the supporting surface. The mounting parts are to be used as specified in the instruction; and, if not otherwise indicated, the securing screws are to be located between the studs and secured in the plasterboard. An adjustable product is to be adjusted to the position that will give the maximum projection from the wall. The force is to be applied through a 3-inch (76-mm) wide strap at the dimensional center of the product and is to be increased during a 5- to 10-second interval, until a load equal to the weight of the product plus a force of three times the weight of the product, is applied to the mounting system. The load is to be maintained for 1 minute.

59.3 Nonmetallic mounting means shall comply with the tests specified in the Tests for Nonmetallic Enclosures and Guards of Moving or Hot Parts, Section 71.

60 Discharge-Fluid Temperature

60.1 A product intended to be connected to other than a cold water source and a product employing means to heat the water shall be provided with:

a) A lance or wand having the trigger mechanism located at least 3 feet (0.9 m) from the discharge nozzle;

b) A manually operated control (deadman control), the actuator of which shall be located or guarded to prevent unintentional operation; and

c) A cautionary marking. See 113.1.10.

61 Surface Temperatures

61.1 The temperatures on a surface that may be contacted during intended operation shall comply with the requirements in Subsection 67.2.

PERFORMANCE – GENERAL

62 Details

62.1 All products

62.1.1 If tests indicate that a product may not continue to comply with the applicable requirements during intended use, supplementary tests are to be conducted, as necessary.

62.1.2 During the tests, a flexible polymeric or elastomeric boot that covers a switch and that is flexed when the switch is operated is to be removed, and a part that can be opened or removed without the use of a tool is to be removed or placed in the most adverse position for the test being conducted.

Exception: A boot that is momentarily flexed and not held in the flexed position when the switch is operated and that meets the following conditions is not required to be removed:

a) The boot shall be mechanically secured by fastening means, such as screws;

b) The boot shall not be able to be removed by hand, or depend upon friction for securement; and

c) The boot shall comply with the Aging Test described in 70.2.

d) For portable equipment for use outdoors, but intended to be stored indoors, and marked in accordance with 112.1.5 and for stationary and fixed equipment intended for indoor installation and marked in accordance with 112.1.5, the boot shall be cold-conditioned at 0.0 +2.0°C (32.0 +3.6° F) for 3 hours. For equipment not marked for storage in accordance with 112.1.5, the boot shall be cold-conditioned at −35.0 +2.0°C (−31.0 +3.6°F) for 3 hours. Immediately after the conditioning, and with the temperature maintained, the boot shall be hand-flexed, with gloves worn to inhibit heat transfer to the boot. The boot shall not harden or otherwise deteriorate to a degree that will impair its sealing properties.

62.2 Electrical systems

62.2.1 Unless otherwise specified, all tests are to be conducted with the product connected to a supply circuit of the frequency specified in 62.2.2. The voltage of the supply circuit is to be as specified in Table 62.1.

Table 62.1
Test voltages

Rated voltage	Undervoltage[a]	Test voltage	Overvoltage
110 – 120	102	120	132
200 – 208	177	208	229
220 – 240	204	240	264
254 – 277	235	277	305
440 – 480	408	480	528
550 – 600	510	600	660
Other	85 percent of rated	rated	110 percent of rated

[a] Values in this column are applicable to alternating-current potentials. Undervoltage tests for a direct-current burner or component are to be conducted at 80 percent of rated voltage.

62.2.2 A product having a single frequency rating is to be tested at that frequency. A product rated both 60 hertz and dc is to be tested on direct current or 60-hertz alternating current, whichever results in higher temperatures. A product rated 50 – 60 hertz is to be tested on 60-hertz alternating current.

62.3 Fuel-fired products

62.3.1 A product with a fuel-fired water-heating system shall comply with the applicable performance requirements when tested with each grade or type of fuel recommended by the manufacturer of the product.

62.3.2 A product intended for fixed installation is to be tested on a noncombustible construction. At the manufacturer's request, the product may be tested for installation on a combustible floor.

62.3.3 During the applicable tests, an oil burner shall operate uniformly and reliably, and following the tests shall not exhibit excessive carbonization or other characteristics that may adversely affect the intended operation of the burner.

62.3.4 An oil burner equipped, or intended to be equipped in the field, with preheaters to heat the fuel oil before it is delivered for combustion is to be tested using fuel oil that has been heated to the intended temperature.

63 Instrumentation

63.1 Temperature measurement

63.1.1 Ordinarily, coil or winding temperatures are to be measured by thermocouples, except that temperatures are to be measured by the change-of-resistance method if:

a) The coil is inaccessible for mounting of these devices – for example, a coil immersed in sealing compound;

b) The coil wrap includes thermal insulation or more than two layers [1/32 inch (0.8 mm) maximum] of cotton, paper, rayon, or similar materials.

63.1.2 Thermocouples used to measure temperatures on motor coil windings are to be located either on the windings or on the integrally applied insulation on the windings. If a coil wrap other than as described in 63.1.1(b) is employed, thermocouples are to be placed under the wrap. For a thermocouple-measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less – items 7 and 9 in Table 67.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor.

63.1.3 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). The thermocouple wire is to conform with the requirements listed in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

63.1.4 Whenever referee temperature measurements by thermocouples are necessary, thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wire and a potentiometer-type instrument are to be used.

63.1.5 Each thermocouple junction and adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material whose temperature is being measured. In most cases, thermal contact will result from taping or cementing the thermocouple in place; but if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

63.1.6 Thermocouples are to be secured to wood surfaces by staples over the insulated portion of the wire and with the tip held in thermal contact with the surface by pressure-sensitive tape; except that for zero clearance, the thermocouples are to be applied to surfaces of the representative product at points of zero clearance.

63.1.7 In using the change-of-resistance method, the windings are to be at room temperature at the start of the test. The temperature rise of a winding is to be calculated from the formula:

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise in °C;

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

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

t_1 is room temperature in °C at the beginning of the test;

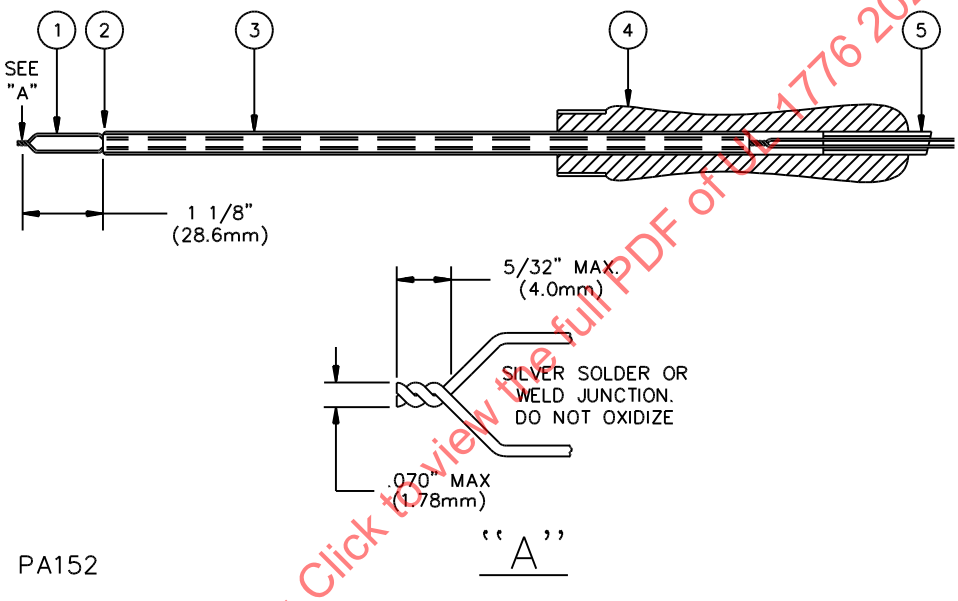
t_2 is room temperature in °C at the end of the test; and

k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum. Values of the constant k for other grades must be determined.

63.1.8 The flue-gas temperature is to be measured by a thermocouple, such as illustrated by Figure 63.1, inserted into the chimney connector as shown on Figure 63.2. There is to be no draft control between the product and the point where the flue-gas temperature is measured. If a draft control is incorporated in the product, it is to be fixed in the position allowing maximum draft during all tests.

Figure 63.1

Standard thermocouple for flue-gas temperature



1. 20 AWG (0.51 mm^2) iron-constantan, asbestos, or woven-glass-covered thermocouple wires extending from hot junction to potentiometer or reference junction.

2. 1 – Leeds & Northrup Standard 714B, or equal, 1/4 inch (6.4 mm) outside diameter of two-hole porcelain insulator cut to length and ends beveled on two sides.

3. 1 – 5/16 inch (7.9 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing. Ream, if necessary, to fit over insulator; then crimp ends over beveled ends of insulator.

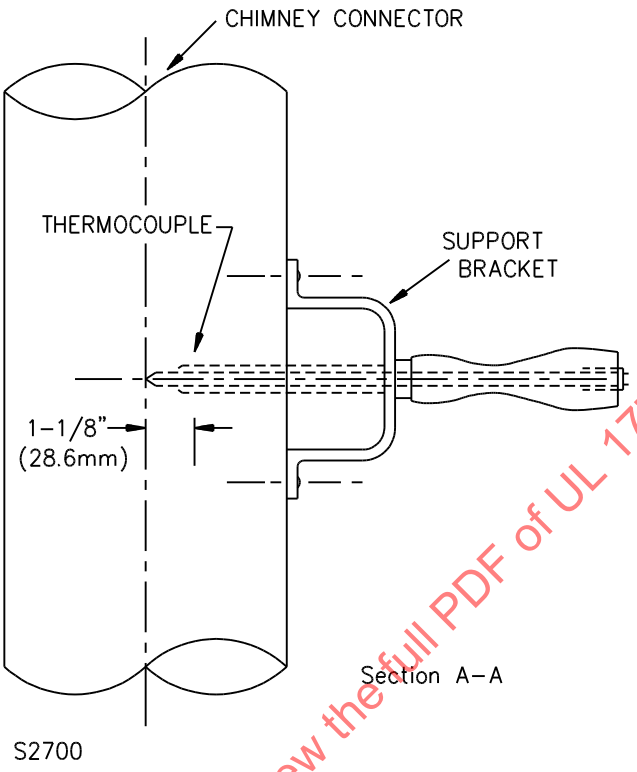
4. 1 – Small wooden handle.

5. 1 – Piece of rubber tubing, approximately 5/16 by 3/32 by 2 inches long (7.9 by 2.4 by 50.8 mm long).

6. In lieu of individual components described in items 1, 2 and 3 above, any combination of preassembled parts of tubing, insulators and thermocouples may be used.

Figure 63.2

Flue gas thermocouple and support bracket



63.2 Draft

63.2.1 Draft is to be measured by a draft gauge which may be read directly to 0.005 inch (0.13 mm) water column and that has an accuracy of ±0.0025 inch (0.064 mm).

63.3 Fuel input

63.3.1 The fuel input rate to an oil-fired burner is to be determined by a scale accurate to 0.01 pound (4 g) or a burette having equivalent accuracy.

63.3.2 The fuel input rate to a gas-fired burner is to be determined by a laboratory-type gas meter.

64 Installation

64.1 Fixed products – corner installation

64.1.1 The representative product is to be placed in a test enclosure as specified in 64.1.2 – 64.1.4. The sides of the product that result in the highest enclosure wall temperatures are to be located nearest to the enclosure walls.

64.1.2 The product is to be leveled prior to testing. Leveling means are to be removed if possible; otherwise they are to be adjusted so that the base of the product is at the minimum distance from the floor.

64.1.3 The test enclosure is to be formed by two walls constructed of not less than 1/2-inch trade size [nominal 1/2 inch (12.7 mm) thick] wood boards, or 1/2-inch thick plywood, set at right angles and painted flat black. See Figure 64.1. A ceiling of equivalent construction is to be placed above the product and in

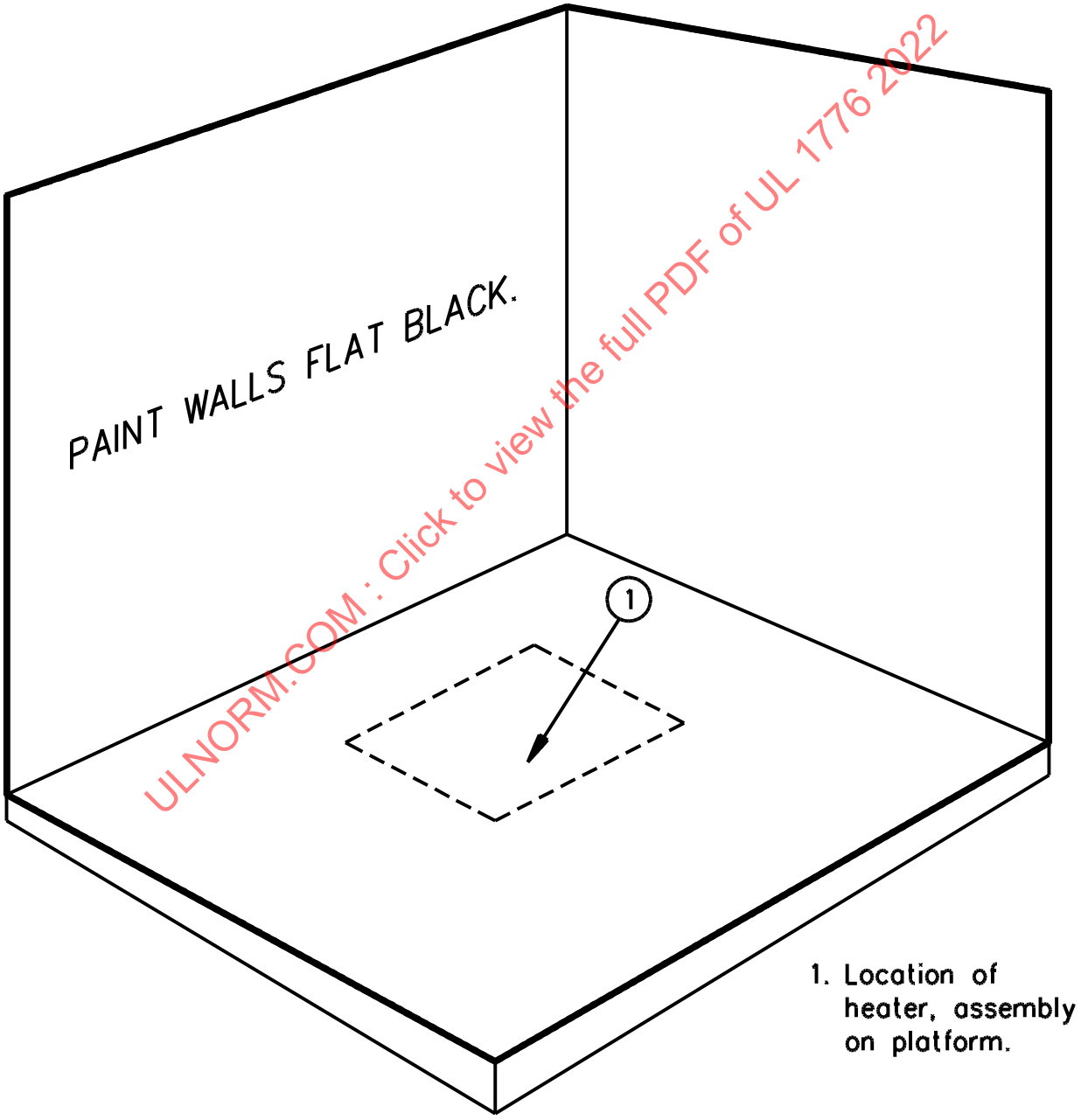
contact with the enclosure walls. All joints in the test enclosure are to be tight or sealed. The walls and ceiling of the enclosure are to:

a) Extend 3 feet (0.91 m) beyond the ends of the product, and

b) Be located at the minimum clearances in integral inches, as specified by the manufacturer, from the sides and top of the product.

Figure 64.1

Test enclosure for fixed and portable installations



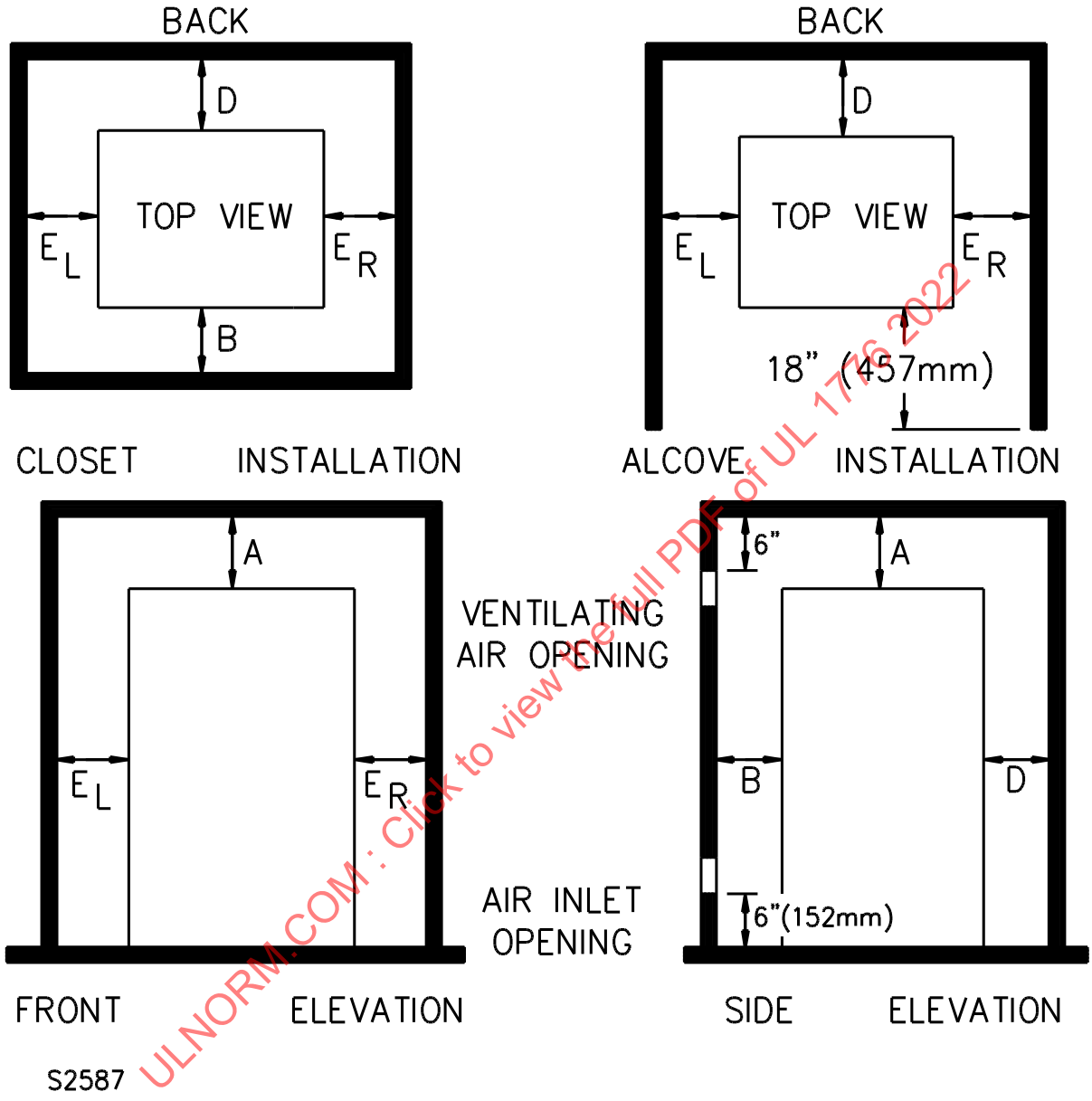
64.1.4 The floor is to be of combustible or noncombustible material as selected by the manufacturer for testing purposes and as indicated on the product nameplate. Combustible floors are to be made of plywood at least 1/2-inch (12.7-mm) thick or equivalent, finished in flat black paint.

64.2 All fixed products – alcove or closet installation

64.2.1 The product is to be installed in an enclosure as described in 64.2.2 – 64.2.4, with clearances in integral inches, as specified by the manufacturer, to walls and ceilings of the test enclosure. The ceiling height of the enclosure is to be that required to obtain the clearance from the top of the product to the ceiling specified by the manufacturer; but in no case is the ceiling height to be more than 7 feet, 6 inches (2.29 m). See Figure 64.2.

Figure 64.2

Test enclosure for alcove or closet installation



A – From top of product.

B – From front of product.

C_H – From chimney connector, measured horizontally or below connector.

C_V – From chimney connector, measured vertically above connector.

D – From back of product.

E_L – From left side of product.

E_R – From right side of product.

64.2.2 The walls and ceiling of the enclosure are to be made of not less than 1/2-inch trade size wood boards, or 1/2-inch (12.7-mm) thick plywood. The walls are to be vertical and at right angles to each other. The interior surface of the walls and ceiling are to be finished in flat black paint. All joints of the enclosure are to be sealed. The floor is to be of combustible or noncombustible material as selected by the manufacturer for testing purposes and as specified on the product nameplate. Combustible floors are to be made of not less than 1/2-inch (12.7-mm) thick plywood or equivalent, finished in flat black paint.

64.2.3 For the alcove installation test, the enclosure is to be open opposite the front of the product. The side walls and ceiling are to extend 18 inches (457 mm) beyond the front of the product, and a wall is to be placed opposite the open side of the enclosure at a distance of 48, 36, or 24 inches (1.22, 0.91, or 0.61 m) as specified by the manufacturer for testing purposes.

64.2.4 For closet installation test, a simulated door is to be provided for the enclosure.

64.3 Fuel-fired fixed products

64.3.1 For a product that has a horizontal flue outlet, a wall opposite the flue collar is to be located the minimum distance, as specified by the manufacturer, from a vertical chimney connector that is connected to the flue collar as described in 64.3.2.

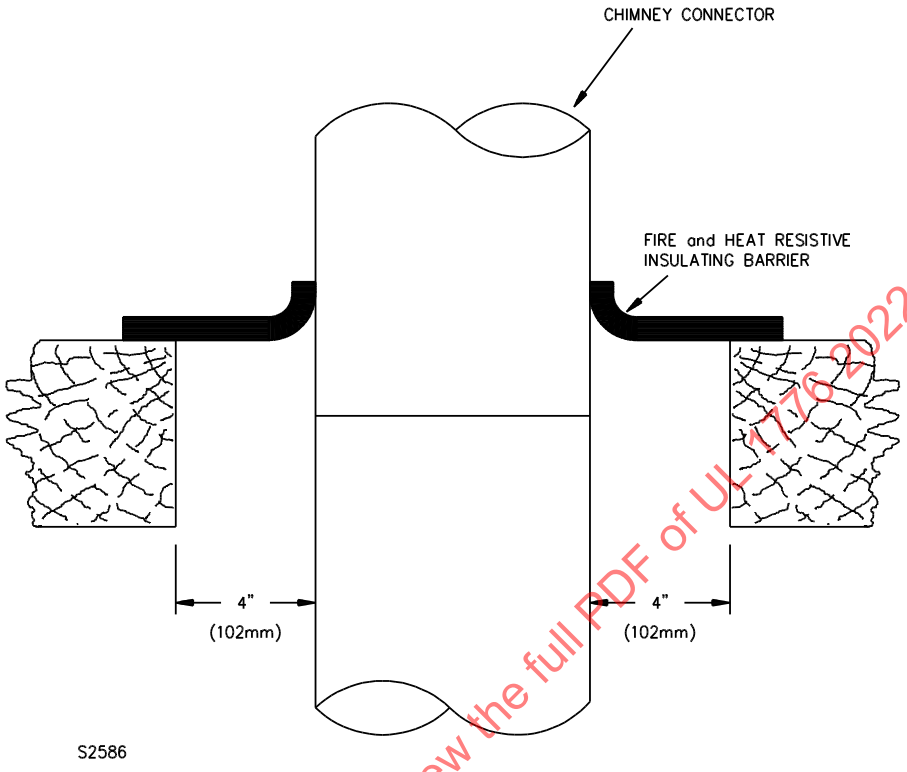
64.3.2 A chimney connector is to be the same nominal size as the flue collar or outlet of the product it is connected to. Galvanized stovepipe not thicker than nominal 0.028 inch (0.71 mm) is to be used. The chimney connector is to extend vertically through the ceiling of the test enclosure. For a vertical flue outlet, the chimney connector is to be connected directly to, and extended vertically above, the outlet. For a horizontal flue outlet, the chimney connector is to be connected to a 90-degree sheet-metal elbow that is connected directly to a vertical flue outlet.

64.3.3 The chimney connector is to be connected to a chimney, stack, or exhaust system capable of maintaining the draft specified by the manufacturer.

64.3.4 If the chimney connector passes through the enclosure, an opening 8 inches (205 mm) larger than the chimney connector is to be cut in the enclosure and the annulus thus formed is to be sealed on the exterior surface with a fire and heat resistive barrier at least 1/8 inch (3.2 mm) thick. See Figure 64.3.

Figure 64.3

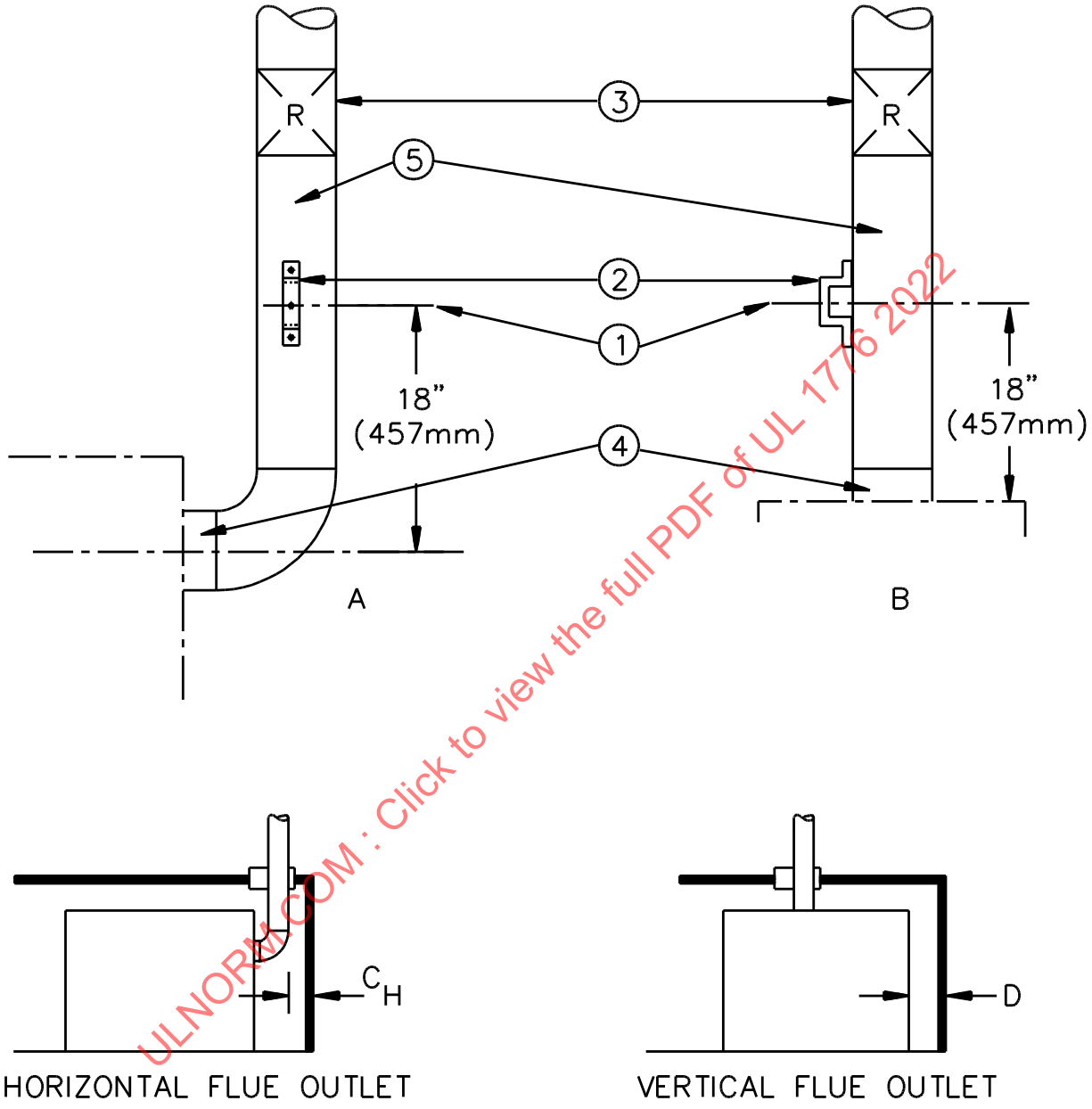
Sealing of annulus around chimney connector



64.3.5 A bracket for supporting the thermocouple used to measure flue-gas temperature is to be located as shown by item 2 of Figure 64.4.

Figure 64.4

Chimney connectors



1. Centerline of thermocouple.
2. Support bracket.
3. Draft regulator.
4. Flue collar.
5. Chimney connector, same nominal diameter as flue collar.

64.3.6 As shown in item 3 of Figure 64.4, a draft regulator is to be located in the chimney connector, outside the test enclosure.

64.3.7 A built-in draft regulator included as part of the product is to be fixed in the position that results in maximum draft.

64.3.8 For the closet installation test, the door is to have two openings located so that the lower edge of the lower opening is 6 inches (152 mm) above the floor level of the enclosure and the other being located so that its upper edge is 6 inches below the ceiling of the enclosure. The height of each opening is to be one-half the width. The free area of each of the two openings is to be at least 1 square inch (6.5 cm^2) per 1000 Btu per hour (300 W) of the heater input rating but not more than an area equivalent to 20 percent of the total area of the simulated door. Both openings are to be centered on the vertical centerline of the enclosure.

64.4 All portable products

64.4.1 The representative product, in the as-received condition, is to be placed in a test enclosure as specified in 64.4.2. The product is to be placed as close to the corner as possible. The sides of the product that result in highest enclosure wall temperatures are to be located nearest to the enclosure walls.

64.4.2 The walls of the test enclosure are to be constructed of not less than 1/2-inch trade size wood boards or 1/2-inch (12.7-mm) thick plywood, set at right angles to each other and finished in flat black. The floor is to be constructed of 1/2-inch-thick plywood or equivalent, finished in flat black paint. All joints in the enclosure are to be tight or sealed.

64.5 Fuel-fired portable products

64.5.1 A bracket for supporting the thermocouple used to measure flue-gas temperature is to be located in the flue gas outlet approximately 4 inches (101.6 mm) below the draft hood, if provided.

64.5.2 A built-in draft regulator, included as part of the product, is to be fixed in the position that results in maximum draft.

PERFORMANCE – ALL PRODUCTS

65 Normal Operation Tests

65.1 All products

65.1.1 Operation of a product as described in 65.1.2 shall not result in a risk of fire, electric shock, or injury to persons. In addition, there shall be no leakage of any combustible fluids within the product that may be ignited and thereby cause a risk of fire.

65.1.2 With reference to 65.1.1, an as-received representative product is to be set up or installed in accordance with the manufacturer's instructions. The representative product is to be operated in accordance with the manufacturer's instructions with respect to all normal uses of the product, and with all accessories recommended by the manufacturer for use with the product. The product is to be operated for a sufficient length of time or through a sufficient number of cycles to determine that all reasonably foreseeable complications are revealed. The representative product is to be manipulated as it would be in actual use, including

a) Adjustment of each control over its full range,

b) Operation under each loading condition that can be expected, and

c) The omission of all recommended maintenance and cleaning operations.

65.2 Gas-fired products

65.2.1 A representative product is to be fired at its rated Btu per hour (W) input, ±2 percent, with the kind or kinds of gas specified and at the test pressures specified. A draft hood, if used, is to be in place.

65.3 Oil-fired products with mechanical atomizing burners

65.3.1 A representative product is to be fired at its rated Btu per hour (W) input, ±2 percent, with a grade of fuel for which the burner is rated. The draft at the flue collar is to be as recommended by the manufacturer but not more than 0.06 inch (1.5 mm) water column for burners fired at 5 gallons (18.9 L) per hour or less and not more than 0.09 inch (2.3 mm) for burners fired at rates from 5 to 16 gallons (18.9 to 60.6 L) per hour.

66 Maximum Pressure Tests

66.1 When tested in accordance with 66.2 – 66.4, the outlet water pressure at the discharge nozzle of any product shall not exceed the maximum rated pressure by more than 10% and in any case, shall not exceed the pressure rating of the Type category of the product.

66.2 The product is to be prepared in accordance with the manufacturer's instructions for operation.

66.3 Controls are to be adjusted to their maximum values of pressure and temperature. For a fuel-fired product, a modulating type operating control provided to regulate the fuel input between high and low fire values is to be rendered inoperative so as to result in continuous operation at high fire. An on-off type operating control, set to cut out at a value below the set point of the limit control, is also to be rendered inoperative during this test.

66.4 The inlet and outlet water valves are to be adjusted so that hot water passes the thermocouple bead during the test.

66.5 The product is to be fired at maximum rated input and the water valve is to be adjusted to raise the temperature of the water in the vessel until the limit control operates.

66A Pressure Hose Tests for Type 4 Machines

66A.1 Pressure hose leakage test

66A.1.1 One sample of the hose shall be subjected to a hydrostatic pressure equal to 70 % of the manufacturer’s specified minimum burst pressure and maintained for 5 minutes before reducing the pressure to zero. The application of the same hydrostatic pressure shall be repeated for another 5 minutes before reducing the pressure to zero.

66A.1.2 As a result of the pressure testing, there shall be no leakage or evidence of failure. Leakage at the end fitting, fitting blowing-off or rupture of the hose is not acceptable.

66A.2 Cold bend test

66A.2.1 A mandrel with an outside diameter equal to twice the minimum bend radius specified for the hose with an arc of at least 180º is to be used for this test. If the minimum bend radius is not specified, the mandrel shall have an outside diameter equal to 12 times the ID of the hose.

66A.2.2 The test shall be conducted on a length of pressure hose adequate to provide a grip at each end in addition to a section which can be bent round the periphery of the mandrel.

66A.2.3 The mandrel and the hose are to be conditioned in a cold chamber maintained at -10 ºC ± 2 ºC for 24 hours.

66A.2.4 Without removing them from the conditioning chamber, the hose shall be bent around the mandrel. For hoses of up to and including 22 mm ID, the hose shall be bent through 180° in 10 s ±2 s. For hoses of greater than 22 mm ID, the hose shall be bent through 90° in 10 s ±2 s.

For hoses of greater than 22 mm ID, testing outside of the conditioning chamber is permitted, provided testing is conducted immediately upon removal from the cold chamber.

66A.2.5 The hose sample shall be examined for any cracking or breaking of the hose lining or cover. The hose sample shall be allowed to return to ambient temperature, and a hydrostatic pressure equal to 1.5 times the maximum working pressure shall be applied for 5 minutes, in order to confirm by test whether any cracking or breaking of the lining or cover has occurred.

66A.3 Burst pressure test

66A.3.1 One sample of the pressure hose shall be subjected to a hydrostatic pressure by increasing the pressure at a rate specified in 66A.3.2 until the hose fails. The location and mode of failure shall be determined.

66A.3.2 For hoses with nominal inside diameters up to 2.0 inch (50 mm), the hydrostatic pressure shall be increased at a steady rate so that it reaches the final test pressure within 30 s and 60 s.

For hoses with nominal inside diameters greater than 2.0 inch (50 mm) and less than or equal to 10 inch (250 mm), the time to reach the final pressure shall be within 60 s and 240 s.

For hoses with nominal inside diameters greater than 10 inch (250 mm), the time to reach the final pressure shall be specified by the manufacturer.

66A.4 Tensile test

66A.4.1 The hose shall be installed in a tensile test machine and a pulling force as specified in 66A.4.2 shall be applied slowly. As a result of the tensile test, there shall be no evidence of tears or signs of failure.

66A.4.2 The hose shall withstand a tensile force equivalent to that caused by a pressure equal to 1.5 times the maximum allowable working pressure or 225 Pound Force (1000 N), whichever value is lower.

66A.5 Hydrostatic pressure hold test

66A.5.1 Each hose shall be subjected to a hydrostatic pressure hold test according to 66A.5.2. The test pressure shall be 1.5 times the maximum allowable working pressure.

Exception: For hoses with a maximum allowable working pressure of ≤ 7250 psig (50 MPa) this test can be omitted provided 100 % of the hoses are pressure tested in production; see 111.2.

66A.5.2 When this test is used to determine leakage of hoses or hose assemblies, the specified pressure shall be applied in accordance with 66A.3.2, and the pressure shall be held between 30 s and 60 s. The test specimen shall be examined during this period for evidence of leakage, cracking, abrupt distortions indicating irregularity in material or manufacture, or other signs of failure.

67 Normal Temperature Test

67.1 General

67.1.1 A product shall not reach a temperature at any point high enough to cause a risk of fire, to damage any materials in the product, or show temperature rises at specific points greater than those indicated in Table 67.1.

Table 67.1
Maximum temperature rises

Materials and components	°C	°F
1. Capacitors:		
A. Electrolytic[a]	40	72
B. Other types[b]	65	117
2. Fuses		
A. Class G, J. L. T, and CC		
Tube	100	180
Ferrule or blade	85	153
B. Others[h]	65	117
3. Fiber employed as electrical insulation	65	117
4. At any point within a terminal box or wiring compartment of a permanently connected machine in which power-supply conductors are to be connected, including such conductors themselves, unless the machine is marked in accordance with 112.2.3	35	63
5. A surface upon which a stationary machine may be fastened in place, and surfaces that may be adjacent to the machine when so mounted.	65	117
6. Class A insulation systems on coil windings of an a-c motor having a diameter of more than 7 inches (178 mm), of a d-c motor, and of a universal motor:[c,d]		
A. In an open motor:		
Thermocouple method	65	117
Resistance method	75	135
B. In a totally enclosed motor:		
Thermocouple method	70	126
Resistance method	80	144
7. Class A insulation system on coil windings of an a-c motor having a diameter of 7 inches of less, not including a universal motor, and on a vibrator coil:[c,d]		
A. In an open motor and on a vibrator coil:		
Thermocouple or resistance method	75	135
B. In a totally enclosed motor:		
Thermocouple or resistance method	80	144
8. Class B insulation system on coil windings of an a-c motor having a frame diameter of more than 7 inches (178 mm), of a d-c motor, and of a universal motor:[c,d]		
A. In an open motor:		
Thermocouple method	85	153
Resistance method	95	171
B. In a totally enclosed motor:		
Thermocouple method	90	162

Table 67.1 Continued on Next Page

Table 67.1 Continued

Materials and components	°C	°F
Resistance method	100	180
9. Class B insulation system on coil windings of an a-c motor having a diameter of 7 inches or less, not including a universal motor[c,d]		
A. In an open motor:		
Thermocouple or resistance method	95	171
B. In a totally enclosed motor:		
Thermocouple or resistance method	100	180
10. Class 105 insulation system on windings of relay, a solenoid, and similar components[c]		
Thermocouple method	65	117
Resistance method	85	153
11. Class 130 insulation system on windings of a relay, a solenoid, and similar components[c]		
Thermocouple method	85	153
Resistance method	105	189
12. Class 130 insulation systems on vibrator coils:		
Thermocouple or resistance method	95	171
13. Transformer coil with		
A. Class 105 insulation system		
Thermocouple method	65	117
Resistance method	75	135
B. Class 130 insulation system		
Thermocouple method	85	153
Resistance method	90	171
14. Transformer enclosures:		
A. Class 2	60	108
B. Power	65	117
15. Phenolic composition employed as electrical insulation or as a part the deterioration of which would result in a risk of fire or electric shock.[e]	125	225
16. Rubber- or thermoplastic-insulated wire and cord.[e,f,g]	35	63
17. Copper conductors		
A. Tinned or bare strands having:		
1. A diameter less than 0.015 inch (0.38 mm)	125	225
2. A diameter of 0.015 inch or more	175	315
B. Plated with nickel, gold, silver, or a combination of these	225	405
18. Rectifiers:		
a. Selenium[k,l]	50	90
b. Silicon	75	135
19. Sealing compound	40°C (104°F) less than melting point	
20. Varnished-cloth insulation	60	108
21. Wood and other combustible material	65	117
22. Engine electrical systems (Ignition system, 12 volts)	150	270
23. Flame spreaders and combustion heads:		
A. Gray cast iron	517	930

Table 67.1 Continued on Next Page

Table 67.1 Continued

Materials and components			°C	°F
	B.	Chrome alloy cast iron, 0.5-1.0 percent chrome, 0.2-0.5 percent nickel or copper	683	1230
	C.	Ductile, modular, cast iron	683	1230
	D.	Type 430 iron-chromium steel	794	1430
	E.	Types 442, 446 iron-chromium steels	867	1560
	F.	Type 501, 502 iron-chromium steels	683	1230
	G.	Type 309 iron-chromium-nickel steel	961	1730
24.	Flue-Gas baffles:			
	A.	Aluminum coated steel	572	1030
	B.	Ceramic coated steel (A19 or equivalent)	572	1030
	C.	Low carbon steel	572	1030
	D.	Gray cast iron	517	930
	E.	Ductile, nodular, cast iron	517	930
	F.	Chrome alloy cast iron, 0.5-1.0 percent chrome, 0.2-0.5 percent nickel or copper	683	1230
	G.	Types 501, 502, iron-chromium steels	683	1230
	H.	Type 430 iron-chromium steel	683	1230
	I.	Type 442 iron-chromium steel	794	1430
	J.	Type 446 iron-chromium steel	867	1560
	K.	Type 309 iron-chromium-nickel steel	961	1730
25.	Heating surfaces:			
	A.	Aluminum coated steel	572	1030
	B.	Ceramic coated steel (A19 or equivalent)	572	1030
	C.	Low carbon steel	461	830
	D.	Gray cast iron	461	830
	E.	Chrome alloy cast iron, 0.5-1.0 percent chrome, 0.1-0.5 percent nickel or copper	561	1010
	F.	Type 410 iron-chromium steel	600	1080
	G.	Type 430 iron-chromium steel	648	1130
	H.	Type 442 iron-chromium steel	867	1560
	I.	Type 446 iron-chromium steel	867	1560
	J.	Type 321 iron-chromium-nickel steel	744	1340
	K.	Type 347 iron-chromium-nickel steel	764	1375
	L.	Type 316 iron-chromium-nickel steel	800	1440
	M.	Type 309 iron-chromium-nickel steel	747	1345
	N.	Aluminum coated steel liners and radiation shields[i]	461	830
	O.	Galvanized steel[j]	267	480
26.	Fuel tubing and fittings:			
	A.	Aluminum	347	625
	B.	Copper and copper alloys	208	375
	C.	Tinned copper	153	275
	D.	Steel (AISI Type C1010)	403	725
	E.	Steel (AISI Type 410)	514	925
	F.	Steel (AISI Type 430)	647	1165

Table 67.1 Continued on Next Page

Table 67.1 Continued

Materials and components	°C	°F
G. Steel (AISI Type 446)	847	1525
27. Fuel:		
A. Gasoline or diesel fuel in a tank	25	45
B. LP-Gas in a fuel tank	m	m
28. Flue gases (permanently installed products):		
A. Gas-fired products		
Equipped with a draft hood	222	400
Other	472	850
B. Oil-fired products	517	930

[a] The temperature rise on insulating material integral with the enclosure of an electrolytic capacitor that is physically integral with or attached to a motor may be not more than 65°C (117°F).

[b] A capacitor that operates at a temperature rise of more than 65°C may be judged on the basis of its marked temperature limit.

[c] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may be higher by the following amount than the maximum specified:

Item	Additional Temperature Rise °C	Additional Temperature Rise °F
Part A of item 6	15	27
Part A of item 7	5	9
Part A of item 8	20	36
Part A of item 9	10	18
10	15	27
11	15	27

provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

[d] This is the diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, boxes, and similar parts, used solely for motor cooling, mounting, assembly, or connection.

[e] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found acceptable for use at higher temperatures.

[f] Rubber-insulated conductors within a Class-A-insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35°C (63°F), provided that a braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords.

[g] A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 60°C (140°F), such as at terminals, is acceptable if supplementary heat-resistant insulation of adequate dielectric strength is employed on the individual conductors of the cord to protect the conductor insulation against deterioration.

[h] A fuse that has been investigated and found acceptable for use at a higher temperature may be used at that temperature.

[i] The specified maximum temperature applies if the reflectivity of aluminum coated steel is utilized to reduce risk of fire; otherwise the allowable temperature rise is as given under Heating Surfaces.

[j] The specified maximum temperature applies if the galvanizing is required as a protective coating or the reflectivity of the surface serves to reduce risk of fire.

[k] A temperature of 85°C (185°F) is acceptable if the stack assembly is insulated with phenolic composition or other insulating material acceptable for 150°C (302°F).

[l] The limitation does not apply to a rectifier that has been investigated and accepted for a higher temperature.

[m] Temperature shall not exceed that which would raise the pressure within an LP-Gas container to more than 80 percent of the design working pressure of an ASME container or 120 percent of the minimum service pressure of a DOT fuel container.

67.1.2 A thermal- or overload-protective device shall not open the circuit during the temperature test.

67.1.3 All values of temperature rise in Table 67.1 are based on an assumed ambient temperature of 25°C (77°F). Tests may be conducted at any ambient temperature within the range 10 – 40°C (50 – 104°F).

67.1.4 If a product incorporates a reel for the power-supply cord, one-third of the length of the cord is to be unreeled for the temperature test.

67.1.5 For fixed fuel-fired products where a chimney connector passes through the test enclosure, enclosure inside surface temperatures are to be measured not less than 2 inches (51 mm) from the annulus, and not farther than 6 inches (152 mm) for a gas-fired product, and 9 inches (228 mm) for an oil-fired product from the chimney connector.

67.1.6 For a product without a water heating system, the inlet water temperature is to be 71°C (160°F), or at the temperature recommended by the manufacturer, whichever is higher.

Exception: A product recommended and marked to indicate it is intended for cold water only, is to be connected to a source of cold tap water.

67.1.7 A temperature is considered to be constant when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change.

67.2 Surface temperature test

67.2.1 During the temperature test, the temperature of a surface that may be contacted by the user shall not rise more than indicated in Table 67.2. If the test is conducted at a room temperature of other than 25°C (77°F), the results are to be corrected to that temperature.

Exception No. 1: Parts in the fluid discharge line of a hot water or steam generated product may have surface temperature rises exceeding those specified in Table 67.2, but shall have designated gripping surfaces for the lance or wand within the handle temperature limits. A cautionary marking in accordance with 113.1.11 warning the user shall be provided.

Exception No. 2: Parts expected to be contacted or subjected to contact during periodic servicing, that require removal of a panel, guard, or cover for access, may exceed the temperature rises in Table 67.2 provided the part or panel is marked in accordance with 113.1.12.

Exception No. 3: Temperatures on a flue pipe of a fuel-fired unit may exceed the limits in Table 67.2. If the flue pipe is provided as an integral part of the product it shall be marked "Caution – Hot."

Table 67.2
Maximum surface temperature rises

Materials and Components	°C	°F
Handle or knob grasped for lifting, carrying, or holding:[a]		
A. Metallic	25	45
B. Nonmetallic	35	63
Handle, knob, or surface of the enclosure intended to be contacted during normal use but not requiring continuous holding:[a]		
A. Metallic	35	63
B. Nonmetallic	60	108
Surface subjected to casual contact:[a]		
A. Metallic	45	81
B. Nonmetallic	70	126

[a] A handle, knob, or similar object, made of a material other than metal, that is plated or clad with metal having a thickness of 0.005 inch (0.127 mm) or less is considered to be, and is judged as, a nonmetallic part.

67.3 Maximum normal load

67.3.1 In tests on a product, maximum normal load is considered to be the load that approximates as closely as possible the most severe conditions of normal use. It is not a deliberate overload except as the conditions of actual use are likely to be somewhat more severe than the maximum load conditions that are recommended by the manufacturer of the product. The recommended nozzle that results in the highest power input to the product is to be installed for the test.

67.3.2 A product is to be operated by spraying water in the intended manner until constant temperatures are obtained. The product is then operated for 10 minutes without spraying water. During the ten minutes, the product is to be in the ON position and the trigger at the gun closed. All temperature and pressure controls are to be adjusted to their maximum setting.

67.3.3 The flue-gas temperature is to be measured by a thermocouple, such as illustrated by Figure 63.1, inserted into the chimney connector as shown in Figure 63.2. There is to be no draft control between the product and the point where the flue-gas temperature is measured. If a draft control is incorporated in the product, it is to be fixed in the position allowing maximum draft during all tests.

68 Abnormal Operation Tests

68.1 All products

68.1.1 A product, when operated continuously under the abnormal conditions described in 68.1.3 – 68.3.3, shall not create a risk of fire, electric shock, or injury to persons. It shall also comply with the requirements in 68.1.2, and the following:

a) There shall be no emission of flame or molten metal, other than molten solder;

b) There shall be no glowing or flaming of combustible material upon which it may be placed or that may be in proximity to the appliance as installed;

c) The fuse in the grounding connection shall not open.

68.1.2 Immediately following each abnormal-operation test condition, the product shall comply with the requirements in the Dielectric voltage-Withstand Test, Section 83. See 68.2.1.

68.1.3 With consideration given to the construction of the machine, it is to be operated under abnormal conditions representing those likely to be encountered in actual service, such as the malfunction of an air-circulating fan, operation of a liquid heater without liquid, or similar abnormal conditions. For a machine that includes a bypass circulation system and a flow indicator device, the abnormal condition is to include also a test to determine that no abnormal pressures will develop in the bypass system with the flow indicator device failed in the flow position. Only one condition of malfunction is to be assumed at any one time. During the test, dead metal parts of the product are to be connected to ground through a 3-ampere fuse.

68.1.4 Each test is to be continued until final results are observed or for 7 hours, whichever is less.

68.2 Electrically heated products

68.2.1 For a product with a liquid heater operated without liquid, the liquid container is to be filled with water following the abnormal operation test and the product operated as intended with the dead metal still connected to ground through a 3-ampere fuse. During this operation the 3-ampere fuse in the grounding connection shall not open and, following operation, the product shall comply with the requirements in the Dielectric voltage-Withstand Test, Section 83.

68.3 Fuel-fired products

68.3.1 A product with a fuel-fired water-heating system, when operated under conditions of restricted inlet water flow as described in 68.3.2 and 68.3.3, shall comply with the requirements in 68.1.1, and become de-energized, and incapable of being reenergized, when a low-water condition exists in the water reservoir.

68.3.2 A limit control is to be adjusted in accordance with 46.4.1 and 46.4.2. An auxiliary limit control, if adjustable, is to be set to the minimum allowable setting. A modulating type operating control provided to regulate the fuel input between high and low fire value is to be bypassed to permit the product to operate on high fire. The on-off type operating control, set to cut out at a value below the set point of the limit control, is also to be bypassed during this test.

68.3.3 A slow closing valve is to be placed in the water inlet line and the product is to be operated at maximum rated input with the inlet water valve completely closed, and water inlet valve restricted until the product is de-energized. Attempts are then to be made to energize the product.

69 Hydrostatic Pressure and Strength Test

69.1 A component or assembly that is subjected to hydraulic pressure during normal or abnormal operation is to be tested as indicated in 69.3 or 69.4. During the test the representative product shall not rupture or leak to the extent that a risk of injury may be introduced.

69.2 For components, if the strength of the material may be sensitive to the temperatures developed in use, the components are to be subjected to the pressure test while exposed to the same temperatures that will be experienced in service and determined during the temperature test.

69.3 A representative component is to be filled with water so as to exclude air and then connected to a hydraulic pump. The pressure is to be raised gradually to, and held for 1 minute at, a test value equivalent to:

a) Twice the setting of the pressure relief device, or

b) If no pressure relief device is provided, twice the maximum pressure that the system is capable of developing.

Exception: If the exception to 54.2 is utilized, the pressure used for this test is to be twice the product marked maximum pressure rating.

69.4 A representative component for a hot water washer is to be subjected to the same pressure test as described in 69.3 but immediately following an operational test with the flow rate adjusted to the value creating the maximum hose surface temperature. Valves and fitting are to be connected to the system so that hydrostatic pressure testing may be conducted immediately after the system is shut down. If the exception to 54.2 is utilized, the pressure used for this test is to be 2-1/2 times the maximum pressure rating marked on the product.

69.5 Components subject to pressure and constructed of, or that rely upon, polymeric material are to be subjected to the test of 69.3 before and after the mold stress test of 71.2.

70 Tests on Gaskets, Seals, and Parts

70.1 Fluid handling parts

70.1.1 A synthetic rubber gasket, seal, or part, in contact with one of the fluids indicated in Table 70.1, when considered on the basis of its intended function, shall comply with the requirements in 70.2.1 – 70.4.2.

Exception No. 1: The weight loss test described in 70.4.1 and 70.4.2 need not be conducted with ASTM Reference Fuel A or IRM 903 Oil.

Exception No. 2: If the limits for volume change or weight loss are exceeded, a complete product assembly shall be filled with the appropriate test liquid for 70 hours. Following the exposure, the product shall comply with the requirements in the Hydrostatic Pressure and Strength Test, Section 69.

Table 70.1
Test liquids for synthetic rubber materials

Fluid in contact with part	Test liquid
Manufactured and Natural Fuel Gases	IRM 903 Oil and n-Hexane
LP-Gas	n-Hexane
Fuel Oils	IRM 903 Oil
Gasoline	A and C Reference Fuels (ASTM D471)

70.2 Aging test

70.2.1 Neoprene or rubber compounds, except foamed materials, used for gaskets to seal a fuel-confining part or electrical enclosure shall have physical properties as specified in Table 70.2 before and after accelerated aging under the conditions specified in Table 70.3.

Table 70.2
Physical properties of gaskets

Materials	Neoprene or rubber compound		Polyvinyl-chloride	
	Before test	After test	Before test	After test
Elongation – Minimum increase in distance between 1-inch (25.4-mm) gage marks at break	Not specified	50 percent of original	Not specified	50 percent or original
Tensile Strength – Minimum force at breaking point	850 psig (5.86 MPa)	50 percent of original	1200 psig (8.27 MPa)	50 percent of original

Table 70.3
Accelerated aging conditions

Measured temperature[a]		Test program	
°C	(°F)	Rubber or neoprene	Thermoplastic
60	140	Air oven aging for 70 hours at 100 ±2°C (212 ±3.6°F)	7 days in an air-circulating oven at 87°C (189°F)
75	167	Air oven aging for 168 hours at 100 ±2°C (212 ±3.6°F)	10 days in an air-circulating oven at 100°C (212°F)
80	176	7 days in an air-circulating oven at 113°C (235.4°F)	
90	194	10 days in an air-circulating oven at 121°C (249.8°F)	7 days at 121°C or 60 days at 97°C (206°F) in an air-circulating oven
105	221	7 days in an air-circulating oven at 136°C (276.8°)	

[a] The temperatures specified correspond to the maximum temperature measured on the gasket during the Normal Temperature Test, Section 67.

70.2.2 Foamed neoprene or rubber compounds forming gaskets to seal a fuel-confining part or an electrical enclosure are to be subjected to accelerated aging under the conditions specified in Table 70.3. The compounds shall not harden or otherwise deteriorate to a degree that will impair their sealing properties.

70.2.3 Thermoplastic materials forming gaskets to seal a fuel-confining part or electrical enclosure are to be subjected to accelerated aging under the conditions specified in Table 70.3. Thermoplastic material shall not deform or melt, or otherwise deteriorate to a degree that will impair its sealing properties. Solid polyvinyl-chloride gasket material shall have physical properties as specified in Table 70.2 before and after the accelerated aging.

70.2.4 Gaskets of materials other than those mentioned in 70.2.1 – 70.2.3 shall be made of material that does not absorb moisture and shall provide equivalent resistance to aging and temperatures.

70.3 Volume change

70.3.1 The volume change of a synthetic rubber gasket, seal, or part, shall be not more than 25 percent swelling or 1 percent shrinkage when tested in accordance with the Standard Test for Rubber Property, Effect of Liquids, ANSI/ASTM D471-95; except as specified in 70.3.2.

Exception: The swelling shall be not more than 40 percent for a gasket or seal tested in ASTM Reference Fuel C.

70.3.2 The tests using ASTM Reference Fuels A and C, n-hexane, and IRM 903 Oil are to be conducted at a temperature of 23 ±2°C (77 ±4°F). Three specimens are to be used in each test. Each specimen is to be placed on a small diameter wire hook. Its volume is then to be determined by weighing first in air (M) and then in water (M_2). The specimens are then to be wiped dry and placed in the test liquid. After 70 hours, the specimens are to be removed from the liquid one at a time, immediately wiped dry, and weighed in air while on the same hook (M_3). The weight is to be obtained within 30 seconds after removal from the test liquid. The final weight in water (M_4) is to be determined immediately thereafter. Before obtaining the weights in water (M_2 and M_4), each specimen is to be dipped in ethyl alcohol, then dipped in water, in order to eliminate surface air bubbles. The change in volume is to be calculated as follows, with the results reported as the average of the three specimens tested:

$$Volume\ Change\ (\%) = \frac{[(M_3 - M_4) - (M_1 - M_2)] \times 100}{(M_1 - M_2)}$$

70.4 Weight loss

70.4.1 The weight loss (extraction) of a synthetic rubber gasket, seal, or part, shall not be more than 10 percent when determined in accordance with the Standard Test for Rubber Property – Effect of Liquids, ANSI/ASTM D471-95, except as specified in 70.4.2.

70.4.2 The test is to be conducted at the same time and using the same specimens as for the volume change test described in 70.3.1 and 70.3.2. For this test, each specimen is to be weighed on a balance pan, in air, to the nearest milligram (M_1) prior to immersion in the test liquid. After 70 hours immersion, and following the weight determinations needed for the volume change calculation, the specimens are to be allowed to reach constant weight by conditioning in air at a temperature of 23 ±2°C (77 ±4°F) for at least 70 hours. The specimens are then to be weighed in air (M_2). The loss in weight is to be calculated as follows, and the results reported as the average of the three specimens tested:

$$Weight\ \ Loss\ \ (\%) = \frac{(M_1 - M_2) \times 100}{M_1}$$

70.5 Gaskets and seals for fuel tank joints

70.5.1 In addition to complying with the requirements specified in 70.2.1 – 70.2.4, gaskets or sealing compounds used to prevent leakage through fuel tank joints and located below the intended fuel level in the tank or below the maximum fuel level in a sump shall also not leak after test when subjected to the tests specified in 70.5.2 – 70.5.6.

70.5.2 Three representative fuel tanks under test are to be placed in an air oven maintained at a temperature of 100°C (212°F) for 168 hours.

70.5.3 Three representative fuel tanks under test are to be filled with the intended fuel and placed in a room ambient of 23 ±2°C (73.4 ±3.6°F) for 720 hours.

70.5.4 Three representative fuel tanks under test are to be filled with a 50 percent water and 50 percent fuel mixture and placed in a room ambient of 23 ±2°C (73.4 ±3.6°F) for 30 days.

70.5.5 Each representative fuel tank is to be subjected to an aerostatic leakage test before and after aging, fuel exposure, and fuel and water exposure and after the drop test described in 70.5.6. Each representative gravity tank shall withstand a pressure of 1 psig (6.9 kPa) for 1 minute.

70.5.6 Each representative fuel tank that is intended to be removed for filling is then to be drop tested. The fuel tank is to be half filled with water and dropped 30 inches (0.8 m), so that impact will be on the bottom of the tank. Each representative fuel tank is then to be subjected to the leakage test specified in 70.5.5.

70.6 Cleaning solution

70.6.1 If the deterioration of a liquid container, seal, or similar component could result in a risk of fire or electric shock, the container, seal, and diaphragm shall be adequately resistant, as determined by investigation, to deterioration from the liquid intended to be used in contact with that component.

70.6.2 The investigation for determining whether a component complies with the requirement in 70.6.1 depends upon the material of which it is composed, its size and shape, the mode of application in the product, and other factors. The investigation may include visual inspection for cracks, deformation, and similar deterioration after artificial aging, as well as comparison of hardness, tensile strength, and elongation before and after artificial aging.

70.6.3 With reference to 70.6.1 and 70.6.2, a component of rubber or neoprene, if tested to compare its tensile strength and elongation before and after artificial aging, is acceptable if these properties are found to be not less than the minimum values specified in Table 70.4 corresponding to the temperature of the component during the normal temperature test.

Table 70.4
Artificial-aging tests

Temperature on component during normal temperature test	Artificial-aging procedure	Tensile strength and elongation
60°C (140°F) or less	Immersion for 168 hours at 70 ±1°C (158.0 ±1.8°F)in the liquid to which the component is exposed	At least 50 percent of original
60°C or less	Air oven aging for 70 hours at 100 ±2°C (212 ±3.6°F)	
More than 60°C	Immersion for 168 hours in a boiling solution of commercial detergent – 25 grams per liter of water[a]	
61 – 75°C (142 – 167°F)	Air oven aging for 168 hours at 100 ±2°C (212 ±3.6°F); and air bomb, 20 hours at 127 ±1°C (260.6 ±1.8°F) and 80 ±3 psig (551.6 ±27.7 kPa)	
76 – 90°C (169 – 194°F)	Air oven for 168 hours at 121 ±1°C (249.8 ±1.8°F)	
91 – 105°C (196 – 221°F)	Air oven for 168 hours at 136 ±1°C (276.8 ±1.8°F)	

[a] If the part is not subjected a detergent solution, the appropriate agent should be substituted for this test.

71 Tests on Nonmetallic Enclosures and Guards

71.1 Ball-impact

71.1.1 To determine compliance with 50.1, the component installed as intended shall not crack to the extent that moving or hot parts that may result in a risk of injury to persons are exposed to unintentional contact when struck with a smooth steel sphere having a diameter of 2 inches (51 mm) and weighing 1.18 pounds (0.53 kg).

71.1.2 If the component being tested can be struck from above, the sphere is to be allowed to fall vertically from rest to strike the component. Otherwise, the sphere is to be suspended by a cord and is to be allowed to fall from rest as a pendulum to strike the component. In either case, the vertical travel of the sphere is to be 51 inches (1.30 m).

71.1.3 If the component is intended for outdoor use, it shall also be struck with the sphere specified in 71.1.1 immediately after being conditioned at −35.0 +2.0°C (−31.0 +3.6°F) for 3 hours.

Exception: For an appliance marked "Store Indoors" (or equivalent) in accordance with 112.1.5, the conditioning temperature shall be 0.0 +2.0°C (32.0 +3.6° F).

71.2 Mold stress-relief distortion

71.2.1 A polymeric enclosure or guard shall withstand the conditioning described in 71.2.2 without:

a) Cracking, shrinkage, warpage, or other distortion that affects the functional strength of the part; and

b) Being affected to the extent that moving or hot parts would be exposed to unintentional contact.

71.2.2 A representative guard or enclosure is to be conditioned in an air-oven for 7 hours at a uniform temperature not less than 10°C (18°F) higher than the maximum operating temperature of the material during the Normal Temperature Test, Section 67, measured under normal operating conditions, but not less than 70°C (158°F).

71.3 Light and water exposure

71.3.1 For a nonmetallic enclosure or guard that is exposed to sunlight during intended operation, the Izod impact strength (71.4.1) and tensile impact strength (71.5.1) of specimens conditioned in accordance with 71.3.2 shall not be less than 70 percent of that obtained on unconditioned specimens.

71.3.2 Five specimens cut from the enclosure or guard are to be exposed for 720 hours to light and water using the test procedure described in the Standard for Light and Water Exposure Apparatus (Carbon Arc Type) for Exposure of Nonmetallic Materials, ASTM G23-1969(1975). After exposure to the light and water the specimens are to be conditioned for at least 24 hours at 23 ±3°C (73 ±5°F) and 50 percent relative humidity.

71.4 Izod impact

71.4.1 The Izod impact strength is to be determined in accordance with the procedures specified in Tests for Impact Resistance of Plastics and Electrical Insulating Materials, ASTM D256-1981, on ten specimens obtained from the finished part, five specimens in the as-received condition, and five specimens conditioned in accordance with 71.3.2. For materials less than 1/8 inch (3.2 mm) thick and on materials that tend to flex (twist) in the test, the tensile impact test in 71.5.1 is generally conducted in lieu of the Izod impact test.

71.5 Tensile impact

71.5.1 The tensile impact strength is to be determined in accordance with the procedures specified in the Test for Tensile-Impact Energy to Break Plastics and Electrical Insulating Material, ASTM D1822-1979, on specimens obtained from the finished part, five specimens in the as-received condition, and five specimens conditioned in accordance with 71.3.1 – 71.3.2.

72 Drop-Impact Test

72.1 The trigger guard on a hand-supported product shall withstand the impact test described in 72.2 and 72.3 without being affected to the extent that:

a) The performance of the product is adversely affected so as to result in a risk of injury to persons, or

b) Parts capable of causing injury to persons are exposed to unintentional contact.

72.2 Three representative products are to be dropped through 5 feet (1.52 m) to strike a flat, concrete surface in the position most likely to produce unacceptable results. Fewer representative products may be used for the test provided a total of nine drops are completed and each representative product completes at least three acceptable drops.

72.3 Each representative product is to be dropped three times so that in each drop, the representative product strikes a surface in a position different from those in the other two drops.

72.4 Trigger guard assemblies for all products shall be dropped as specified in 72.2 and 72.3 after being conditioned for 3 hours at −35.0 +2.0°C (−31.0 +3.6°F).

Exception No. 1: Portable equipment for use outdoors, but intended to be stored indoors, and marked in accordance with 112.1.5 shall be conditioned for 3 hours at 0.0 +2.0°C (32.0 +3.6° F) instead of −35.0 +2.0°C (−31.0 +3.6°F).

Exception No. 2: Stationary and fixed equipment intended for indoor installation and marked in accordance with 112.1.5 shall be conditioned for 3 hours at 0.0 +2.0°C (32.0 +3.6° F) instead of −35.0 +2.0°C (−31.0 +3.6°F).

73 Test for Strength of Support Handles

73.1 A support handle shall withstand a load of four times the weight of the product without damage to the support handle, its securing means, or that portion of the enclosure to which the support handle is attached.

73.2 The load is to be uniformly applied over a 3-inch (76-mm) width at the center of the support handle, without clamping. The load is to be started at zero and gradually increased so that the test value is attained in 5 to 10 seconds; the test value is to be maintained for 1 minute. If a product has more than one support handle and cannot be carried by one support handle, the load is to be distributed between the support handles. The distribution of the load is to be determined by measuring the percentage of the product weight sustained by each support handle with the product in the normal carrying position. If a product is furnished with more than one support handle and can be carried by only one support handle, each support handle shall withstand the total load.

73.3 Support handles constructed of, or that rely upon, polymeric materials are to be subjected to the test of 73.2 before and after the mold stress test of 71.2.

74 Tests on Pressure-Regulating Control Switches

74.1 General

74.1.1 There shall be no shift in calibration greater than 5 percent above initial calibration pressure setting after a pressure-regulating control switch has been subjected to its rated load for 30,000 cycles of operation. An adjustable control is to be tested at its highest pressure setting unless the adjusting means is reliably sealed at a lower setting.

74.2 Overpressure protection tests

74.2.1 To determine compliance with the requirements in 54.1, a product provided with a pressure-regulating control or pressure-relief device is to have its controls set to allow maximum pressure to build up within the vessel. The nozzle valve is to be closed and any bypass or dump valves are to be blocked or otherwise set in the position that will provide the highest pressure. The system design shall inhibit the pressure from rising after the pressure-regulating control or pressure-relief device has activated or discharged.

74.2.2 To determine the start-to-discharge pressure described in 54.2, each of three representative devices is to be subjected to a gradually increasing hydraulic pressure, and the pressure at which the device begins to open is to be recorded. For a rupture-disc type relief device, these values shall be within 5 percent of each other and their average identified as the setting for the rupture-disc type relief device to be used. For a relief valve, the pressure setting of each representative device is considered to be the average of the three opening-pressure values obtained for that representative device. The three average values shall be within 5 percent of each other and their average identified as the start-to-discharge pressure setting for the relief valve to be used.

75 Metallic-Coating-Thickness Test

75.1 Except as specified in 75.2, the metallic-coating-thickness test described in 75.3 – 75.10 is to be used to determine the thickness of a zinc or cadmium coating. The test is only to be conducted when a required coating thickness is specified.

75.2 With the concurrence of those involved, a nondestructive test method may be used to determine the thickness of a zinc or cadmium coating. The test method described in 75.3 – 75.10 is to be used whenever referee measurements are necessary.

75.3 The solution used for this test is to be made from distilled water and is to contain 200 grams per liter of chemically pure chromic acid (CrO_3) and 50 grams per liter of chemically pure concentrated sulfuric acid (H_2SO_4). The latter is equivalent to 27 milliliters per liter of chemically pure concentrated sulfuric acid, specific gravity 1.84, containing 96 percent of H_2SO_4.

75.4 The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube of approximately 0.025 inch (0.64 mm) inside bore and 5.5 inches (140 mm) long. The lower end of the capillary tube is to be tapered to form a top, the drops from which are approximately 0.025 milliliters each. To preserve a constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100 ±5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

75.5 The representative device and the test solution are to be kept in the test room long enough to acquire the temperature of the room, and the room temperature is to be noted and recorded. The test is to be conducted at an ambient temperature of 21.1 – 32.2°C (70 – 90°F).

75.6 Each representative device is to be cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed completely by means of solvents. Representative devices then are to be rinsed in water and dried. Care is to be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

75.7 The representative device to be tested is to be supported from 0.7 – 1 inch (18 – 25 mm) below the orifice, so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested is to be inclined approximately 45 degrees from horizontal.

75.8 The stopcock is to be opened and the time in seconds is to be measured until the dropping solution dissolves the protective metallic coating, exposing the base metal. The test is to end at the first appearance of the base metal recognizable by the change in color at that point.

75.9 Each representative test lot is to be subjected to this test at three or more points, excluding cut, stenciled, and threaded surfaces, on the inside surface and at an equal number of points on the outside surface, at places where the metallic coating may be expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation may have thin coatings.

75.10 To calculate the thickness of the coating being tested, the thickness factor appropriate for the temperature at which the test was conducted is to be selected from Table 75.1 and multiplied by the time, in seconds, required to expose base metal as determined in 75.8.

Table 75.1
Coating thickness factors

Temperature,		Thickness factors	
°C	(°F)	Cadmium platings	Zinc platings
21.1	70	1.331	0.980
21.7	71	1.340	0.990
22.2	72	1.352	1.000
22.8	73	1.362	1.010
23.3	74	1.372	1.015
23.9	75	1.383	1.025
24.4	76	1.395	1.033
25.0	77	1.405	1.042
25.6	78	1.416	1.050
26.1	79	1.427	1.060
26.7	80	1.438	1.070
27.2	81	1.450	1.080
27.8	82	1.460	1.085
28.3	83	1.470	1.095
28.9	84	1.480	1.100
29.4	85	1.490	1.110
30.0	86	1.501	1.120
30.6	87	1.513	1.130
31.1	88	1.524	1.141
31.7	89	1.534	1.150
32.2	90	1.546	1.160

76 Permanence of Markings

76.1 General

76.1.1 Labels shall be acceptable and appropriate for the application. Ordinary usage, handling, and similar treatment, of the product and the atmosphere in which used are considered in the determination of the permanence of the marking.

76.1.2 To determine if a pressure-sensitive label, or a label secured by cement or adhesive is of a permanent nature, representative samples are to be subjected to exposure conditions for indoor use (As-Received, Water Immersion, and Elevated Temperature) or, if applicable, to exposure conditions for outdoor use (indoor use plus Low Temperature and Ultraviolet Light and Water Exposure), to determine compliance with requirements for permanence and legibility in the Standard for Marking and Labeling Systems, UL 969.

76.1.3 If a label is exposed to unusual conditions in service such as oils, detergents, or other conditions, representative samples are to be subjected to an additional immersion test. This test is to be conducted in the same manner as the immersion test described in UL 969 except that the samples are to be immersed in a representative solution of service use, instead of in demineralized water. For exposure to detergents, the solution is to consist of a mixture of 25 grams of a commercial detergent per liter of water. Following the test, the labels shall comply with the requirements for permanence and legibility in the Standard for Marking and Labeling Systems, UL 969.

76.2 Cord tags

76.2.1 A tag used for the cautionary marking described in 113.5.1 shall comply with the requirements:

a) In 76.2.2 – 76.2.5; and

b) For permanence and legibility in the Standard for Marking and Labeling Systems, UL 969, when tested as specified in 76.1.1.

Exception: A tag used for the cautionary marking that complies with the applicable requirements in the Standard for Marking and Labeling Systems – Flag Labels, Flag Tags, Wrap-Around Labels and Related Products, UL 969A, for the intended cord surface, the specific environmental conditions (indoor dry, indoor damp, and outdoor locations, as applicable), and limited slippage rating, is not required to comply with this requirement.

76.2.2 Three as-received samples and six samples of the tag that have been subjected to the conditioning specified in 76.2.4, three for each condition, are to be subjected to the test described in 76.2.5. After testing, the samples shall comply with the following requirements:

a) The tag shall not tear for more than 1/16 inch (1.6 mm) at any point;

b) The tag shall not separate from the power-supply cord;

c) The tag shall not slip or move along the length of the power-supply cord more than 1/2 inch (12.7 mm).

d) There shall be no permanent shrinkage, deformation, cracking, or any other condition that will render the marking on the tag illegible; and

e) Overlamination shall remain in place and not be torn or otherwise damaged. The printing shall remain legible.

76.2.3 Each sample is to consist of a length of power-supply cord. The tag is to be affixed to the power-supply cord in the intended manner. If tags are applied by an adhesive, tests are to be conducted no sooner than 24 hours after application of the tag.

76.2.4 The conditioning required by 76.2.2 is to consist of the following:

a) The samples are to be conditioned for 24 hours in an air-circulating oven maintained at a uniform temperature of 87.0 ±1.0°C (188.6 ±1.8°F). Following removal from the oven, the samples are to remain at a temperature of 23.0 ±2.0°C (73.4 ±3.6°F) and a relative humidity of 50 ±5 percent for 30 minutes before testing.

b) The samples are to be conditioned for 72 hours in a humidity of 85 ±5 percent at 32.0 ±2.0°C (89.6 ±3.6°F). The samples are to be tested within 1 minute after the conditioning.

76.2.5 The power-supply cord, with the attachment plug pointing up, is to be held tautly in a vertical plane. A force of 5 pounds (22.3 N) is to be applied to the uppermost corner of the tag farthest from the power-supply cord, within 1/4 inch (6.4 mm) of the vertical edge of the tag. The force is to be applied vertically downward in a direction parallel to the major axis of the cord and maintained for 1 minute. In determining compliance with 76.2.2(d), manipulation is possible, such as straightening of the tag by hand.

PERFORMANCE – ELECTRICAL SYSTEMS

77 Leakage Current Test

77.1 A cord-connected product rated for a nominal 240-volt or less supply is to be tested in accordance with 77.3 – 77.8. Leakage current shall not be more than:

a) 0.5 milliampere for a portable product, and

b) 0.75 milliampere for a product intended to be fastened in place or located in a designated space, and employing a standard attachment plug rated 20 amperes or less.

77.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of a product and ground or other exposed conductive surfaces of the product.

77.3 All exposed conductive surfaces are to be tested for leakage currents. If simultaneously accessible, the leakage currents from exposed conductive surfaces are to be measured to the grounded supply conductor individually as well as collectively, and from one surface to another. A part is considered to be an exposed surface unless guarded by an enclosure that complies with the requirements in Section 15. Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that do not present a risk of electric shock (Class 2 or less).

77.4 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil having an area of 10 by 20 centimeters in contact with the surface. If the surface is less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the product.

77.5 The measurement circuit for leakage current is to be as illustrated in Figure 77.1. The measurement instrument is defined in (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument; it need not have all the attributes of the defined instrument.

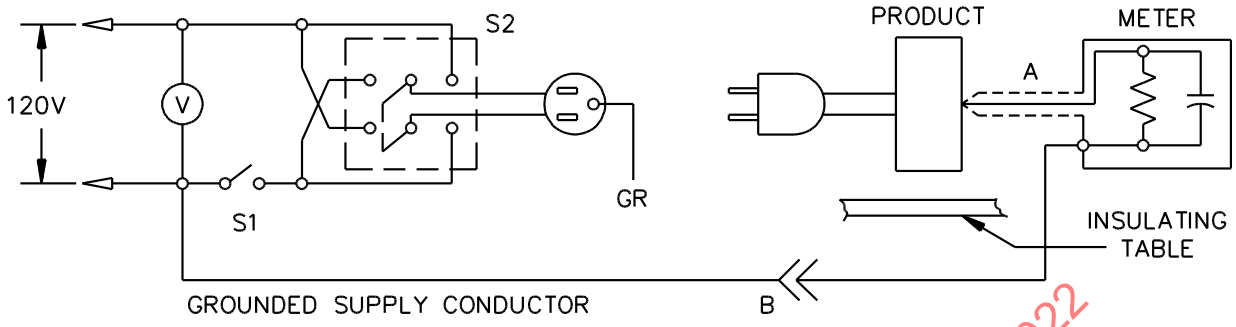
a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

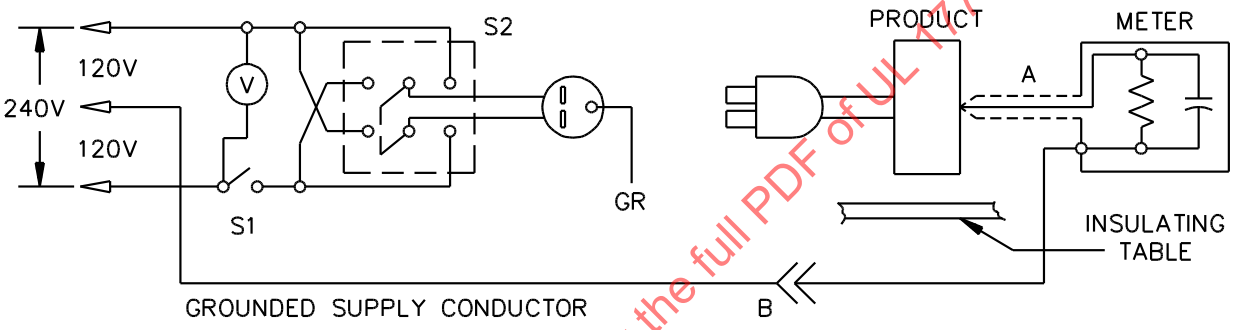
c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 milliampere, the measurement is to have an error of not more than 5 percent at 60 hertz.

Figure 77.1

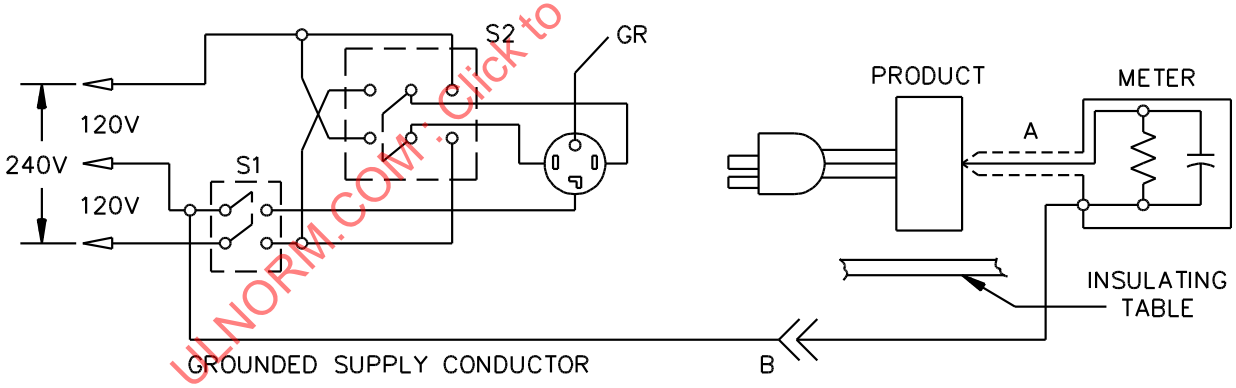
Leakage current measurement circuits



Product intended for connection to a 120–volt power supply, as illustrated above.



Product intended for connection to a 3–wire, grounded neutral power supply, as illustrated above.



Product intended for connection to a 3–wire, grounded neutral power supply, as illustrated above.

LC300J

A. – Probe with shielded lead.

B. – Conductor separated and used as clip when measuring leakage currents from one part of appliance to another.

77.6 Unless the meter is being used to measure leakage from one part of a product to another, it is to be connected between accessible parts and the grounded supply conductor.

77.7 A sample of a product is to be tested for leakage current starting with the as-received condition – with the grounding conductor, if any, open at the attachment plug. The as-received condition is without prior energization, except as may occur as part of the production-line testing. The supply voltage is to be adjusted to rated voltage. The test sequence, with reference to the measurement circuit – Figure 77.1 – is to be as follows:

a) With switch S1 open, the product is to be connected to the measurement circuit. Leakage current is to be measured using both positions of switch S2, and with the product switching devices in all their normal operating positions.

b) Switch S1 is then to be closed energizing the product, and within 5 seconds, the leakage current is to be measured using both positions of switch S2 and with the product switching devices in all their normal operating positions.

c) The leakage current is to be monitored until thermal stabilization. Both positions of switches S1 and S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation as in the normal temperature test.

77.8 Normally the complete leakage current test, as specified in 77.7 is to be conducted, without interruption for other tests. With the concurrence of those concerned, the leakage current test may be interrupted to conduct other nondestructive tests.

78 Leakage Current Test Following Humidity Conditioning

78.1 A product as described in 77.1 shall comply with the requirements for leakage current in 77.1 following exposure for 48 hours to air having a relative humidity of 88 ±2 percent at a temperature of 32 ±2°C (90 ±4°F).

78.2 A representative product is to be heated to a temperature just above 34°C (93°F). The heated representative product is to be placed in the humidity chamber under the conditions specified in 78.1. Following the conditioning and while still in the chamber, the representative product is to be tested unenergized as described in 77.7(a). Either while the representative product is still in the humidity chamber or immediately after it has been removed from the chamber, the representative product is to be energized and tested as described in 77.7 (b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

79 Insulation Resistance Test Following Humidity Conditioning

79.1 A permanently connected product, and a cord connected product rated more than 240 volts, which employs insulation material likely to be adversely affected by moisture under condition of normal use shall be conditioned for 48 hours in moist air having a relative humidity of 88 ±2 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F). After the conditioning, the product shall have an insulation resistance of not less than 50,000 ohms between live parts and dead metal parts.

79.2 The product is to be conditioned for 48 hours in moist air having a relative humidity of 88 ±2 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F).

79.3 Ordinarily, insulation resistance is to be measured by means of a voltmeter having an internal resistance of 30,000 ohms and using 250-volt direct-current circuit.

80 Starting Current Test

80.1 A product shall start and operate normally on a circuit protected by an ordinary – not time-delay – fuse having a current rating corresponding to that of the branch circuit to which the product would normally be connected. The performance is unacceptable if the fuse opens or an overload protector provided as part of the product trips.

Exception No. 1: The requirement concerning an ordinary fuse does not apply if:

a) The construction of the product or the nature of its use is such that it is likely to be used continually on the same branch circuit after installation,

b) The product will start and operate normally on a circuit protected by a time-delay fuse, and

c) The product is marked in accordance with 112.1.21.

Exception No. 2: The requirement concerning an ordinary fuse does not apply to a Type 1 or Type 2 product that would normally be used on a 15- or 20-ampere branch circuit, provided that the product starts and operates normally on a circuit protected by a time-delay fuse having an ampere rating corresponding to that of the branch circuit on which the product would normally be used.

80.2 The product is to be started three times, with the product at room temperature at the beginning of the test. Each start of the product is to be made under conditions representing maximum normal loading. All motors are to be allowed to come to rest between successive starts.

81 Input Test

81.1 The current or wattage input to a product shall not be more than 110 percent of the rated value.

81.2 The current input or the wattage input, as applicable, is to be measured with the product at normal operating temperature under maximum normal load conditions.

82 Bonding Conductor Tests

82.1 A conductor as mentioned in Exception No. 4 to 21.13 may be used if, using a separate representative product for each test, neither the bonding conductor nor the connection opens under either of the following conditions:

a) When carrying a current equal to twice the rating or setting of the intended branch-circuit overcurrent-protective device for the time specified in Table 82.1.

b) When subjected to the limited-short-circuit test described in 82.2.

Table 82.1
Duration of current flow, bonding-conductor test

Overcurrent-device rating, amperes	Minimum duration current flow, minutes
30 or less	2
31 – 60	4
61 – 100	6
101 – 200	8
201 – 400	10
401 – 600	12

82.2 The circuit for the test described in 82.1(b) is to have a power factor of 0.9 – 1.0 and is to be limited to the current specified in Table 82.2, at the voltage specified in Table 62.1. The open-circuit voltage of the test circuit is to be 100 – 105 percent of the specified voltage. The circuit is to be connected through a nonrenewable time delay type fuse. The rating of the fuse is to be equal to that of the intended branch circuit overcurrent device.

Table 82.2
Short-circuit test currents

Products rating, amperes				Circuit capacity, amperes
Single phase				
110 – 120 V	200 – 208 V	220 – 240 V	277 V	
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
Three phase				
200 – 208 V	220 – 240 V	440 – 480V	550 – 600 V	
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000

83 Dielectric Voltage-Withstand Test

83.1 A product shall withstand for 1 minute without breakdown the application of a 60-hertz essentially sinusoidal potential between live parts and dead metal parts with the product at the maximum operating temperature reached in normal use. The test potential for the primary circuit is to be:

a) One-thousand volts for a product employing a motor rated 1/2 horsepower (373 W output) or less and 250 volts or less.

b) One-thousand volts plus twice the voltage specified in Table 62.1 for a product employing a motor rated more than 1/2 horsepower or more than 250 volts.

83.2 The test potential for the secondary circuit of a product employing a transformer or autotransformer is to be:

a) One-thousand volts plus twice the operating voltage if the secondary operates at 251 – 600 volts.

b) One-thousand volts if the secondary operates at 51 – 250 volts.

c) Five-hundred volts if the secondary operates at 50 volts or less.

Exception: This does not apply if the secondary circuit is supplied from a Class 2 transformer.

83.3 The product is to be tested by means of a 500 volt-ampere or larger transformer, having an output voltage that is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test value is reached and is to be held at that value for 1 minute. The increase in the

applied potential is to be at a substantially uniform rate and as rapidly as possible, consistent with its value being correctly indicated by a voltmeter.

83.4 The ignition system specified in 36.1.3 shall withstand for 1 minute, without breakdown, the application of a 60 hertz potential of:

a) 150 percent of the maximum voltage to ground between high-tension live parts and noncurrent-carrying parts; and

b) 150 percent of the maximum voltage to each other between live parts of opposite polarity.

84 Flooding Tests

84.1 General

84.1.1 As a result of each condition described in 84.2.1 – 84.6.1, there shall be no wetting of live parts, film-coated wire, or insulation likely to be adversely affected by the liquid involved, and no liquid shall enter a compartment housing field-installed wiring. For a cord-connected product rated 250 volts or less, the leakage current is to be monitored during and after each test for compliance with Section 77. Following each test, the product shall comply with the requirements in a repeated Dielectric Voltage-Withstand Test, Section 83, and is then to be examined for presence of liquid.

84.2 Component malfunction or breakdown test

84.2.1 A product with a timer switch or a float or pressure-operated switch is to be operated with the switch defeated in the most adverse position.

84.2.2 A product that employs a boot or diaphragm or a liquid seal or gasket of rubber or similar material, and water or other electrically conductive liquid is to be operated through one complete cycle of normal operation with the boot, diaphragm, seal, or gasket removed.

Exception: The boot, diaphragm, seal, or gasket is not to be removed if it is not subject to flexing, and has been investigated and found to be acceptably resistant to the effects of the liquid involved. See Section 70.

84.3 Overflow test

84.3.1 For a product with a reservoir or liquid storage chamber that can be filled to overflowing, the reservoir is to be filled to overflowing with distilled water to which 0.02 ounce (0.57 g) of sodium chloride and 0.18 ounce (5.1 g) of a low sudsing detergent, both per quart of solution, have been added. Additional solution equal to 10 percent of the capacity, but not more than 1 quart, is then to be poured into the reservoir through an orifice 3/8 inch (9.5 mm) in diameter. During this test the product is to be in the normal position for filling the reservoir or liquid chamber.

Exception: This test need not be conducted on a product with a reservoir that must be removed for filling.

84.4 Test on polymeric components intended for water-handling

84.4.1 A reservoir or tank assembly of polymeric material, including attached tubing, is to be drilled with a 1/4-inch (6.4-mm) diameter hole in the most adverse location. If a hole is to be drilled in tubing that is less than 1/4 inch inside diameter, the hole size is to be equal to the inside diameter of the tubing. The hole is to be plugged and the tank or reservoir filled to 50 percent of its capacity with the solution described in 84.3.1. The plug is then to be removed and the entire contents permitted to flow out. During this test the reservoir is to be in its intended position on the product and the product is to be in the most adverse position that may exist during normal operation.

84.5 Water spray test I

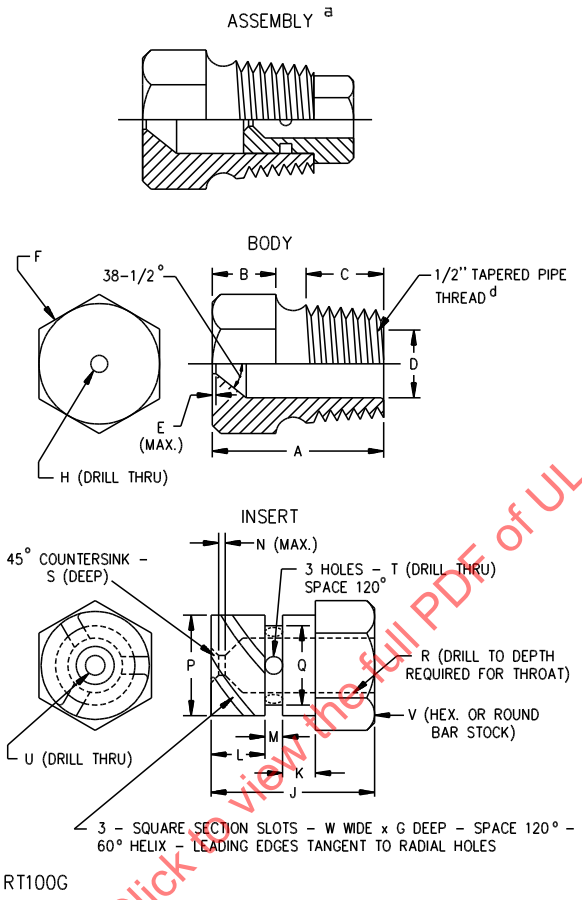
84.5.1 The test described in 84.5.2 and 84.5.3 is to be conducted on a product that is stationary or fixed and intended for outdoor use, but not intended to be installed in a washing area.

84.5.2 The product is to be mounted under the apparatus described in 84.5.3 and subjected to a water spray for 1 hour while operating and 1 hour while not operating.

84.5.3 The water spray apparatus is to consist of three spray heads constructed in accordance with the details illustrated in Figure 84.1 and mounted in a water supply pipe rack as illustrated in Figure 84.2. The water pressure is to be maintained at each spray head at approximately 5 psig (34 kPa). The distance between the center nozzle and the appliance is to be approximately 5 feet (1.5 m). The product is to be brought into the focal area of the three spray heads in such a position and under such conditions that water will be most likely to enter, except that consideration is to be given to the intended mounting position.

Figure 84.1

Rain-test spray head



Item	Inch	mm	Item	Inch	mm
A	1-7/16	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
				.576	14.63
C	9/16	14.0	Q	.453	11.51
				.454	11.53
D	.578	14.68	R	1/4	6.35
	.580	14.73	S	1/32	0.80
E	1/64	0.40	T	(No. 35)[b]	2.80
F	c	c	U	(No. 40)[b]	2.50
G	0.06	1.52	V	5/8	16.0
H	(No. 9)[b]	5.0	W	0.06	1.52
J	23/32	18.3			
K	5/32	3.97			
L	1/4	6.35			
M	3/32	2.38			

[a] Nylon Rain – Test Spray Heads are available from Underwriters Laboratories Inc.

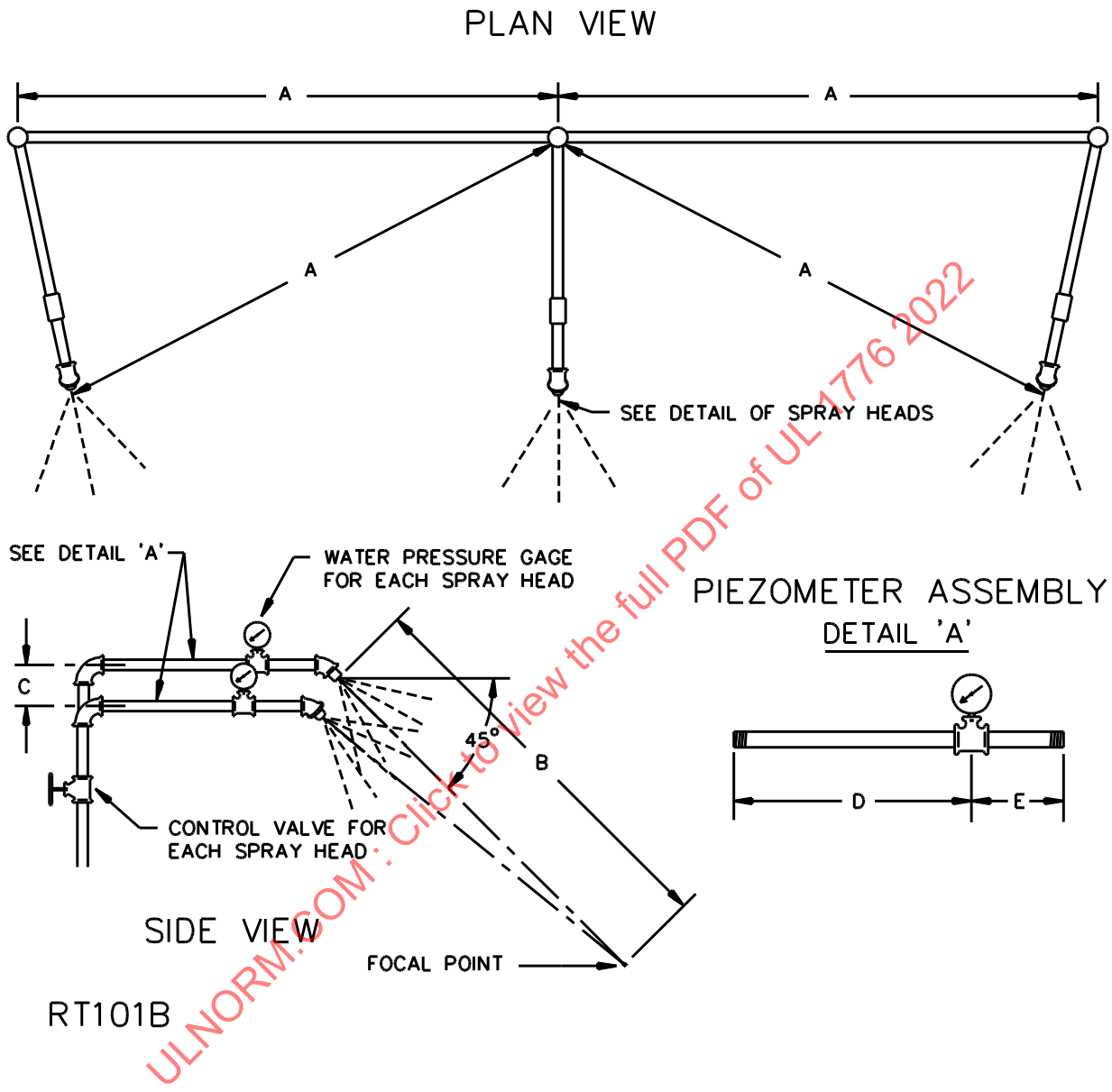
[b] Drill size per ASME B94.11 (1993), Twist Drills.

[c] Optional – To serve as wrench grip.

[d] ASME B1.20.1 (1983)(R1992) Pipe Threads, General Purpose (Inch).

Figure 84.2

Rain-test spray-head piping



Item	inch	mm
A	28	710
B	55	1400
C	2-1/4	55
D	9	230
E	3	75

84.6 Water spray test II

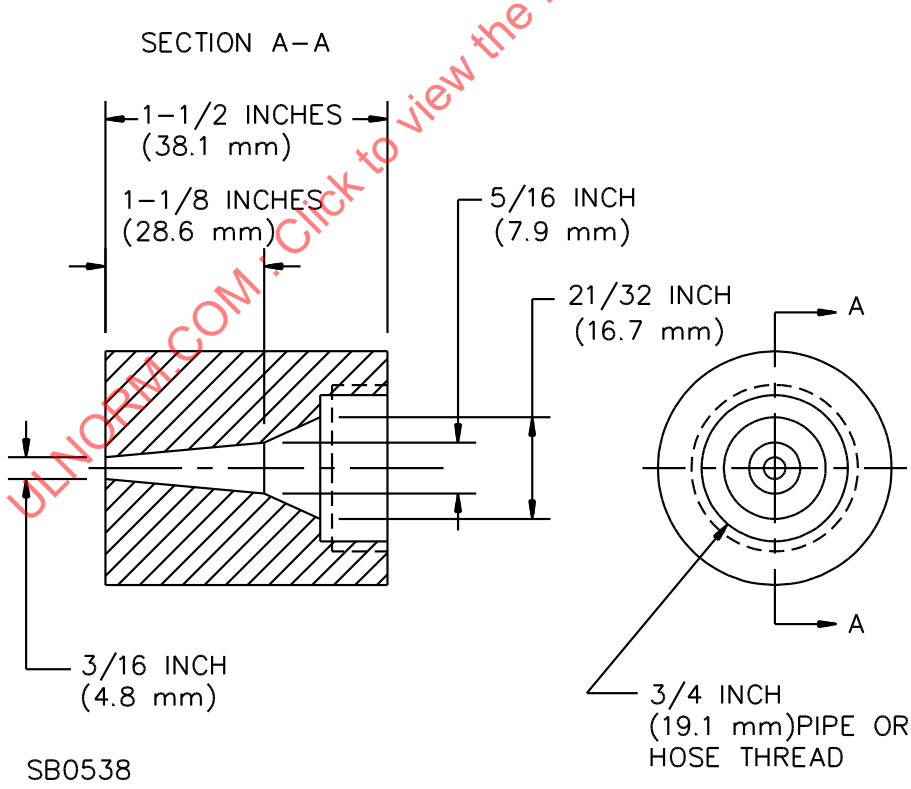
84.6.1 A portable product or a product intended to be located in a wash area is to be subjected to a solid stream of water from a hose fitted with a nozzle as illustrated in Figure 84.3. Unless there are other possible operational positions of the product as stated in the manufacturer's instruction manual, the unit is to be placed on a flat horizontal surface for the duration of the test. The hose is to be connected to a water supply capable of maintaining a flow rate of 5 gallons (19 L) per minute as measured at the outlet orifice of the nozzle. The hose stream is to be directed over the entire surface of the product, at several angles, including the indirect splashing described in 84.6.2, from a distance of 6 – 7 feet (1.8 – 2.1 m) for 5 minutes with the product not operating, and for 5 minutes with the product operating and the trigger depressed in the full flow position.

Exception: The water spray test conducted by means of the product's own high pressure discharge for 5 minutes from a distance of 5 ft (1.5 m) meets the intent of the requirement. The discharge shall be made using the nozzle or nozzles supplied with the product that produces the worst case test criteria (highest pressure and highest flow rate).

84.6.2 During the 10 minute spray test described in 84.6.1, the product is to be subjected to casual splashing caused by the hose stream directed at the supporting surface of the product to indirectly spray the underside of the machine.

Figure 84.3

Nozzle



85 Test on Gripping Areas

85.1 If insulating material used for a gripping area as specified in 13.1 overlies dead metal, it shall:

a) Show no holes, cracks, distortion, or other visible evidence of deterioration after being conditioned as described in 85.2;

b) Not break, crack, rupture, or show other adverse affects after being subjected to the impacts described in 85.3. The impacts are to be conducted on separate representative products that have been conditioned as described in 85.2 (a) and (b); and

c) Comply with the requirements in 85.4 following the impacts described in 85.3, and conditioning described in 85.2(c).

85.2 The conditioning mentioned in 85.1 is to consist of placing:

a) A representative product in an air-circulating oven for 7 hours at a temperature that is 10°C (18°F) higher than the maximum temperature of the gripping area under the conditions of intended operation, but not less than 70°C (158°F). The representative product is to be allowed to return to room temperature before testing.

b) A separate representative product in a conditioning chamber for 3 hours at a temperature of −35.0 +2.0°C (−31.0 +3.6°F). The representative product is to be subjected to the impact test specified in 85.3 immediately upon removal from the chamber.

Exception: Portable equipment for outdoor use, but intended to be stored indoors, and marked in accordance with 112.1.5, shall be conditioned for 3 hours at 0.0 +2.0°C (32.0 +3.6° F) instead of -35.0 +2.0°C (-31.0 +3.6°F).

c) A separate representative product in a conditioning chamber for 48 hours at a relative humidity of 88 ±2 percent at a temperature of 32 ±2°C (90 ±4°F).

85.3 With reference to 85.1(b), each area under consideration is to be subjected to two impacts of 5 foot-pounds (6.8 J). Each impact is to be applied by dropping a steel sphere, 2 inches (51 mm) in diameter and weighing 1.18 pounds (0.54 kg), through a vertical distance of 51 inches (1.30 m). The side opposite the side being impacted is to be placed against a rigid, supporting surface.

85.4 The gripping areas shall comply with the requirements in the Dielectric Voltage-Withstand Test, Section 83, with the potential applied between aluminum foil wrapped around the gripping area and the dead metal of the handle, lance, or wand.

86 Tests on Switches and Controls

86.1 A switch or other device that controls a motor, a solenoid, a relay coil, or other equipment, shall perform acceptably when subjected to an overload test consisting of 50 cycles of making and then breaking current to the test loads described in 86.3 and 86.4, as applicable. There shall be no electrical or mechanical malfunction or breakdown of the device or undue burning or pitting of the contacts. The fuse in the grounding connection shall not open.

Exception No. 1: This requirement does not apply to a device known to be acceptable for the application.

Exception No. 2: A device interlocked so that it will never break the locked-rotor motor current need not be tested.

86.2 Dead metal parts of a product are to be connected to ground through a 3-ampere plug fuse. During the test the device is to be operated at a rate of not more than 10 cycles per minute, except that a faster rate of operation may be employed if agreeable to those concerned. The product is to be connected such that any single-pole, current-interrupting device is located in the ungrounded conductor of the supply circuit. If the product is intended for use on direct current, or on direct current as well as alternating current,

the exposed dead metal parts of the product are to be connected so as to be positive with respect to a single-pole, supply-circuit current-interrupting device.

86.3 A switch or other device that controls a solenoid, relay coil, or other equipment, is to be tested while controlling its maximum load during normal operation. For this test the product is to be connected to a supply circuit of rated frequency and 110 percent of the test voltage specified in Table 62.1.

86.4 A switch or other device that controls a motor is to be tested with the rotor locked. For this test the product is to be connected to a supply circuit of rated frequency and voltage as specified in 62.2.1.

87 Tests on Temperature Controls

87.1 An automatically-reset temperature control shall be tested as described in 87.3. In addition, a temperature-regulating control is to be tested as described in 87.5, and a temperature-limiting control is to be tested as described in 87.6. There shall be no electrical or mechanical malfunction or breakdown of the temperature control nor welding or undue pitting or burning of the contacts. The fuse in the grounding connection shall not open.

87.2 During the tests described in 87.3 – 87.6, the enclosure of the product is to be connected to ground through a 3-ampere fuse.

87.3 A temperature control is to be operated for 50 cycles with the product connected to a supply circuit of rated frequency and 120 percent of the test voltage specified in Table 62.1.

87.4 For the test described in 87.3, connections are to be made so that the full test voltage occurs between:

a) Live parts of the control mechanism, and

b) The enclosure and other dead metal parts of the product.

87.5 A temperature-regulating control is to be operated for 100,000 cycles of making and then breaking the current to the maximum load that it controls during intended operation.

87.6 An automatically reset temperature-limiting control is to be operated for 100,000 cycles of making and then breaking the maximum load that it controls during normal operation. A manually reset temperature-limiting control is to be operated for 1000 cycles of making and then breaking the current to the maximum load that it controls during intended operation, followed by 5000 cycles of no-load operation.

88 Strain-Relief Test

88.1 A strain relief means provided on an attached flexible cord, is to be tested in accordance with 88.2. At the point of disconnection of the conductors, there shall be no movement of the cord as to indicate that stress would have resulted on the connections.

88.2 The connections of the attached flexible cord within the appliance are to be disconnected. A 35 pound (15.9 kg) weight is to be suspended on the cord and supported by the product so that the strain-relief means will be stressed for 1 minute from any angle that the construction of the product permits.

88.3 Strain relief constructed of, or mounted in, polymeric materials is to be subjected to the test of 88.2 before and after the mold stress test of 71.2. The representative strain relief is to be allowed to cool before repeating the strain relief test after mold stress conditioning.

89 Radiation Test

89.1 A product that produces radiation, such as X-rays, microwaves, ultrasonic sound, laser, ultraviolet, or infrared light, shall be investigated with respect to the effects of the radiation on users and service personnel.

90 Ozone Generation Test

90.1 A product that produces ozone during normal operation shall not produce an average time weighted concentration above background in excess of 0.1 part per million, nor a transitory concentration of more than 0.3 part per million when tested as described in 90.3 – 90.6.

90.2 With reference to the requirement in 90.1, the normal functioning of electrical contact points is not considered to be capable of generating an unacceptable concentration of ozone.

90.3 Ozone concentration is to be measured with the product located in the center of a closed test room having a volume of 1000 cubic feet (28.3 m^3) and approximate dimensions of 8 by 12 by 10 feet (2.4 by 3.7 by 3.0 m). All test room walls are to be covered with sheet polyethylene. The test room is to be maintained at a temperature of approximately 25°C (77°F) and a relative humidity of 50 percent.

90.4 Prior to and immediately after the test, the ozone background level is to be measured with the product off. The background level average is to be calculated and subtracted from the maximum measurement during the test.

90.5 The product is to be operated in the same manner, and for same length of time, as specified in the Normal Temperature Test, Section 67. The average time weighted concentration is to be considered as the average concentration of ozone extrapolated for an 8-hour operating period.

90.6 If the product can be operated with any of its fans, heaters, or similar components not functioning, with replaceable charges, filters, or similar parts removed, or with fluid, or similar material exhausted, the test described in 90.3 – 90.5 is to be repeated a sufficient number of times with the various components not operating, or with the items removed or exhausted, to determine that these conditions do not result in ozone emission exceeding that specified in 90.1.

91 Overvoltage Test

91.1 A product employing a series motor is to be operated for 1 minute at the no-load speed resulting from application of 1.3 times the rated voltage. There shall be no breakage, release, or loosening of a part that could result in a risk of injury to persons.

PERFORMANCE – FUEL-FIRED SYSTEMS

92 Combustion Tests

92.1 Gas-fired products

92.1.1 Combustion shall be complete in the space provided by the product over the full operating range of the burner assembly in accordance with 92.1.2 – 92.1.16. See 94.1.2, 95.9.2, and 95.16.2.

92.1.2 Ignition shall occur and stable combustion shall be maintained at the minimum rate of firing or during any sudden change in the gas firing rate between maximum and minimum rates.

92.1.3 A product shall function uniformly and reliably at the maximum input recommended by the manufacturer without a loss of heat to the chimney or vent in excess of 25 percent of the heat input to the product.

92.1.4 The maximum temperature of flue gases at the maximum input recommended by the manufacturer shall not exceed the applicable value specified in Table 67.1. The maximum flue gas temperatures specified are for combustible construction in proximity of the chimney or vent connector when the indicated clearances are maintained.

92.1.5 Only a product equipped with an integral draft hood is acceptable for connection to a Type B gas vent. Any other product is acceptable only for connection to a chimney.

92.1.6 The performance shall be such that:

a) Ignition is obtained on each cycle within the prescribed ignition time period.

b) Ignition is obtained at each cycle without flash of flame outside the representative product being fired and without damage to parts of the product.

c) Stable fires are obtained at all operating firing rates.

d) The concentration of carbon monoxide in the flue gases is not in excess of 0.04 percent in an air free representative product taken at all firing rates.

e) No soot has been deposited on surfaces of the heat exchanger, flue passages, or vent connector of the representative product fired for the test.

f) Surfaces of the fire box, hearth, electrodes, and igniters and their insulators are free from detrimental formation of carbon, soot, and tar.

g) A pilot does not deposit detrimental carbon when adjusted according to the manufacturer's instructions.

92.1.7 The product is to be arranged for operation in accordance with the instructions furnished by the manufacturer and is to be fired at rates representing the full operating range of the burner assembly.

92.1.8 The product is to be fired with all the test gases for which the product is rated. The input, air-fuel ratio, and other operating conditions are to be in accordance with the manufacturer's instructions.

92.1.9 Each test is to be conducted at rated gas pressure. The manifold pressure is to be as recommended by the manufacturer.

92.1.10 The water level in the product is to be maintained at intended level.

92.1.11 A burner assembly of the on and off type is to be fired 10 minutes on and 10 minutes off for intermittent firing tests.

92.1.12 A product with a modulating burner assembly is to be fired in successive cycles, each cycle consisting of 10 minutes on high fire, 10 minutes on intermediate fire, 10 minutes on minimum fire, and 10 minutes off for intermittent firing tests.

92.1.13 During each test period, observations and recordings are to be made of the draft on each operating rate, ignition, and combustion characteristics, combustion-chamber conditions, and any unintentional performance.

92.1.14 The fuel burning rate, draft over fire, CO_2 and any CO are to be observed and recorded for each operating fire.

92.1.15 The test duration is to be sufficient to obtain conclusive performance data.

92.1.16 Measurements of flue-gas temperature and CO_2 are to be made. The hourly flue or stack loss is to be computed as the summation of heat above room temperature carried by CO_2, N_2, free air, and water vapor. For the purpose of this computation, water vapor is assumed to exist as a vapor above room temperature; condensation occurring at room temperature. The stack loss is not to exceed 25 percent of the gross heating value of the gas being fired. The maximum flue-gas temperature is not to exceed the limits specified in Table 67.1.

92.2 Oil-fired products

92.2.1 Combustion shall be stable and complete at all firing rates over the operating range of the product when tested in accordance with 92.3.1 – 92.4.14, provided that:

a) Automatic ignition is obtained on each cycle within the intended period of time.

b) Ignition is obtained at each cycle without backfire, flash, or puff.

c) Stable combustion is obtained at all operating firing rates without flash of flames outside the representative product being fired.

d) The observed smoke at all firing rates during each prescribed test does not exceed that indicated by a number 2 spot for products firing a distillate fuel and a number 4 spot for products firing a residual type fuel on the Shell-Bacharach scale with the Model RDC smokemeter.

e) Combustion at all firing rates is complete and consistent.

f) No excess amount of soot is deposited on surfaces of the heat exchanger, flue passages, or the flue pipe of the representative product fired for the test. Any tar or flocculent soot accumulation is considered to be excessive.

g) Surfaces of the fire box, hearth, nozzles, electrodes, and igniters and their insulators are free from detrimental formation of carbon, soot, and tar.

h) No excess amount of carbon, soot, and tar has been deposited on surfaces or accumulated on or in vaporizing burners and ignition rings of wall-flame burners. Any accumulation likely to have an adverse affect on the performance of the burner that continually increases as the test progresses, or that reduces the area of air openings in the burner or restricts fuel input, is considered to be excessive.

i) A pilot does not deposit detrimental carbon when adjusted according to the manufacturer's instructions.

j) An escapement or bleed pilot flame is freely ignited by the constant-burning pilot.

92.3 Oil-fired products with mechanical-atomizing burners

92.3.1 The representative product is to be fired with the heaviest grade of fuel for which it is rated and the air-fuel ratio adjusted in accordance with the manufacturer's instructions. The draft over fire is to be the value recommended by the manufacturer, but is not to exceed 0.06 inch water column (15 Pa) for burners fired at 5 gph (18.9 L/hr) or less; and is not to exceed 0.09 inch water column (22 Pa) for burners fired at more than 5 gph, but not more than 16 gph (60.1 L/hr); except that for a burner intended only for

application to a specific product equipped with forced or induced draft fan, or both, the draft is to be as specified by the manufacturer.

92.3.2 The burner is to be fired until steady-state combustion conditions exist. Observations are to be made for each operating fire. For a modulating burner, these observations are to be made at minimum, intermediate, and maximum operating fires. The observed smoke shall not be more than that indicated on the Shell-Bacharach smoke scale as specified in 92.2.1(d).

92.3.3 A product with an automatically-lighted burner of the on and off type is to be fired intermittently 10 minutes on and 10 minutes off.

92.3.4 A product with an automatically-lighted modulating-burner is to be fired in successive cycles, each cycle consisting of 10 minutes on high fire, 10 minutes on intermediate fire, 10 minutes on minimum fire, and 10 minutes off.

92.3.5 A product with a manually-lighted automatically-regulated burner is to be fired in successive cycles, each cycle consisting of 10 minutes on high fire, 10 minutes on intermediate fire if the burner is constructed to be so fired, and 10 minutes on minimum fire.

92.3.6 A product with a manually-lighted manually-regulated burner is to be fired in successive cycles, each cycle consisting of 2 hours on high fire, 2 hours on intermediate fire, and 4 hours on minimum fire.

92.3.7 During the test period, daily observations and recordings are to be made of the draft on each operating fire, ignition, and combustion characteristics, combustion chamber conditions, and any abnormal performance.

92.3.8 The fuel-burning rate, draft over fire, smoke, and CO_2 on each operating fire are to be observed and recorded at the beginning of the test, after each 50 hours of operation thereafter, and at the end of the test.

92.3.9 The duration of each test is to be sufficient to obtain conclusive performance data, and is expected to be until the representative product has been fired for 250 hours.

92.3.10 Following each test the total electrical input and the electrical input of each component, except those having a pilot duty rating, are to be measured.

92.4 Oil-fired products with vaporizing burners

92.4.1 The smoke observed during the tests specified in 92.4.2 – 92.4.14 shall not be more than that indicated by number 2 spot on the Shell-Bacharah smoke scale.

92.4.2 The burner is to be fired with the heaviest grade of fuel for which it is rated and the air-fuel ratio adjusted in accordance with the manufacturer's instructions. The draft regulator is to be adjusted to maintain the manufacturer's recommended high-fire draft which is not to exceed 0.06 inch (15 Pa) water column. Draft settings are to be made normally on high fire. No change in draft or combustion air adjustment is to be made for other firing rates unless changed automatically, except for a manually regulated burner when the instructions on the burner so state, in which case correlation of the calibrations of the fuel and draft or air adjustment shall be included with those instructions.

92.4.3 The burner is to be fired at each firing rate until steady-state combustion conditions exist.

92.4.4 Observations are to be made of the smoke produced by a pilot fire over the allowable range of pilot firing rates in 1 cubic centimeter increments from the minimum rate to and including a rate of 10 cubic

centimeters per minute or the maximum pilot rate allowed by the fuel-metering device, whichever is smaller.

92.4.5 A product with a manually-regulated burner and a modulating burner are to be fired successively at rates beginning with a firing rate of 10 cubic centimeters per minute or the minimum rate allowed by the fuel-metering device and then at rates progressively increasing in increments equivalent to approximately 10 percent of the maximum high-fire rate as allowed by the metering device. The smoke is to be observed at each firing rate.

92.4.6 A product with an automatically-regulated burner intended to fire at one or more predetermined firing rates is to be fired at the minimum and maximum firing rates allowed by the fuel-metering device and at allowable intermediate rates in steps equivalent to approximately 10 percent of the maximum firing rate. Smoke observations are to be made at each firing rate.

92.4.7 The burner is to be fired in accordance with the appropriate schedule described in 92.4.8 – 92.4.10. The firing rate selected is to be the allowable rate in each range which produced more smoke as determined in accordance with 92.4.3 – 92.4.6. The air-fuel ratio for the test is to be adjusted as recommended by the manufacturer's instructions.

92.4.8 A product with a manually-regulated burner is to be fired each week of the test in accordance with the following schedule:

a) Five successive days per week –

1) Four hours at high fire.

2) Four hours at intermediate fire.

3) Sixteen hours at low or pilot fire.

b) Two successive days per week at low or pilot fire.

c) The duration of the test is to be four weeks.

92.4.9 A product with an automatically-regulated burner intended to operate with an oil pilot is to be fired 30 minutes on a high fire, 30 minutes on an intermediate fire if the burner is intended to be so fired, and 30 minutes on pilot fire, as a continual cycle for five successive days per week, then on pilot fire continuously for two successive days per week, each week of the test. The duration of the test is to be sufficient to obtain 250 hours of operation on high fire.

92.4.10 A product with an automatically-regulated burner equipped with electric or gas ignition is to be fired 30 minutes on high fire, or on each fire stage if the burner is intended to operate with multiple stage fires, and then be off for 30 minutes as a continual cycle throughout the test. The duration of the test is to be sufficient to obtain 250 hours of operation on high fire.

92.4.11 During the test period, daily observations and recordings are to be made of the draft on all operating fires, ignition and combustion characteristics, combustion chamber conditions, and any abnormal performance.

92.4.12 The fuel-burning rate and draft over fire are to be determined and smoke observation and flue-gas analyses are to be made on each operating fire and recorded at the beginning of the test, after each period of 50 hours of operation on high fire, and at the end of the test.

92.4.13 At the end of a test described in 92.4.8 or 92.4.9, smoke observations as described in 92.4.5 and 92.4.6 are to be made.

92.4.14 Following each test the voltage is to be adjusted to rated voltage and the total electrical input and the electrical input of each component, except those having a pilot duty rating, are to be measured.

93 Ignition Tests – General

93.1 A burner assembly or device equipped with multiple igniters, each of which can function independently of the others is to be tested in accordance with 93.2 – 95.15.1, and with all other igniters rendered inoperative, each individual igniter shall provide ignition.

93.2 Unless otherwise indicated, all tests are to be conducted with:

a) The representative product arranged as described in the Combustion Tests, Section 92;

b) The combustion air supplied at room temperature; and

c) Oil, when applicable, supplied at the intended temperature.

94 Ignition Tests – Gas Fired Products

94.1 Pilot supervision

94.1.1 Pilot supervision by a safety control shall be only at a point where the pilot flame ignites the fuel at the main burner or burner group with the pilot burning with any flame capable of actuating the primary safety control.

94.1.2 Compliance with 94.1.1 is to be determined in conjunction with the Combustion Tests, Section 92. Before the test is begun, the gas supply to the pilot is to be regulated to provide a flame which will actuate the primary safety control. At least five trials are to be made for each pilot flame tested.

94.1.3 The combustion detector of a primary safety control that detects the presence of ignition spark is to be positioned so that the combustion detector responds to flame properties only. At the rated voltage, the signal strength due to an ignition spark shall be not more than 50 percent of the signal strength required to hold in the flame relay at 110 percent of rated voltage.

94.1.4 Compliance with 94.1.3 is to be determined in conjunction with the Combustion Tests, Section 92. Before the test is begun, the gas supply to the pilot is to be shut off. Five trials are to be made to determine that ignition spark, or reflection from any part of the burner or device capable of reflecting the spark, does not result in a signal strength in excess of the specified value. Each trial is to have at least 5 minutes duration.

94.2 Ignition, gas-electric high tension

94.2.1 A gas-electric high tension ignition system shall ignite the pilot of a gas burner assembly having an input of more than 400,000 Btu per hour, per individual combustion chamber, or the pilot or main burner of a gas burner having an input of 400,000 Btu per hour or less, per individual combustion chamber immediately upon admission of gas when the ignition system is connected to a power supply having a voltage equal to 70 percent of rated voltage. The pilot, if provided, shall ignite fuel introduced into the ignition zone.

94.2.2 Compliance with 94.2.1 is to be determined immediately following the Combustion Tests, Section 92. Each spark gap is to be adjusted to the maximum recommended by the manufacturer, but not less than 1/16 inch (1.6 mm).

94.2.3 The voltage of the power supply to the ignition system is to be regulated to 70 percent of rated voltage, and the voltage of the power supply to the safety control circuit is to be regulated to 85 percent of rated voltage for an alternating-current product and 80 percent of rated voltage for a direct-current product. Except that a direct spark ignition circuit that incorporates an integral ignition transformer is to be tested at 70 percent of rated voltage on the primary circuit of the ignition system or the minimum voltage the ignition system will operate, whichever is higher.

94.2.4 Five trials are to be made. If the burner or device employs an interchangeable transformer, an appropriate interchangeable test transformer is to supply the burner assembly or device and five additional trials for ignition are to be made. During each trial, ignition shall occur and no flame shall flash outside the representative product.

94.3 Gas-electric hot-wire – reduced voltage

94.3.1 No flame shall flash outside the burner when tested as described in 94.3.2 – 94.3.5.

Exception: This requirement does not apply to a burner or device equipped with a positive means to prevent the burner from attempting ignition at voltages less than 85 percent of rated voltage for an alternating-current product or 80 percent of rated voltage for a direct-current product.

94.3.2 A burner with a gas-electric hot-wire ignition system is to be connected to a power supply having a voltage that is 70 percent of the rated voltage, or not less than the minimum voltage below which the burner or device is positively prevented from attempting ignition, whichever is higher. See 94.3.3.

94.3.3 A positive means for preventing a burner assembly from attempting ignition below a given voltage is one that will always prevent an attempt to start when the voltage is below a specific value and will disconnect the burner assembly from the power source if the voltage drops below a specific value after an attempt to start has begun.

94.3.4 Compliance with 94.3.2 is to be determined immediately following the Combustion Tests, Section 92.

94.3.5 Ignition is to be attempted at the voltage specified in 94.3.2. Five trials are to be made.

94.4 Gas – electric hot-wire – endurance

94.4.1 The igniter of a gas-electric hot-wire ignition system shall function as intended for at least 6000 ignition cycles when tested in accordance with 94.4.2. There shall be no electrical or mechanical failure of the igniters.

94.4.2 Three representative igniters are to be tested. The ignition system is to be connected to a power supply having a voltage equal to 110 percent of the rated primary voltage. The ignition system is to be energized and then de-energized successively as repeating cycles. The duration of the on period is to be the pilot flame-establishing period for the burner. The duration of the off period is to be twice the on period unless the ignition system requires a longer time to complete a cycle of operation, in which case the off period is to be the minimum allowed by the system.

94.5 Gas-electric hot-wire – component temperatures

94.5.1 Parts of an electric hot-wire ignition system shall not attain temperatures in excess of those indicated for such parts in Table 67.1 when the system is energized as follows:

a) A system that automatically recycles on ignition or flame failure is to be allowed to cycle until equilibrium temperatures are attained.

b) A system that requires manual reset upon ignition or flame failure is to be energized and then reset as quickly as the system will allow after lockout until five attempts for ignition have been made.

c) A system that remains energized upon ignition failure is to be energized continuously until equilibrium temperatures are attained by the parts.

d) A system manually energized by means of a momentary contact switch that cannot be left in the on position is to be energized for 5 minutes.

e) A system manually energized by means of a switch that can be left in the on position is to be energized continuously until equilibrium temperatures are attained by the parts.

94.5.2 The fuel supply to the burner is to be shut off during attempted trials for ignition.

94.5.3 For a product with automatically-lighted multiple burners, fuel delivered for combustion to any burner shall be ignited by the flame at any other burner when tested in accordance with 94.5.4 and 94.5.6. In addition, when the fuel delivered by one or more burners is interrupted during an ignition or firing cycle, when tested in accordance with 94.5.4 and 94.5.6, ignition or combustion shall not increase the risk of fire or injury to persons.

94.5.4 For a product with multiple igniters, each of which can function independently of the others, all igniters but one are to be rendered inoperative. The representative product is to be energized to fire in accordance with its intended sequence of operation. Five trials-for-ignition are to be made. During each trial, ignition of the fuel introduced into the ignition zone by each burner shall occur, no flame shall flash outside the representative product, and stable combustion shall be maintained. The test is to be repeated on each igniter.

94.5.5 For the tests in 94.5.4 and 94.5.6, multiple burners with multiple igniters, each of which can function independently of the others, shall light as intended when all igniters but one are rendered inoperative. An igniter for an automatically lighted multiple burner that delivers main gas fuel through the ports of more than one orifice shall provide acceptable ignition when the orifice of one burner adjacent to the igniter is plugged, and the initial plugged orifice is unplugged and any other orifice plugged.

94.5.6 The port or ports of one burner are to be plugged. The representative product is to be energized to fire in accordance with its intended sequence of operation. Five trials are to be made. During each trial, fuel introduced into the ignition zone shall be ignited, no flame shall flash outside the representative product being fired, and stable combustion shall be maintained. The test is to be repeated on each burner.

95 Ignition – Oil-Fired Products

95.1 Ignition, electric high-tension – reduced voltage

95.1.1 An electric high-tension ignition system for an automatically- or remotely-lighted burner shall ignite fuel introduced into the ignition zone when connected to a power supply having a voltage equal to 70 percent of the normal test voltage. Also, the primary safety control is to be connected to a power supply having a voltage equal to 85 percent of normal test voltage for an alternating-current product and 80 percent of normal test voltage for a direct-current product. See 95.1.3.

95.1.2 Compliance with 95.1.1 is to be determined immediately following the Combustion Tests, Section 92. During this test:

a) The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum temperature recommended in the manufacturer's instructions for the grade of oil fuel being used;

b) Each spark gap is to be adjusted to the maximum recommended by the manufacturer, but not less than 1/8 inch (3.2 mm), if the burner is to employ an interchangeable transformer;

c) The temperature of the oil as supplied to any parts of the burner, except those located downstream from the preheater, is to be 1.7 ±3°C (35 ±5°F); and

d) If a burner is equipped with a preheater, the temperature of the oil at the inlet to the preheater is to be not less than 11°C (20°F) above the pour point of the test fuel.

95.1.3 For a burner with a primary safety control that can be connected only for interrupted ignition, the voltage of the power supply to both the ignition system and primary safety control is to be regulated to the minimum voltage necessary to initiate a trial for ignition.

95.1.4 The burner is to be energized and allowed to remain energized for the designed trial-for-ignition period. Five trials are to be made. If the burner may employ an interchangeable transformer, an appropriate interchangeable test transformer is to supply the burner and five additional trials for ignition are to be made. During each trial, ignition shall occur and no flame shall flash outside the representative product.

95.1.5 Following the last trial for ignition and as a continuation thereof, the burner is to be fired at high-fire rate for at least 15 minutes, during which period stable combustion shall be maintained.

95.2 Electric high-tension – combustion detectors

95.2.1 The combustion detector of a primary safety control that can detect the presence of ignition spark is to be positioned so that the combustion detector senses only the presence or absence of flame.

95.2.2 Compliance with 95.2.1 is to be determined in conjunction with the Combustion Tests, Section 92. Before the test is begun, a minimum pilot condition is to be established with the safety control operating at the appropriate overvoltage as specified in Table 62.1. The minimum signal strength, current or voltage, capable of permitting the flame relay to remain energized, is to be recorded. The fuel supply to the pilot, if provided, is then to be shut off and the voltage reduced to normal test voltage. Five trials are to be made to determine that ignition spark, or a reflection of the spark from any part of the burner or product cannot be detected by the combustion detector at a value greater than 50 percent of the recorded signal strength that actuates and holds in the flame relay.

95.3 Electric hot-wire – reduced voltage – test 1

95.3.1 If ignition occurs after being tested as specified in 95.3.2 – 95.3.5, no flame shall flash outside the burner.

Exception: This requirement does not apply to a burner equipped with a positive means to prevent the burner from attempting a trial-for-ignition at voltages less than 85 percent of normal test voltage for an alternating current product or 80 percent of rated voltage for a direct current product.

95.3.2 A product with an electric hot-wire ignition system is to be connected to a power supply having a voltage that is 70 percent of the rated voltage, or not less than the minimum voltage below which the burner is positively prevented from attempting a trial for ignition, whichever is higher. See 95.3.3.

95.3.3 A positive means for preventing a burner from attempting a trial for ignition below a given voltage is specified in 95.3.4.

95.3.4 Compliance with 95.3.2 is to be determined immediately following the Combustion Tests, Section 92. During this test:

a) The oil-temperature control for a burner intended to burn preheated oil is to be set for the maximum temperature recommended in the manufacturer's instructions;

b) The oil supplied to any parts of the burner, except those located downstream from the preheater, is to be at room temperature;

c) If a burner is equipped with a preheater, the temperature at the outlet of a preheater is to be the maximum recommended in the manufacturer's instructions for the grade of fuel being used.

95.3.5 Ignition is to be attempted at selected voltages specified in 95.3.2. The burner is to be energized and allowed to remain energized for the intended trial-for-ignition period. Five trials are to be made.

95.4 Electric hot-wire – reduced voltage – test 2

95.4.1 An electric hot-wire ignition system for an automatically- or remotely-lighted burner shall ignite fuel introduced into the ignition zone and no flame shall flash outside of the burner during each trial when tested as specified in 95.4.3 – 95.4.5.

95.4.2 The ignition system and burner are to be connected to a power supply having a voltage equal to 85 percent of normal test voltage for an alternating-current product or 80 percent of the normal test voltage for a direct-current product.

95.4.3 Compliance with 95.4.1 is to be determined immediately following the Combustion Tests, Section 92. During this test:

a) The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum temperature recommended in the manufacturer's instructions for the grade of oil fuel being used for the test;

b) The temperature of the oil as supplied to any parts of the burner, except those located downstream from a preheater, is to be 1.7 ±3°C (35 ±5°F); and

c) If a burner is equipped with an oil preheater, the temperature of the oil at the inlet to the preheater is to be at room temperature.

95.4.4 The burner is to be energized and allowed to remain energized for the designed trial-for-ignition period. Five trials are to be made.

95.4.5 Following the last trial for ignition and as a continuation thereof, the burner is to be fired at high-fire rate for at least 15 minutes. Stable combustion shall be maintained.

95.5 Electric hot-wire – endurance

95.5.1 The igniter of an electric hot-wire ignition system for an automatically- or remotely-lighted burner shall function as intended for at least 6000 ignition cycles. There shall be no electrical or mechanical failure of the igniters.

95.5.2 Three representative igniters are to be tested. The burner is to be connected to a power source having the appropriate overvoltage as specified in Table 62.1. The system is to be energized and then de-energized successively as repeating cycles.

a) The duration of the on period is to be the trial-for-ignition period for automatically-lighted burners and the average time required to establish ignition as determined during the Combustion Tests, Section 92.

b) The duration of the off period is to be twice the on period unless the control system requires a longer time to complete a cycle of operation, in which case the off period is to be the minimum allowed by the control system.

95.6 Electric hot-wire – component temperatures

95.6.1 Parts of an electric hot-wire ignition system shall not attain temperatures in excess of those indicated for such parts in Table 67.1 when the system is energized as described in 94.5.1.

95.6.2 For the test in 95.6.1, the fuel supply to the burner is to be shut off during attempted trials for ignition.

95.7 Gas – reduced voltage

95.7.1 A pilot flame for an automatically- or remotely- lighted burner with a gas ignition system shall, during each trial, ignite fuel introduced into the ignition zone in accordance with 95.7.2 – 95.7.5 and the ignition shall not flash outside the burner.

95.7.2 The ignition system and burner are to be connected to a power supply as described in 95.4.2 having a voltage equal to 85 percent of rated voltage for an alternating-current product and 80 percent of rated voltage for a direct-current product.

95.7.3 Compliance with 95.7.1 is to be determined immediately following the Combustion Tests, Section 92. During this test:

a) The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum recommended in the manufacturer's instructions;

b) The temperature of the oil supplied to any parts of the burner, except those located downstream from the preheater is to be 1.7 ±3°C (35 ±5°F); and

c) If a burner is equipped with an oil preheater, the temperature of the oil at the inlet to the preheater is to be at room temperature.

95.7.4 The representative product is to be energized and allowed to remain energized for the design trial-for-ignition period. Five trials are to be made.

95.7.5 Following the last trial for ignition and as a continuation thereof, the burner is to be fired at high-fire rate for at least 15 minutes. Stable combustion shall be maintained.

95.8 Gas – pilot supervision

95.8.1 Pilot supervision by a safety control shall be only at a point where the pilot flame ignites the oil at the main burner or burner group when the gas supply to the pilot is reduced so the flame is just sufficient to actuate the primary safety control.

95.8.2 Compliance with 95.8.1 is to be determined in conjunction with the Combustion Tests, Section 92. Initially the trial to ignite the main burner fuel is to be made with the fuel to the pilot regulated to produce a flame of the minimum size which can be detected by the combustion detector of the primary safety control. The pilot flame size is then to be increased in small increments up to the maximum pilot size and trials to ignite the main burner fuel are to be made with each pilot size. At least five trials to ignite the main burner fuel are to be made with the minimum pilot and with any other size pilot which appears to be critical.

95.9 Gas – flame failure response

95.9.1 A burner employing steam for an atomizing fuel shall not provide a false indication of pilot or main flame due to the atomizing media.

95.9.2 Compliance with 95.9.1 is to be determined in conjunction with the Combustion Tests, Section 92. Before the test is begun, the fuel supply to the pilot is to be regulated to provide the minimum pilot flame required to actuate the primary safety control. During the initial startup the main manual fuel shutoff valve is to be closed and after the pilot flame is supervised, the pilot fuel supply is to be shut off by the manual valve. The primary safety control shall actuate to de-energize the pilot safety valve.

95.9.3 As a continuation of this test and providing the safety control responded to shut off the pilot safety valve, the burner assembly is to be operated at the high-fire rate for at least 15 minutes after which time the fuel to the main burner is to then be shut off by action of a manual valve. The primary safety control shall actuate to de-energize the main fuel safety valve.

95.10 Gas – stability

95.10.1 A pilot flame shall not become extinguished unintentionally when the main burner or burners are turned on or off in the intended manner, either manually or by automatic controls. Visual examination for compliance with this requirement is to be made in conjunction with the Combustion Tests, Section 92.

95.11 Gas-electric – ignition

95.11.1 A burner equipped with a gas-electric ignition system shall not ignite the gas or oil when the burner and ignition systems are connected to a power supply having a voltage equal to 110 percent of normal test voltage and a trial-for-ignition is made with no gas available.

Exception: This requirement does not apply to a product equipped with a proved pilot or a control which prevents a trial-for-ignition when no gas is available.

95.11.2 Compliance with 95.11.1 is to be determined immediately following the Combustion Tests, Section 92. During this test:

a) The oil-temperature control for a burner intended to burn preheated oil is to be set for the maximum recommended in the manufacturer's instruction;

b) The oil supplied to any parts of the burner, except those located downstream from a preheater, is to be at room temperature; and

c) If a burner is equipped with a preheater, the temperature of the oil at the outlet of a preheater is to be the maximum recommended in the manufacturer's instructions for the grade of fuel being used for the test.

95.11.3 The gas supply to the ignition system is to be shut off. The representative product is to be energized and allowed to remain energized for the designed trial-for-ignition period. Five trials are to be made.

95.12 Gas-electric high-tension

95.12.1 During each trial specified in 95.12.2 – 95.12.5, ignition shall occur and no flame shall flash outside the burner.

95.12.2 A gas-electric high-tension ignition system for an automatically- or remotely-lighted burner shall ignite the pilot immediately upon admission of pilot gas when the ignition system is connected to a power supply having a voltage equal to 70 percent of normal test voltage and the safety control circuit is connected to a power supply having a voltage equal to 85 percent of normal test voltage for an alternating-current product and 80 percent of normal test voltage for a direct-current product. If the burner is equipped with a primary safety control that can be connected only for interrupted ignition, the voltage of the power supply to both the ignition system and primary safety control is to be regulated to the minimum voltage necessary to initiate a trial for ignition.

95.12.3 Compliance with 95.12.1 is to be determined immediately following the Combustion Tests, Section 92, except that the test voltage is to be as indicated in 95.12.4. During this test:

a) The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum temperature recommended in the manufacturer's instructions for the grade of oil fuel being used for the test;

b) Each spark gap is to be adjusted to the maximum recommended by the manufacturer, but a gap is to be not less than 1/16 inch (1.6 mm);

c) The temperature of the oil as supplied to any parts of the burner, except those located downstream from a preheater, is to be 1.7 ±3°C (35 ±5°F);

d) The combustion air is to be supplied at room temperature; and

e) If a burner is equipped with an oil preheater, the temperature of the oil at the inlet to the preheater is to be not less than 11°C (20°F) above the pour point of the test fuel.

95.12.4 The representative product is to be energized and allowed to remain energized for the designed trial-for-ignition period. Five trials are to be made. If the product may employ an interchangeable transformer, an appropriate interchangeable test transformer is to supply the product, and five additional trials-for-ignition are to be made.

95.12.5 Following the last trial for ignition and as a continuation thereof, the burner is to be fired at high-fire rate for at least 15 minutes. Stable combustion shall be maintained.

95.12.6 A gas-electric high-tension ignition system shall perform acceptably when tested in accordance with 95.8.1 – 95.11.1.

95.13 Gas-electric hot-wire – reduced voltage – test 1

95.13.1 If ignition occurs after being tested as specified in 95.13.2 – 95.13.4, no flame shall flash outside the burner.

Exception: This requirement does not apply to a burner equipped with a positive means to prevent the burner from attempting a trial-for-ignition at voltage less than 85 percent of rated voltage for an alternating current product or 80 percent of rated voltage for a direct current product.

95.13.2 A product with a gas-electric hot-wire ignition system is to be connected to a power supply having a voltage that is 70 percent of the rated voltage, or not less than 70 percent of the normal test voltage or not less than the minimum voltage below which the burner is positively prevented from attempting a trial-for-ignition, whichever is higher. See 93.3.3.

95.13.3 Compliance with 95.13.2 is to be determined immediately following the Combustion Tests, Section 92. During this test the product is to be operated as described in 95.11.2.

95.13.4 Ignition is to be attempted at selected voltages within the range specified in 95.13.2. The burner is to be energized and allowed to remain energized for the intended trial-for-ignition period. Five trials are to be made.

95.14 Gas – electric hot-wire– reduced voltage – test 2

95.14.1 A gas-electric hot-wire ignition system for an automatically- or remotely-lighted burner shall ignite the pilot immediately upon admission of pilot gas and no flame shall flash outside of the burner during each trial when tested as specified in 95.14.2 – 95.16.1. The pilot shall effect complete ignition of the oil fuel as introduced into the ignition zone. The ignition system and burner are to be connected to a power supply having a voltage equal to 85 percent of normal test voltage for an alternating-current product or 80 percent of the normal test voltage for a direct-current product.

95.14.2 Compliance with 95.14.1 is to be determined immediately following the Combustion Tests, Section 92. During this test:

a) The oil-temperature control for a burner intended to burn preheated oil is to be set for the minimum recommended in the manufacturer's instructions;

b) The temperature of the oil supplied to any part of the burner, except those located downstream from a preheater, is to be 1.7 ±3°C (35 ±5°F); and

c) If a burner is equipped with an oil preheater, the temperature of the oil at the inlet to the preheater is to be at least 11°C (20°F) above the pour point of the test fuel.

95.14.3 The representative product is to be energized and allowed to remain energized for the intended trial-for-ignition period. Five trials are to be made.

95.14.4 Following the last trial for ignition and as a continuation thereof, the burner is to be fired at high-rate for at least 15 minutes. Stable combustion shall be maintained.

95.15 Gas – electric hot-wire – general

95.15.1 A gas-electric hot-wire ignition system shall perform acceptably when tested in accordance with 95.5.1 – 95.6.2 and 95.8.1 – 95.10.1.

95.16 Manual – general

95.16.1 A manually-lighted-vaporizing burner shall ignite within 5 minutes when lighted in accordance with the instructions marked on the product. Visual examination for compliance with this requirement is to be made in conjunction with the Combustion Tests, Section 92.

95.16.2 For this test the fuel feed rate, with the oil-regulating device set at the lighting position and any allowable predetermined oil level in the burner, is to be the minimum to be maintained in production.

95.16.3 The burner is to be lighted in accordance with the instructions and allowed to fire at the high-fire input and draft for at least 15 minutes if it has not been fired previously. The fuel is then to be turned off. After the burner has returned to room temperature, it is to be lighted again in accordance with the instructions. Stable ignition shall occur within 5 minutes after the fuel-regulating device opens.

95.17 Stability

95.17.1 A manually-lighted burner is to be lighted in accordance with the instructions marked on the product and fired at high-fire rate for at least 30 minutes. The fuel is then to be shut off. As soon as burner