UL 2208

STANDARD FOR SAFETY

Solvent Distillation Units

UL Standard for Safety for Solvent Distillation Units, UL 2208

Fourth Edition, Dated May 29, 2025

Summary of Topics

This new Fourth Edition of ANSI/UL 2208 dated May 29, 2025 incorporates editorial changes including renumbering and reformatting to align with current style.

The new requirements are substantially in accordance with Proposal(s) on this subject dated March 21, 2025.

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MAY 29, 2025

ANSI/UL 2208-2025

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UL 2208

Standard for Solvent Distillation Units

First Edition –September, 1996
Second Edition – February, 2005
Third Edition – July, 2010

Fourth Edition

May 29, 2025

This ANSI/UL Standard for Safety consists of the Fourth Edition.

The most recent designation of ANSI/UL 2208 as an American National Standard (ANSI) occurred on May 29, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover solvent distillation units, with a maximum capacity of 60 gallons (227 L), used for recycling flammable or combustible liquids as indicated in the instruction manual provided with each unit.

1.2 These requirements cover solvent distillation units which utilize electricity, steam, or heated liquids to distill solvents.

1.3 These units are intended for installation and use in accordance with the following:

a) NFPA 70®, *National Electrical Code®* (NEC®);

NFPA 70®, *National Electrical Code®*, and NEC® are registered trademarks of the National Fire Protection Association, Quincy, MA.

b) Flammable and Combustible Liquids Code, NFPA 30;

c) Standard for Spray Application Using Flammable or Combustible Materials, NFPA 33;

d) Fire Code, NFPA 1; and

e) International Fire Code, IFC.

1.4 Solvent distillation units investigated for use in laboratories are only intended for installation in facilities that comply with requirements of the Standard for Fire Protection for Laboratories Using Chemicals, NFPA 45.

1.5 Solvent distillation units investigated for use in commercial dry cleaning plants are intended for installation in accordance with requirements of the Standard for Drycleaning Plants, NFPA 32.

1.6 Requirements additional to those specified in this Standard are necessary as follows:

a) Electrically powered steam generating units having an electrical input power rating of more than 15 kW per steam generating vessel shall also comply with the applicable requirements in the Standard for Heating, Water Supply, and Power Boilers – Electric, UL 834;

b) Units intended for use in dry cleaning establishments shall also comply with applicable requirements of the Standard for Drycleaning Plants, NFPA 32;

c) Units intended for use in laboratory work areas shall also comply with applicable requirements of the following standards:

1) Standard for Medical Electrical Equipment, Part 1: General Requirements for Safety, UL 60601-1;

2) Standard for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, UL 61010-1;

3) Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements, IEC 61010-1;

4) Fire Protection for Laboratories Using Chemicals, NFPA 45; and

5) Health Care Facilities, NFPA 99.

d) Units intended for use in commercial garages shall comply with the applicable requirements of Article 511 of NFPA 70®, *National Electrical Code*® (NEC®), and of the Standard for Garage Equipment, UL 201;

e) Units intended for use in aircraft hangars shall comply with the applicable requirements of Article 513 of NFPA 70®, *National Electrical Code*® (NEC®); and

f) Units intended for use in dispensing and service stations shall comply with the applicable requirements of Article 514 of NFPA 70®, *National Electrical Code*® (NEC®).

1.7 These requirements do not apply to:

a) Carbon-bed units;

b) Units intended to be installed outdoors;

c) Units used to distill solvents classified as unstable or solvents used for nitrocellulose or other unstable reactives;

d) Units intended for high volume distillation processes or equipment typical of the petrochemical or distilled spirits industries;

e) The storage, use, and disposal of any flammable or combustible liquids or hazardous materials used with or produced by the equipment

f) The physiological effects of using the equipment with solvents or hazardous waste; or

g) Units used in processing plant material for extraction of the oil. These units shall comply with the applicable requirements UL/ULC 1389, Standard for Plant Oil Extraction Equipment for Installation and Use in Ordinary (Unclassified) Locations and Hazardous (Classified) Locations.

2 Components

2.1 A component of a product covered by this Standard shall:

a) Comply with the requirements for that component as specified in this Standard;

b) Be used in accordance with its rating(s) established for the intended conditions of use;

c) Be used within its established use limitations or conditions of acceptability.

2.2 A component of a product covered by this Standard 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;

b) Is superseded by a requirement in this Standard; or

c) Is separately evaluated when forming part of another component, provided the component is used within its established ratings and limitations.

2.3 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.

2.4 A component that is also intended to perform other functions such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable standard(s) that cover devices that provide those functions.

3 Units of Measurement

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

4 Referenced Publications

4.1 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.

4.2 The following publications are referenced in this Standard:

ASTM D5, *Standard Test of Penetration for Bituminous Materials*

ASTM D56, *Standard Test Method for Flash Point by Tag Closed Cup Tester*

ASTM D93, *Standard Test Method for Flash Point by the Pensky-Martens Closed Cup Tester*

ASTM D3278, *Standard Test Method for Flash Point of Liquids by Small Scale Closed-Cup Apparatus*

ASTM D3828 REV A, *Standard Test Method for Flash Point by Small Scale Closed Tester*

ASTM E28, *Standard Test Method for Softening Point of Resins Derived from Pine Chemicals and Hydrocarbons, by Ring-and-Ball Apparatus*

ASTM E659, *Standard Test Method for Autoignition Temperature of Liquid Chemicals*

IEC 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements*

International Fire Code, IFC

ISA 12.12.01, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2, and Class III, Divisions 1 and 2 Hazardous (Classified) Locations*

NFPA 1, *Fire Code*

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 32, *Standard for Drycleaning Plants*

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*

NFPA 45, *Standard for Fire Protection for Laboratories Using Chemicals*

NFPA 70®, *National Electrical Code®* (NEC®)

NFPA 99, *Health Care Facilities*

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*

UL 157, *Gaskets and Seals*

UL 201, *Garage Equipment*

UL 674, *Electric Motors and Generators for Use in Hazardous (Classified) Locations*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 796, *Printed Wiring Boards*

UL 817, *Cord Sets and Power-Supply Cords*

UL 823, *Electric Heaters for Use in Hazardous (Classified) Locations*

UL 834, *Heating, Water Supply, and Power Boilers – Electric*

UL 840, *Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment*

UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1, Hazardous (Classified) Locations*

UL 969, *Marking and Labeling Systems*

UL 1203, *Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations*

UL 1581, *Reference Standard for Electrical Wires, Cables, and Flexible Cords*

UL 60601-1, *Medical Electrical Equipment, Part 1: General Requirements for Safety*

UL 61010-1, *Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements*

UL/ULC 1389, *Plant Oil Extraction Equipment for Installation and Use in Ordinary (Unclassified) Locations and Hazardous (Classified) Locations*

5 Glossary

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

5.2 AUTOIGNITION TEMPERATURE – The minimum temperature at which fuel-air mixtures will ignite spontaneously. This temperature is to be determined either at atmospheric pressure (14.7 psig) or at the maximum pressure present in the area of the fuel-air mixture, whichever is higher. At atmospheric pressure, the autoignition temperature of a solvent shall be determined in accordance with ASTM E659.

5.3 BATCH TYPE UNIT – A unit that distills a single batch of solvent at a time. Dirty solvent is poured or otherwise manually introduced into the unit from a container, safety can, or similar vessel. After

processing, the distilled solvent is discharged into a collection vessel. The unit does not connect directly to solvent utilization equipment.

5.4 COMBUSTIBLE LIQUID – A material that has a fluidity greater than 300 penetration asphalt when tested in accordance with ASTM D5, and that has a closed cup flash point at or above 100 °F (37.8 °C). Combustible liquids are subdivided as follows:

a) Class II liquids include those having flash points at or above 100 °F (37.8 °C) and below 60 °C (140 °F).

b) Class IIIA liquids include those having flash points at or above 140 °F (60 °C) and below 93 °C (200 °F).

c) Class IIIB liquids include those having flash points at or above 200 °F (93 °C).

5.5 FLAMMABLE LIQUID – A material that has a fluidity greater than 300 penetration asphalt when tested in accordance with ASTM D5, and that has a closed cup flash point below 100 °F (37.8 °C) and a vapor pressure not exceeding 40 psia (2068 mm Hg). Flammable liquids are Class I liquids, and are subdivided as follows:

a) Class IA liquids include those having flash points below 73 °F (22.8 °C) and having a boiling point below 100 °F (37.8 °C).

b) Class IB liquids include those having flash points below 73 °F (22.8 °C) and having a boiling point at or above 100 °F (37.8 °C).

c) Class IC liquids include those having flash points at or above 73 °F (22.8 °C) and below 100 °F (37.8 °C).

5.6 FLASH POINT – The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid within the vessel as specified by the appropriate test procedure and apparatus as follows:

a) The flash point of a liquid having a viscosity less than 45 Saybold Universal Seconds (SUS) at 100 °F (37.8 °C) and a flash point below 200 °F (93 °C) as determined in accordance with ASTM D56.

b) The flash point of a liquid having a viscosity of 45 SUS or more at 100 °F (37.8 °C) or a flash point of 93 °C or higher as determined in accordance with ASTM D93.

c) ASTM D3278 may be used for paints, enamels, lacquers, varnishes, and related units and their components having flash points between 32 °F (0 °C) and 230 °F (110 °C) and having a viscosity lower than 150 centistokes at 77 °F (25 °C).

d) ASTM D3828 REV A, may be used for materials other than those for which specific setaflash methods exist.

5.7 FLOW THROUGH UNIT – A solvent distillation unit that connects to equipment that utilizes the solvent being distilled. Dirty solvent is pumped or otherwise introduced into the unit, and the distilled solvent is returned to the equipment, or a reservoir associated with the equipment.

5.8 IGNITABLE MIXTURE – A vapor-air, gas-air, dust-air mixture or combinations of these mixtures that can be ignited by a static spark.

5.9 INTRINSICALLY SAFE CIRCUIT – A circuit in which any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under prescribed test conditions.

5.10 LINE-VOLTAGE CIRCUIT – A line-voltage circuit is one involving a potential of not more than 600 V and having circuit characteristics in excess of those of a low-voltage circuit.

5.11 LOW-VOLTAGE CIRCUIT – A low-voltage circuit is one involving a potential of not more than 30 V (42.4 volts peak) and supplied by a primary battery, by a standard Class 2 transformer, or by an impedance which, as a unit, complies with all of the performance requirements for a Class 2 transformer.

5.12 LOWER FLAMMABILITY LIMIT (LFL) – The minimum concentration of vapor in air at which propagation of flame will occur in the presence of an ignition source. LFL is sometimes referred to as LEL, or lower explosive limit.

5.13 SAFETY CAN – A container of not more than 5 gallons (18.9 L) capacity, having a spring closing lid and spout cover and constructed so that it will safely relieve internal pressure when subjected to fire exposure.

5.14 SEMICONDUCTIVE HOSE – A hose with an electrical resistance great enough to limit the flow of stray electric currents to a safe level, yet not so high as to prevent relaxation of static charges to ground.

5.15 SOLVENT – A flammable or combustible liquid capable of dissolving another substance to form a uniformly dispersed mixture at the molecular or ionic level.

5.16 SOLVENT DISTILLATION UNIT – A unit that receives contaminated flammable or combustible liquid and distills the contents to remove the contaminants and recover the solvent.

5.17 STATIC ELECTRICITY – An electrical charge that is significant only for the effects of its electrical field component and that manifests no significant magnetic field component.

5.18 STATIC SPARK – An impulsive discharge of electricity across a gap between two points not in contact.

5.19 UNSTABLE LIQUID – A liquid that, in the pure state or as commercially produced or transported, will vigorously polymerize, decompose, undergo condensation reaction, or become self-reactive under conditions of shock, pressure, or temperature.

5.20 VESSEL – A container, safety can, portable tank, tank, or other receptacle intended to contain contaminated solvent, distilled solvent, or other liquids.

CONSTRUCTION

6 General

6.1 All constructions

6.1.1 Units that do not produce mixtures above 25 % of the lower flammability limit (LFL) at potential sources of ignition under normal and single fault conditions shall comply with the requirements of this Standard for non-hazardous locations.

6.1.2 The following shall comply with the requirements of this Standard for non-hazardous locations and Class I, Division 2 Hazardous Locations:

a) Units that produce mixtures above 25 % of the lower flammability limit (LFL) at potential sources of ignition only under single fault conditions; and

b) Units intended to be installed in Class I, Division 2 locations.

Exception: Units intended for use in a laboratory work area in accordance with requirements of NFPA 45, need not be evaluated for Class I, Division 2 locations provided they are marked in accordance with 49.3.

6.1.3 The following shall comply with the requirements of this Standard for non-hazardous locations and Class I, Division 1 Hazardous Locations:

a) Units that produce mixtures above 25 % of the lower flammability limit (LFL) at potential sources of ignition under normal conditions; and

b) Units intended to be installed in Class I, Division 1 locations.

Exception: Units intended for use in a laboratory work area in accordance with requirements of NFPA 45, need not be evaluated for Class I, Division 1 locations provided that they are marked in accordance with 49.3.

6.1.4 Only materials determined to be acceptable for the particular use shall be used. All nonmetallic components and polymeric materials likely to be exposed to flammable liquids or vapors during normal operation of the unit and that are required to comply with other requirements of this Standard shall be investigated and determined compatible with the solvents to which they are exposed.

6.1.5 If the operation of a unit involves the generation and confining under pressure of steam or other gas, consideration is to be given to the possibility of risk of explosion incident to such operation. This applies in the case of a unit having immersed electrodes, where the electrolysis of water may result in the accumulation of oxygen and hydrogen. The unit is not acceptable unless its strength has been investigated with respect to any risk of explosion that may be involved.

6.2 Class I, Division 1 hazardous (classified) location construction

6.2.1 The requirements for Class I, Division 1 locations supersede those for non-hazardous locations, where any conflict exists.

6.2.2 The unit shall be evaluated for use in a Class I, Division 1 hazardous location per Articles 500 and 501 of the National Electrical Code (NEC), NFPA 70.

6.2.3 Components used in Hazardous (Classified) locations shall comply with the applicable requirements of the following standards:

a) UL 674.

b) UL 823.

c) UL 1203.

6.3 Class I, Division 2 hazardous (classified) location construction

6.3.1 The requirements for Class I, Division 2 locations supersede those for non-hazardous locations, where any conflict exists.

6.3.2 The unit shall be evaluated for use in a Class I, Division 2 hazardous location per Articles 500 and 501 of the National Electrical Code (NEC), NFPA 70.

6.3.3 If the unit uses an electric heater, it shall comply with the applicable requirements of UL 823.

6.3.4 The unit shall comply with the applicable requirements of ISA 12.12.01.

6.4 Intrinsically safe circuits and components

6.4.1 Circuits and components that are to be considered intrinsically safe shall comply with requirements of UL 913.

6.4.2 When determined acceptable for use in any hazardous location, the use of intrinsically safe components and wiring shall be permitted.

6.4.3 Wiring of intrinsically safe circuits shall be separated at least 2 inches (50.8 mm) from wiring of all other circuits that are not intrinsically safe.

6.4.4 Intrinsically safe conductors shall be secured so that any conductor that might come loose from a terminal cannot come in contact with another terminal.

6.4.5 Terminals connected to and wiring of intrinsically safe circuits shall be identified as "Intrinsically Safe Circuits" in accordance with the National Electrical Code (NEC), NFPA 70.

7 Frame and Enclosure

7.1 The frame and enclosure of a unit shall be strong and rigid to resist the abuses to be encountered during intended use. The degree of resistance inherent in the unit shall preclude total and partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other defects which alone or in combination constitute an increase in the risk of fire, electric shock, or injury to persons.

7.2 A unit shall be provided with an enclosure of material determined to be acceptable for the application. The enclosure shall house all electrical parts that may result in risk of electric shock or injury to persons under any condition of use. If a unit is for permanent installation (intended for permanent connection to the power supply), the enclosure shall be provided with means for mounting in the intended manner and shall be furnished with any necessary fittings, such as brackets or hangers.

7.3 If openings for ventilation are provided in the enclosure of a unit or in an externally mounted component intended for permanent connection to the power supply, they shall be located so that they will not vent into concealed spaces of a building structure, such as into a false-ceiling space or hollow spaces in the wall, when the unit is installed.

7.4 Among the factors used to determine the suitability of an enclosure are:

a) Physical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of use.

For a nonmetallic enclosure, all of these factors are to be considered with respect to thermal aging.

7.5 Cast- and sheet-metal portions of the enclosure shall not be thinner than indicated in Table 7.1 unless the enclosure complies with 7.4 and 7.6.

Table 7.1
Minimum Thickness of Enclosure Material

Metal	At small, flat, unreinforced surfaces and at surfaces that are reinforced by curving, ribbing, and the like or are otherwise of a shape and/or size to provide physical strength		At surfaces to which a wiring system is to be connected in the field		At relatively large unreinforced flat surfaces	
	inch	(mm)	inch	(mm)	inch	(mm)
Die-cast	3/64	(1.2)	–	–	5/64	(2.0)
Cast malleable iron	1/16	(1.6)	–	–	3/32	(2.4)
Other cast metal	3/32	(2.4)	–	–	1/8	(3.2)
Uncoated sheet steel	0.026[a]	(0.66[a])	0.032	(0.81)	0.026	(0.66)
Galvanized sheet steel	0.029[a]	(0.74[a])	0.034	(0.86)	0.029	(0.74)
Nonferrous sheet metal	0.036[a]	(0.91[a])	0.045	(1.14)	0.036	(0.91)

[a] Thinner sheet metal may be used if it is determined to be acceptable when the enclosure is evaluated under considerations such as those mentioned in 7.4.

7.6 In addition to the factors in 7.4, an enclosure of sheet metal is to be considered with respect to its size and shape, the thickness of metal and the intended use of the unit.

7.7 Electrical parts of a unit shall be located or enclosed so that protection against unintentional contact with uninsulated live parts will be provided. Insulated motor brush caps do not require an additional enclosure.

7.8 The enclosure shall be such that molten metal, burning insulation, or flaming particles, are not likely to fall on combustible materials, including the surface upon which the enclosure is supported.

7.9 The requirement in 7.8 necessitates the use of a barrier of metal, phenolic, urea, ceramic, or similar material:

a) Under a motor unless:

1) The structural parts of the motor or of the unit 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 unit when the motor is energized under each of the following fault conditions:

i) Open main winding;

ii) Open starting winding; and

iii) Starting switch short-circuited.

3) The motor is provided with a thermal motor protector (a protective device that is sensitive to both temperature and current) that restricts the temperature of the motor windings from becoming more than 257 °F (125 °C) under the maximum load under which the motor runs without causing the protector to cycle, and from becoming more than 302 °F (150 °C) with the rotor of the motor locked.

4) The motor complies with the requirements for impedance-protected motors.

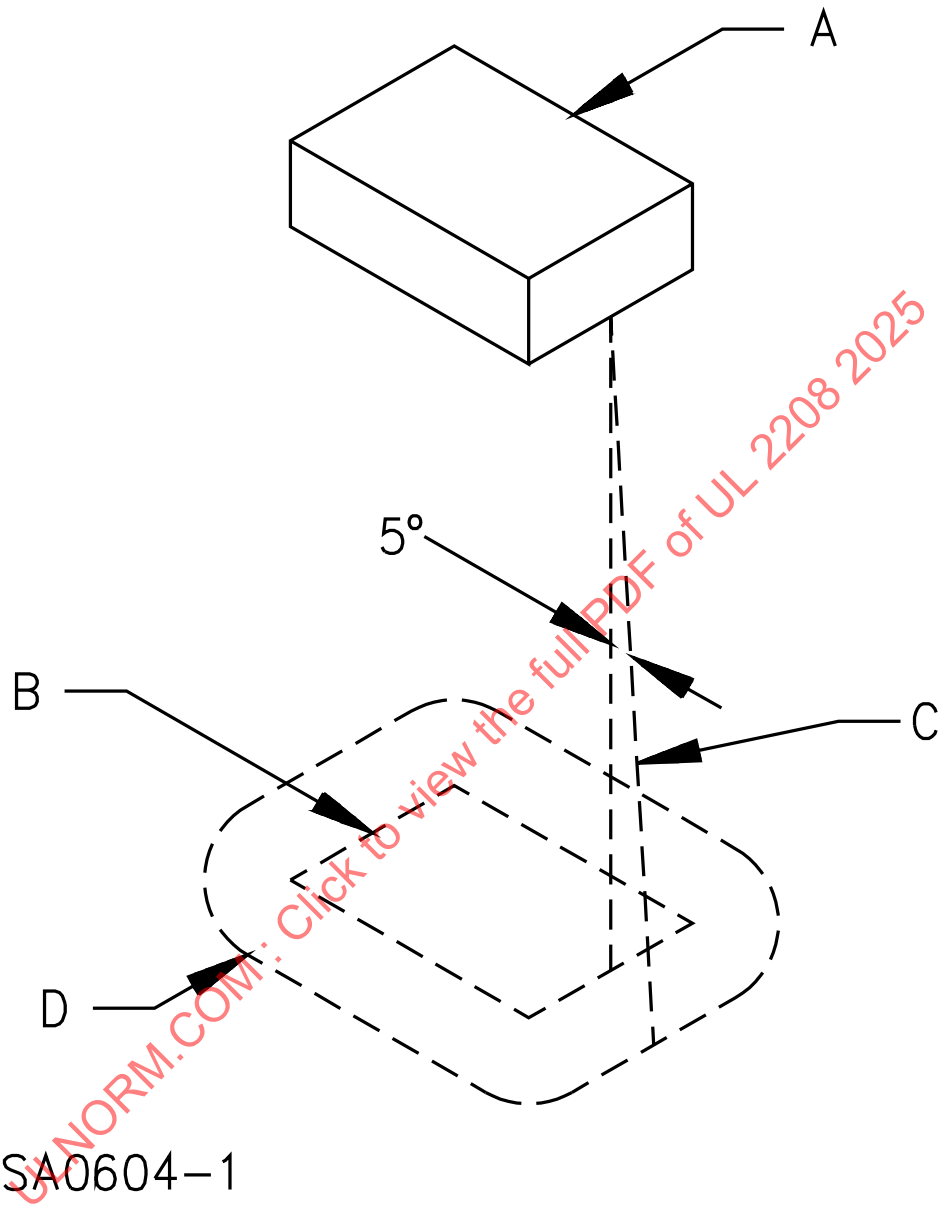
b) Under wiring, unless it complies with the VW-1 flame test in accordance with UL 1581.

7.10 The requirement in 7.8 also necessitates that a switch, transformer, relay, solenoid, or similar device be individually and completely enclosed except at terminals, unless it can be shown that malfunction of the component is not likely to result in a fire, or unless there are no openings in the bottom of the enclosure. An opening in the bottom of the enclosure shall not be located directly below field- or factory-made splices or overload or overcurrent protective devices.

7.11 The barrier mentioned in 7.9 shall be horizontal, located as indicated in Figure 7.1, and shall not have an area less than that described in that illustration. Openings for drainage and ventilation may be used provided molten metal, burning insulation, or similar materials, are not likely to fall through the opening onto combustible material.

Figure 7.1

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 horizontal plane.

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

a) Tangent to the component;

b) 5° from the vertical; and

c) Oriented so that the area traced out on a horizontal plane is maximum.

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

7.12 The criteria for judging an enclosure other than as described in 7.4 are given in 7.14 and in the following items and related illustrations:

a) An opening in the enclosure complies when the probe (illustrated in Figure 7.2) inserted into the opening cannot touch any uninsulated live part or film-coated wire that involves a risk of electric shock. The probe is to be applied to any depth that the opening will permit and shall be rotated and articulated in all possible configurations before, during, and after insertion.

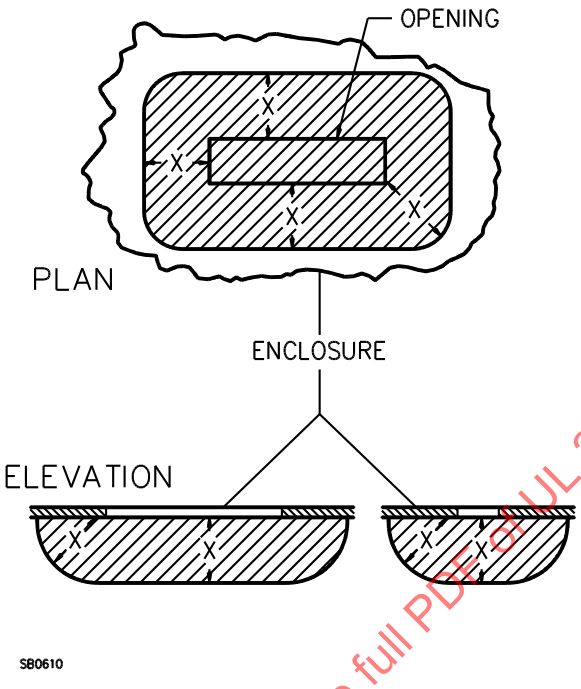
b) An opening that will not prevent entrance of the probe as mentioned in (a) complies under the conditions described in Figure 7.3.

Figure 7.2

Articulate Probe with Web Stop

Figure 7.3

Opening in Enclosure



NOTE – Proportions exaggerated for clarity

7.13 The opening illustrated in Figure 7.3 complies if, within the enclosure, there is no uninsulated live part or enamel-insulated wire:

a) Less than X distance from the perimeter of the opening, as well as

b) Within the volume generated by projecting the perimeter X distance perpendicular to its plane. X equals five times the diameter of the largest diameter rod which can be inserted through the opening, but not less than 4 inches (102 mm).

In evaluating an opening, any barrier located within the volume usually is ignored unless it intersects the boundaries of the volume in a continuous, closed line.

7.14 When a marking draws the user's attention to a hole of any size in the enclosure for the adjustment of a thermostat or for a similar activity, it shall not be possible to damage insulation or contact uninsulated live parts through the hole with a 1/16-inch (1.6-mm) diameter rod.

7.15 During the examination of a unit in connection with the requirements in 7.7 – 7.12, a part of the outer enclosure that may be removed without the use of tools by the user of the unit (for the attachment of accessories, for access to make operating adjustments, or for other reasons) is to be disregarded – it is not to be assumed that the part in question affords protection against risk of electric shock. A warning marking, such as that specified in 49.11, is not considered to eliminate this risk of electric shock.

7.16 Any moving parts, such as rotors of motors, chains, pulleys, belts, and gears, shall be enclosed or guarded to reduce the risk of injury to persons.

7.17 With reference to the requirement in 7.16, the degree of protection required of the enclosure depends upon the general construction and intended use of the unit. The factors to be taken into consideration in judging the acceptability of exposed moving parts are:

a) The degree of exposure;

b) The sharpness of the moving parts;

c) The likelihood of unintentional contact with the moving parts;

d) The speed of movement of those parts; and

e) The likelihood of fingers, arms, or clothing being drawn into the moving parts – such as at points where gears mesh, where belts travel onto a pulley, or where moving parts close in a pinching or shearing action.

7.18 The door or cover of an enclosure shall be provided with a means for securing it in place in the closed position.

7.19 The door or cover of an enclosure shall be hinged or otherwise attached in a similar manner if it gives access to any overload protective device whose functioning requires renewal, or if it is necessary to open the cover in connection with the operation of the protective device. Such a door or cover shall be provided with a latch or similar device, and shall be tight-fitting or overlap the surface of the enclosure around the opening.

7.20 A component of a unit that is likely to need inspection, replacement, cleaning, or other servicing shall be as accessible as possible. The component shall be readily accessible without the use of special tools – tools not available to other than service personnel – if it is intended to be manually operated or adjusted or periodically serviced.

7.21 The bulb and capillary tube of a thermostat shall be protected from physical damage when such damage of the tube or bulb results in a risk of fire.

7.22 The sheath used to enclose the heating element of an immersion-type heater for use with fuel oil shall be of steel, stainless steel, or other metal resistant to corrosion in fuel oil; brass, bronze, or copper is not considered acceptable for this application. The sheath used to enclose the heating element of an immersion-type water heater shall be of a metal resistant to corrosion in water.

8 Assembly

8.1 A switch, lampholder, attachment-plug receptacle, or plug-type connector provided as a part of a unit shall be secured so that it is not likely to turn.

8.2 Uninsulated live parts shall be secured to the base or surface so that they are not likely to turn or shift in position as the result of stresses if such motion results in a reduction of spacings below the minimum required in Table 27.1.

8.3 Friction between surfaces is not acceptable as a means to keep live parts or components from shifting or turning. A lock washer, properly applied, is acceptable for this purpose.

9 Corrosion Protection

9.1 Except as noted in 9.2, iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other means if the deterioration of such unprotected parts would be likely to result in risk of fire or electric shock.

9.2 In certain equipment where the oxidation of steel is not likely to be accelerated due to the exposure of metal to air and moisture or other oxidizing influence – thickness of metal and temperature also being factors – surfaces of sheet steel within an enclosure may not be required to be protected against corrosion. Cast-iron parts are not required to be protected against corrosion. A sheath used on a heating element operating in air and terminal parts attached directly to the heating element need not be protected against corrosion.

10 Supply Connections

10.1 Permanently-connected units

10.1.1 General

10.1.1.1 A unit intended for fixed installation to the building or permanent connection electrically to the power supply shall have provision for connection of one of the wiring systems that, in accordance with the National Electrical Code (NEC), NFPA 70, would be acceptable for the unit.

10.1.1.2 The location of a terminal box or compartment, where power-supply connections are to be made to a unit intended to be permanently connected, shall be constructed so that these connections may be readily inspected after the unit is installed as intended.

10.1.1.3 A terminal compartment intended for the connection of a supply raceway shall be attached to the unit so that it will not turn with respect to the unit.

10.1.1.4 An electrical component shall not be mounted on a part, such as the cover of a wiring-terminal compartment, that must be removed for the purpose of making or inspecting field-wiring connections.

Exception: A single electrical component, such as a switch, a pilot light, or a similar device, may be mounted on a wiring compartment cover when:

a) The component connecting leads are of a length that provides for the making and examination of field-wiring connections;

b) None of the component connections are to be field wired;

c) Strain relief is provided to prevent stress from being transmitted to the component wiring terminations and complies with the strain relief test described in 47.2;

d) The minimum size of the component leads is 18 AWG (0.82 mm^2); and

e) Wiring terminations on the component are recessed or protected by barriers of insulating or similar material that will provide protection from contact with wiring installed in the box, or unintentional contact during installation or inspection of field wiring.

10.1.2 Wiring terminals

10.1.2.1 A unit intended for permanent connection to the power supply shall be provided with wiring terminals or leads for the connection of conductors having an ampacity of not less than 125 % of the current rating of the unit when the load is continuous (3 hours or more) and not less than the current rating of the unit when the load will be intermittent.

10.1.2.2 For the purpose of these requirements, wiring terminals are terminals to which power-supply or control connections will be made in the field when the unit is installed. It is to be assumed that 140 °F (60 °C) wire will be used for connections to a continuous-load type of unit rated at 80 A or less and an

intermittent-load type of unit rated at 100 A or less. Wire rated for 167 °F (75 °C) will be assumed to be used with units rated in excess of these values.

10.1.2.3 A wiring terminal shall be provided with a soldering lug or a pressure wire connector securely fastened in place; for example, bolted or held by a screw, except that a wire-binding screw may be used 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 position.

10.1.2.4 A wiring terminal shall not turn or shift in position. Friction between surfaces is not an acceptable means to prevent turning or shifting. Examples of acceptable means are:

a) The use of two screws or rivets;

b) Square shoulders or mortises;

c) A dowel pin, lug, or offset; or

d) A connecting strap or clip fitted into an adjacent part.

10.1.2.5 A wire-binding screw at a wiring terminal shall not be smaller than No. 10, except that a No. 8 screw may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) or smaller conductor. A No. 6 screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) control-circuit conductor.

10.1.2.6 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.3 mm) thick, except that a plate not less than 0.030 inch (0.8 mm) thick complies when the tapped threads have mechanical strength that has been determined acceptable. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

10.1.2.7 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size mentioned in 10.1.2.1, but not smaller than 14 AWG (2.1 mm^2), under the head of the screw or the washer.

10.1.2.8 A wire-binding screw shall thread into metal.

10.1.2.9 A unit intended for connection to a grounded power-supply conductor shall have one terminal or lead identified for connection of the grounded conductor of the supply circuit when it uses:

a) A lampholder or element holder of the Edison-screw-shell type;

b) A single-pole switch; or

c) A single-pole automatic control.

The identified terminal or lead shall be the one that is connected to screw shells of lampholders or element holders. There shall be no connection to single-pole switches or single-pole automatic controls, except as noted in 25.2.

10.1.2.10 A terminal provided for the connection of a grounded circuit conductor shall be made of or plated with a metal white in color, or have the word "white" located adjacent to the terminal and shall be readily distinguishable from the other terminals. Or, proper identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram. A lead intended for the connection of a grounded circuit conductor shall be finished to show a white or gray color and shall be distinguishable from the other leads.

10.1.2.11 Except as noted in 10.1.2.12, the free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152 mm) or more if the lead is intended for field connection to an external circuit.

10.1.2.12 A lead may be less than 6 inches (152 mm) in length when it is evident that the use of a longer lead might result in a risk of fire or electric shock, and that the intended connection to the lead is practical.

10.1.2.13 The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead in the field wiring area shall be so identified.

10.1.2.14 A wire-binding screw intended for the connection of and equipment-grounding conductor shall have a green-colored head that is hexagonal-shaped, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified by being marked "g," "gr," "grd," "grounding," or with a similar mark, or by a marking on the wiring diagram provided on the unit. The wire-binding screw or pressure wire connectors shall be located so that they are unlikely to be removed during servicing of the unit.

10.1.2.15 A terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size acceptable for the particular unit, in accordance with Table 10.1.

Table 10.1
Bonding Wire Conductor Size

Maximum rating or setting of automatic overcurrent device in circuit ahead of equipment, amperes	Minimum size of copper conductor		Minimum size of aluminum conductor	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)
40	10	(5.3)	8	(8.4)
60	10	(5.3)	8	(8.4)
100	8	(8.4)	6	(13.3)
200	6	(13.3)	4	(21.2)

10.2 Cord-connected units

10.2.1 General

10.2.1.1 A cord-connected unit shall be provided with a non-detachable flexible cord and an attachment plug for connection to the supply circuit.

10.2.1.2 The power supply cord shall comply with the requirements of UL 817.

10.2.1.3 The power supply cord shall be at least as serviceable as Type SJ cord and be evaluated for exposure to oil.

10.2.1.4 The power supply cord shall not be rated less than the rated voltage and current of the unit. In addition, the attachment plug shall be rated not less than 125 % of the rated current of the unit.

10.2.1.5 The maximum length of the power supply cord shall be 8 feet (2.44 m). The minimum length of the power supply cord shall be determined by the Vapor Concentration Measurement Test, Section 39.

10.2.2 Strain relief

10.2.2.1 Strain relief shall be provided to restrict a mechanical stress on an attached power-supply cord from being transmitted to terminals, splices, or interior wiring.

10.2.2.2 If wood, pressed board, or other fibrous material is used to secure the strain-relief assembly, the fibrous material shall be secured to the unit by a pin, setscrew, or other positive means.

10.2.2.3 Means shall be provided to restrict an attached power supply cord from being pushed into the enclosure of a unit through the cord-entry hole if such displacement is likely to:

a) Subject the cord to mechanical damage;

b) Expose the cord to a temperature higher than that for which it is acceptable; or

c) Reduce spacings, such as to a metal strain-relief clamp, below the minimum required values.

10.2.3 Bushings

10.2.3.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or similar device that shall be secured in place, and shall have a smooth, well-rounded surface against which the cord may bear. The heat- and moisture-resistant properties of the bushing material shall be such that the bushing is acceptable for the particular application.

10.2.3.2 If the cord hole is in wood, porcelain, phenolic composition, or other nonconducting material, a smooth, well-rounded surface is considered to be equivalent to a bushing.

10.2.3.3 Ceramic materials and some molded compositions are acceptable generally for insulating bushings, but a separate bushing of wood, hot-molded shellac and tar composition, or rubber material (other than in a motor) is not acceptable. Vulcanized fiber may be used if the bushing is not less than 3/64 inch (1.2 mm) thick and if it is formed and secured in place so that it will not be affected adversely by moist conditions.

10.2.3.4 A separate soft-rubber, neoprene, or polyvinyl chloride bushing may be used in the frame of a motor or in the enclosure of a capacitor physically attached to a motor – but not elsewhere in a unit, except as indicated in 10.2.3.5 – if the bushing is:

a) Not less than 3/64 inch (1.2 mm) thick; and

b) Located so that it will not be exposed to oil, grease, oily vapor, or other substances having a deleterious effect on the compound used.

10.2.3.5 A bushing of any of the materials mentioned in 10.2.3.4 may be used at any point in a unit if used with a type of cord for which an insulating bushing is not required, and if the edges of the hole in which the bushing is mounted are smooth and free from burrs and fins.

10.2.3.6 An insulated metal grommet is acceptable in place of an insulating bushing if the insulating material used is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

11 Current-Carrying Parts

11.1 Each current-carrying part shall be made of metal that is acceptable for the particular application.

11.2 Current-carrying parts made of corrosion-resistant alloys, for example, stainless steel, are acceptable regardless of temperature. Current-carrying parts made of ordinary iron and steel are not acceptable unless they are rendered corrosion-resistant by a coating and, even then, they are acceptable only as follows:

a) Pin terminals.

b) Terminals and other parts of a motor and its governor (if any).

c) Parts whose normal operating temperature is higher than 212 °F (100 °C).

d) Parts of a component that the requirements referred to in 2.1 indicate as being acceptable with coated iron and steel parts.

11.3 A unit that is provided with a reservoir (intended to hold a liquid), shall have all live parts located or otherwise protected so that they will not be subject to wetting if the reservoir were to leak.

Exception: Live parts need not be so located or protected if the reservoir:

a) Is resistant to corrosion from the liquid intended for use in it; and

b) Complies with the applicable requirements in the Resistance to Impact Test, Section 44.

11.4 The unit shall be constructed so that a source of ignition is not located below the rim of the distillation vessel.

12 Internal Wiring

12.1 General

12.1.1 The internal wiring of a unit shall consist of wires of a size and type or types that are acceptable for the particular application, when considered with respect to:

a) The temperature and voltage to which the wiring is likely to be subjected;

b) Its exposure to oil or grease; and

c) Other conditions of service to which it is likely to be subjected.

12.1.2 There is no temperature limit applicable to glass fiber, beads of inorganic material, or similar materials used as conductor insulation.

12.1.3 Thermoplastic-insulated wire used for the internal wiring of a unit shall be standard building wire, fixture wire, or appliance-wiring material acceptable for the particular application.

12.2 Protection of wiring

12.2.1 The wiring and connection between parts of a unit shall be protected or enclosed. A length of flexible cord may be used for external connections, or for internal connections that may be exposed during servicing, if flexibility of the wiring is essential. A bare conductor or a conductor with beads for insulation shall not be used outside an enclosure.

12.2.2 Internal wiring which is exposed through an opening in the enclosure of a unit is considered to be protected as required in 12.2.1 if, when evaluated as if it were enamel-insulated wire, the wiring would comply according to 7.7 – 7.12. When it can be touched by a probe, internal wiring within an enclosure complies when protected or guarded so that it cannot be grasped, hooked, or subjected to stress.

12.2.3 If the wiring of a unit is located so that it may be in proximity to combustible material or may be subjected to mechanical injury, it shall be of a type suitable for the application or shall otherwise be protected.

12.2.4 Wires within an enclosure, compartment, or raceway shall be located or protected so that damage to conductor insulation cannot result from contact with any rough, sharp, or moving part.

12.2.5 A hole by means of which insulated wires pass through a sheet-metal wall within the overall enclosure of a unit shall be provided with a smooth, well-rounded bushing or shall have smooth, well-rounded surfaces upon which the wires may bear, so as not to abrade the insulation. A flexible cord used for external interconnection as mentioned in 12.2.1 shall be provided with a strain relief and bushings in accordance with 10.2.2.1 – 10.2.3.6 unless the unit is constructed so that the cord will be protected from stress or motion.

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

12.3 Splices

12.3.1 All splices and connections shall be mechanically secure and shall provide good electrical contact. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection would result in a risk of fire or electric shock.

12.3.2 A splice shall be provided with insulation equivalent to that of the wires involved if permanence of spacing between the splice and other metal parts of the unit is not reliably maintained.

12.3.3 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 not more than 250 V. In determining whether splice insulation consisting of coated fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its dielectric properties, heat-resistant and moisture-resistant characteristics. Thermoplastic tape wrapped over a sharp edge is not acceptable.

12.3.4 Where stranded internal wiring is connected to a wire-binding screw, loose strands of wire shall not contact any other uninsulated live part that is not always of the same polarity as the wire, and shall not contact any dead metal part. This may be accomplished by the use of pressure terminal connectors, soldering lugs, crimped (open-type) eyelets, soldering all strands of the wire together, or other reliable means.

12.3.5 Open-type eyelets shall have upturned edges or shall crimp around the screw shank so that loosening of the terminal screw will not result in the conductor coming away from the intended connection. In making this determination, one screw at a time is to be loosened.

Exception: Wiring may be secured in harnesses and constructed to comply with the connection requirement in 12.3.5.

12.3.6 Quick connect terminals may be used for factory connections under the following conditions:

a) They mate as intended with terminals integrally provided on components that have been investigated for the intended use; and

b) They have a dimple, depression, or spring-type connection so that a snap-action connection is accomplished.

12.4 Separation of circuits

12.4.1 General

12.4.1.1 Unless provided with insulation rated for the highest voltage involved, insulated conductors of circuits connected to separate sources of supply shall be separated by barriers or segregated. Except as described in 12.4.1.3, an insulated conductor of one circuit shall be separated or segregated from any uninsulated live parts of a different circuit.

12.4.1.2 Segregation of insulated conductors may be accomplished by clamping, routing, or a similar means that provides permanent separation from insulated or uninsulated live parts of a different circuit. Separation distance shall be based on the requirements for Spacings, Section 27.

12.4.1.3 Field-installed conductors of any circuit shall be segregated by barriers from:

a) Field-installed and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are or will be insulated for the maximum voltage of either circuit; and

b) Uninsulated live parts of any other circuit of the unit, whose short-circuiting would result in a risk of fire or electric shock.

12.4.1.4 Regarding 12.4.1.3(a), when the intended uses of a unit are such that in some applications a barrier is required, a removable barrier or one having an opening for the passage of conductors may be used when instructions for the barrier are a permanent part of the unit. Complete instructions in conjunction with a wiring diagram may be used instead of a barrier if, upon investigation, the combination is determined to be acceptable.

12.4.1.5 Segregation of field-installed conductors from other field-installed conductors and from uninsulated live parts of a unit connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors – with respect to the terminals or other uninsulated live parts – so that there is no likelihood of the intermingling of the conductors or parts of different circuits. If the number of openings in the enclosure does not exceed the minimum required for the proper wiring of the unit, and if each opening is located opposite a set of terminals, it is to be assumed – for the purpose of determining whether the unit complies with the requirement in 12.4.1.3 – that the conductors entering each opening will be connected to the terminals opposite the opening. If more than the minimum number of openings are provided, the possibility of conductors entering at points other than those opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit shall be investigated. To determine whether the unit complies with the requirement in 12.4.1.3, it shall be wired as in service. In doing so, a reasonable amount of slack shall be left in each conductor within the enclosure, and no more than average care is to be exercised in stowing this slack in the wiring compartment.

12.4.2 Barriers

12.4.2.1 When a barrier is used to provide separation between the wiring of different circuits, it shall be:

a) Of metal or of insulating material;

b) Of adequate mechanical strength if exposed or otherwise likely to be subjected to mechanical damage; and

c) Reliably held in place.

Unclosed openings in a barrier for the passage of conductors shall not be larger in diameter than 1/4 inch (6.4 mm) and shall not exceed in number, on the basis of one opening per conductor, the number of wires that will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may be in contact with it. The area of any such opening, with the closure removed, shall not be larger than that required for the passage of the necessary wires.

12.4.2.2 A metal barrier shall have a thickness at least as great as the minimum required thickness of the enclosure metal. A barrier of insulating material shall not be less than 0.028 inch (0.71 mm) thick and shall be of greater thickness if its deformation may be readily accomplished so as to defeat its purpose.

13 Heating Elements

13.1 A heating element shall be supported in a manner determined to be acceptable. It shall be protected against mechanical damage and contact with outside objects.

13.2 In determining whether a heating element is acceptably supported, consideration is to be given to sagging, loosening, and other adverse conditions of the element resulting from continuous heating.

13.3 A unit in which the heating element is constructed for use only in conjunction with a cooling mechanism shall be wired or controlled so that the element can be operated only while under the cooling effect of the mechanism. A unit in which the cooling effect of the motion of a part is necessary to limit temperatures shall be wired or controlled so that the element cannot be operated without such motion.

14 Electrical Insulation

14.1 Insulating washers, bushings, and similar items that are integral parts of a unit and bases or supports for the mounting of current-carrying parts shall be of a moisture-resistant material that will not be damaged by the temperatures to which they will be subjected under conditions of actual use. Molded parts shall be constructed so that they will have the mechanical strength and rigidity necessary to withstand the stresses of actual service.

14.2 Insulating material used in a unit shall be evaluated with regard to its acceptability for the particular application. Materials, such as mica, some molded compounds, and certain refractory materials are usually acceptable for use as the sole support of live parts. Some other materials that are not acceptable for general use, such as magnesium oxide, may be used if used in conjunction with other insulating materials that have been determined acceptable or if located and protected so that they are not subject to mechanical damage and the absorption of moisture is minimized. When it is necessary to investigate a material to determine whether it is acceptable, consideration is to be given to:

a) Its mechanical strength;

b) Dielectric properties;

c) Insulation resistance;

d) Heat-resistant qualities;

e) The degree to which it is enclosed or protected; and

f) Any other features having a bearing on the risk of fire or electric shock involved, in conjunction with conditions of actual service.

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

14.3 In the mounting or supporting of small, fragile insulating parts, screws or other fastenings should not be tight enough to cause cracking or breaking of these parts with expansion and contraction. Generally, such parts should be slightly loose.

15 Thermal Insulation

15.1 Thermal insulation, if used, shall be of such a nature and so located and mounted or supported that it will not be adversely affected by any intended operation of the unit. See 36.19.

15.2 Combustible or electrically conductive thermal insulation shall not make contact with uninsulated live parts of a unit.

15.3 Some types of mineral-wool thermal insulation contain conductive impurities in the form of slag, which make its use unacceptable if in contact with uninsulated live parts. See 37.1.

16 Gaskets, Seals, and Tubing

16.1 Gaskets, o-rings, seals, and tubing shall be investigated and determined acceptable for use with the liquids, atmospheres, temperatures, and materials with which they may come into contact during normal use conditions. Applicable requirements in UL 157, shall be used as a basis for this investigation.

Exception No. 1: This requirement does not apply to gaskets, o-rings, seals, and tubing, the failure of which does not increase the risk of fire, electric shock, injury to persons, or other hazards.

Exception No. 2: This requirement does not apply to gaskets, o-rings, seals, and tubing made of Polytetrafluoroethylene (PTFE).

17 Motors

17.1 A motor shall be acceptable for the particular application; and shall be capable of handling its maximum intended load without risk of fire, electric shock, or injury to persons.

17.2 A motor winding shall resist the absorption of moisture and shall be formed and assembled in a manner representative of industry practice.

17.3 With reference to the requirement in 17.2, enameled wire is not required to be additionally treated, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials should be provided with impregnation or otherwise treated.

18 Overcurrent Protection of Conductors and Heating Elements

18.1 Except as noted in 18.2 and 18.3, each insulated wire, including those in heater, motor, and control circuits, in a circuit drawing more than 40 A, shall be protected by an overcurrent protective device provided as a part of the unit. If the unit is intended for connection to more than one branch circuit, each section of the unit intended for connection to a different branch circuit is to be considered individually in applying the foregoing requirement. The rating of the overcurrent protective device shall be in accordance with Table 18.1.

Table 18.1
Maximum Overcurrent Protective Device Size

Conductor protected within the unit				Current rating of maximum overcurrent protective device, A
Copper		Aluminum		
AWG	(mm^2)	AWG	(mm^2)	
18 – 14	(0.83 – 2.1)	12	(3.3)	50
12	(3.3)	–	–	60
–	–	10	(5.3)	80
10	(5.3)	8	(8.4)	90
8	(8.4)	6	(13.3)	125
6	(13.3)	4	(21.2)	175
4	(21.2)	3	(26.7)	200

18.2 The requirement in 18.1 does not apply to a conductor that:

a) Is not longer than 10 feet (3.05 m);

b) Is completely within the enclosure of the unit;

c) Terminates at its load end in one or more overcurrent protective devices; and

d) Has an ampacity according to the 140 °F (60 °C) tables in the National Electrical Code (NEC), NFPA 70, and not less than 80 % of the combined ratings of the overcurrent protective devices supplied by the conductor.

18.3 No overcurrent protective device is required as a part of the unit if comparable protection will be obtained from the branch-circuit overcurrent protective device through which the unit will be supplied. For cord-connected units, the branch circuit size is determined by the blade configuration of the plug. For permanently-connected units, the branch circuit size shall be as recommended by the manufacturer. See 50.1(b).

18.4 The rating of the branch-circuit overcurrent protective device shall be 150 % of the rating of the unit unless the unit is marked to specify the use of a protective device having a lower rating. Standard ampere ratings for overcurrent protective devices are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, and 200. If 150 % of the rating of the unit does not equal one of the standard overcurrent-protective-device ratings mentioned above, then the next lower rating or setting of overcurrent protective device shall be used.

18.5 The overcurrent protection mentioned in 18.1 – 18.4 and 18.6 – 18.8 shall be of a type intended for branch-circuit protection. A fuse used for this purpose shall be a Class CC, G, H, J, K, R, or T cartridge fuse or a plug fuse.

18.6 A unit that uses resistance-type heating elements and is rated at more than 48 A shall have the heating elements subdivided. Each subdivided load shall not exceed 48 A and shall be protected at not more than 60 A.

18.7 Open coil or exposed sheathed-coil types of surface elements shall be protected by overcurrent protective devices at not more than 50 A.

18.8 The overcurrent protective devices required in 18.7 shall be provided as an integral part of the unit.

19 Motor-Running Overload Protection

19.1 The following units in which a 1-hp or smaller motor is used shall incorporate thermal or overload protection so that the motor shall not attain excessively high temperatures under any operating conditions:

a) A remotely or automatically controlled product.

b) A permanently connected, continuous-duty, manually started product.

An impedance-protected motor is not required to have additional thermal or overload protection.

19.2 A unit intended to be automatically or remotely controlled and using a motor rated at more than 1 hp shall incorporate thermal or overcurrent protection.

19.3 Fuses shall not be used in motor-overload-protective devices unless the motor is protected by the largest size fuse that can be inserted in the fuseholder.

20 Motor and Power-Transformer Short-Circuit and Ground-Fault Protection

20.1 A motor or power transformer in a unit rated more than 16 A shall be protected against short circuits and grounding by an overcurrent device having a maximum ampere rating in accordance with the National Electrical Code (NEC), NFPA 70. Such overcurrent protection shall be provided as a part of the unit unless it can be determined in accordance with 18.3 that equivalent overcurrent protection would be incorporated as the branch-circuit protective device.

20.2 The overcurrent protection mentioned in 20.1 shall be of a type indicated as being acceptable for branch-circuit protection.

21 General (Short-Circuit and Ground-Fault) Overcurrent Protection

21.1 Overcurrent protection at not more than 20 A shall be provided by means of a circuit breaker or fuse, as a part of a unit, for each general-use receptacle circuit and each lampholder circuit independent of a heating element, included in the unit, unless the unit is intended for connection to a branch circuit rated at 20 A or less.

21.2 The overcurrent protection mentioned in 21.1 shall be of a type acceptable for branch-circuit protection.

21.3 A fuseholder or circuit breaker provided as a part of a unit shall not be accessible without opening a door or cover. However, the operating handle of a circuit breaker, and a removable end cap of a fuseholder may project outside of the enclosure. A fuseholder shall be installed so that no uninsulated live parts other than the screw shell or clips of the fuseholder are exposed to contact by a person removing or replacing a fuse. If the fuseholder is intended to be accessible only to service personnel, uninsulated live parts other than the screw shell or clips may be exposed if they are guarded, or the fuseholder is located so that these live parts shall not be subjected to unintentional contact.

22 Thermal Cutoffs

22.1 When a unit is provided with a thermal cutoff, it shall be secured in place and shall be located so that it will be accessible for replacement without damaging other connections or internal wiring. See 49.11.

23 Lampholders

23.1 When a unit intended for permanent connection to the power supply, or a unit equipped with a polarized attachment plug, is intended to be connected to the identified (grounded) conductor of a power-supply circuit, a lampholder supplied as a part of the unit shall be wired so that the screw shell is connected to the identified conductor.

23.2 A lampholder shall be constructed and installed so that uninsulated live parts other than the screw shell will not be exposed to contact by persons removing or replacing lamps.

Exception: The requirement in 23.2 does not apply if, in order to remove or replace a lamp, it is necessary to dismantle the unit by means of tools.

23.3 A medium-base lampholder or screw-shell receptacle shall not be used as a holder for a heating element rated at more than 6 A or 660 W, except that a screw shell with a left-handed thread may be used with a heating element rated at not more than 10 A.

23.4 A screw-shell lampholder for an infrared lamp shall be of the unswitched, medium-base type and shall be used with a 300-W or smaller lamp.

Exception: A lamp-and-lampholder combination need not comply with the requirement in 23.4 when temperatures, determined acceptable, are recorded on the components in the normal-temperature test, and when the switching mechanism of a switched lampholder performs as intended without undue burning, pitting, or similar results.

23.5 A female screw shell used as a holder for a heating element shall be of copper or of a copper-base alloy and shall be plated with nickel or comparable oxidation-resistant metal.

24 Switches

24.1 A switch or other control device provided as part of a unit shall be of a type intended for the particular application and shall have a current and voltage rating not less than that of the circuit (load) that it controls.

24.2 A switch used on a unit shall be located or protected so that it will not be subjected to mechanical damage during use.

24.3 If the position of a switch conveys information related to the safe operation of the unit, the switch shall include a means to clearly indicate its position.

24.4 A switch or other device controlling one or more elements of a unit intended for permanent connection to the power supply shall be arranged so that the opening of the switch will disconnect all of the ungrounded conductors of the supply circuit, unless:

a) There will be no live parts exposed to unintentional contact when the switch is open; or

b) The fact that such parts are live is definitely apparent.

24.5 A switch or other means of control intended for the use of a limited number of elements at one time shall be located or of a type so that the user cannot change the connections to energize more elements than intended.

24.6 A switch controlling a lampholder shall be intended for use with tungsten-filament lamps.

24.7 A switch shall not be incorporated in a wooden handle or in other combustible material unless enclosed in metal or insulating material.

24.8 If a unit that is intended for connection to the supply circuit by means of flexible cord and an attachment plug uses a motor rated at more than 1/3 hp, a manually operated motor controller shall be provided in the unit.

25 Auxiliary Controls

25.1 A control circuit shall comply with the requirements in 12.4.1.1 – 12.4.2.2.

25.2 The operation of an auxiliary control device in a unit shall disconnect the element or elements that it controls from all ungrounded conductors of the supply circuit, unless:

a) There will be no live parts exposed to unintentional contact when the auxiliary control device is open; or

b) The fact that such parts are live is apparent.

25.3 An auxiliary control is considered to be one that is intended primarily for time, temperature, or pressure regulation under conditions of intended operation, and not for protection against overload or excessive temperature conditions resulting from abnormal operation.

25.4 A control device shall not be constructed to deliberately overload the branch-circuit protective device as a means of disconnecting the unit from the supply.

25.5 A contactor or similar device, such as a silicon controlled rectifier, required for use with a limit control shall be provided by the manufacturer of the unit.

25.6 The terminals of an auxiliary control within the enclosure of a unit shall be located or further enclosed so that they will be protected against unintentional short circuiting and damage.

26 Safety Controls and Interlock

26.1 Safety controls and interlocks shall be provided to reduce the risk of fire, electric shock, explosion, or casualty hazards that can be created by the use or maintenance of solvent distillation units.

26.2 Except as specifically noted, safety controls, components, systems, and interlocks shall be investigated and determined acceptable for 100,000 cycles of operation.

26.3 Solid state safety controls are to be subjected to a minimum 50 cycles of operation to demonstrate their reliability and proper interconnection within the unit.

26.4 Safety controls shall be provided which disconnect the heat source, and provide an audible and visual indication under conditions that may cause a hazard.

26.5 High and low liquid level switches, circuits, and controls in the distillation chamber that are required for the unit to comply with these requirements shall comply with 26.2.

26.6 Steam operated units shall include a pressure relief valve on the steam supply downstream of the reducing valve with a setting of not more than 10 psi (68.9 kPa) above the normal operating pressure. The relief valve shall be allowed to be omitted if the steam heating system is designed and investigated for a working pressure at least equal to the maximum main line pressure upstream of the reducing valve.

26.7 Solvent distillation units that discharge cleaned solvent or waste products into collection vessels shall be provided with safety controls or comparable construction features to automatically prevent the risk of collection vessels overflowing. See the Overflow Test, Section 46.

Exception: Batch type units with a maximum single load capacity of 15 gallons (56.8 L) may be exempt from this requirement if the installation or user's instructions comply with 50.1(f).

26.8 Interlocks that have been investigated and determined acceptable for 6,000 cycles of operation shall be provided to reduce the risk of the cover or access openings to the distillation chamber being opened:

a) When the unit is operating;

b) When the contents are in a heated condition exceeding 140 °F (60 °C); or

c) If there is a risk of fire, electric shock, or injury to persons by opening the cover or access opening.

An interlock shall also be provided to disconnect power to all electrical components and interrupt the source of heat when the cover or access opening is opened or unlatched.

Exception No. 1: Covers or other access openings that are not intended to be used during normal operation of the unit, and that require the use of tools to remove, need not be provided with interlock protection.

Exception No. 2: Visual indicators and appropriate instructions marked on the unit may be used to inform the user when it is acceptable to open the cover or other access opening.

27 Spacings

27.1 Line-voltage circuits

27.1.1 The spacings in a unit shall be in accordance with Table 27.1.

Exception: At closed-in points only, such as the screw-and-washer construction of an insulated terminal mounted in metal, a spacing of 3/64 inch (1.2 mm) is acceptable in a unit rated at 250 V or less. Within a thermostat, except at contacts, the spacings between uninsulated live parts on opposite sides of the contacts shall not be less than 1/32 inch (0.8 mm) through air and 3/64 inch over surface of insulating material. The unit shall be constructed so that the spacings will be maintained permanently.

Table 27.1
Minimum Spacings

Parts involved	Potential involved in volts	Through air		Over surface	
		inch	(mm)	inch	(mm)
Between live parts of opposite polarity and between a live part and a dead metal part, other than the enclosure, which may be grounded	0 – 250	1/4	(6.4)	3/8	(9.5)
	251 – 600	3/8	(9.5)	1/2[a]	(12.7[a])
Between a live part and the enclosure	0 – 600	1/2	(12.7)	1/2	(12.7)

NOTES

1 – These spacings do not apply to connecting straps or busses extending away from wiring terminals.

2 – Applies to the sum of the spacings involved where an isolated dead part is interposed.

[a] A spacing of not less than 3/8 inch (9.5 mm), 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.

27.1.2 An insulating liner or barrier of fiber or similar material used where spacings would otherwise not comply shall not be less than 1/32 inch (0.8 mm) thick and shall be located or constructed of a material so that it cannot be affected by arcing, except that 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 % of the spacing required for air alone.

Exception: An insulating material having a thickness less than that specified in 27.1.3 may be used when it has been determined equivalent in the appropriate properties.

27.1.3 Unless protected from mechanical abuse during assembly and intended functioning of a unit, a barrier of mica shall be 0.010 inch (0.25 mm) or thicker.

27.2 Low-voltage circuits

27.2.1 The spacings in a low-voltage limiting control shall comply with the requirements in 27.1.1 – 27.1.3 and Table 27.1. They shall also comply with the separation of circuits requirements in 12.4.1.1 – 12.4.1.5, where applicable.

27.2.2 The spacing between uninsulated live parts of opposite polarity and between those parts and dead metal that may be grounded in service is not specified for parts of circuits that are classified as low-voltage in 5.11. However, separation of circuits requirements in 12.4.1.1 – 12.4.1.5 shall be maintained where applicable.

27.3 Alternative spacing measurements

27.3.1 As an alternative approach to the spacing requirements in this section, creepage and clearance distances can be evaluated in accordance with UL 840, as described in 27.3.2.

27.3.2 In coating evaluations in accordance with UL 840, the following guidelines shall be used:

a) When encapsulation or a coating is intended to be used to achieve Pollution Degree 1, in addition to complying with the requirements in UL 840, the material shall also be resistant to the environment to which it is capable of being exposed.

b) A coating which complies with the requirements for conformal coatings in UL 746C shall be determined to comply with the requirements for coatings for printed wiring boards used to achieve Pollution Degree 1 in accordance with UL 840.

c) Evaluation of creepage and clearance distances shall be conducted in accordance with the requirements of UL 840.

d) Any printed wiring board which complies with UL 796 shall be determined to provide a Comparative Tracking Index (CTI) of 100; and when it further complies with the requirements for direct support in UL 796, it shall be determined to provide a CTI of 175.

28 Grounding

28.1 In a unit intended for permanent connection to the power supply by a metal-enclosed wiring system (such as rigid metal conduit or armored cable), all exposed dead metal parts and all dead metal parts inside the enclosure that are exposed to contact during any servicing operation – including maintenance and repair – and that are likely to become energized shall be conductively connected to the point at which the cable armor and conduit is attached to the unit.

28.2 An equipment-grounding terminal or lead shall be provided (see 10.1.2.13 and 10.1.2.14) in a unit intended for permanent connection to the power supply by means other than a metal-enclosed wiring system, such as nonmetallic-sheathed cable. Additionally, all exposed dead metal parts and all dead metal parts inside the enclosure that are exposed to contact during any servicing operation – including maintenance and repair – and that are likely to become energized shall be conductively connected to the equipment-grounding terminal or lead.

28.3 On a portable unit where grounding is required or provided, the power-supply cord or cord set shall include a grounding conductor that is:

a) Green with or without one or more yellow stripes;

b) Connected to the grounding blade of an attachment plug of a grounding type; and

c) Connected to the enclosure of the unit by means of a screw not likely to be removed during servicing, or by other similar means. Solder alone is not acceptable for making this connection.

28.4 If any accessible dead metal part of a unit is grounded, all accessible dead metal parts that are likely to become energized, including those exposed during any servicing operation – including maintenance and repair – shall be grounded.

28.5 A cord-connected unit constructed for operation on a circuit involving a potential of more than 150 V to ground shall have provision for grounding, in accordance with 28.3, of all exposed dead metal parts, and all dead metal parts exposed during any servicing operation – including maintenance and repair – that are likely to be energized.

28.6 A cord-connected, 2-wire unit intended to operate at a nominal potential of 240 V – and similarly any other potential within the 220 – 250 V range – requires provision for grounding in accordance with 28.3 unless the marked rating on the unit is 120/240 V or unless the unit is otherwise marked to indicate that it is to be connected only to a 120/240-V circuit with a grounded neutral.

29 Bonding for Grounding

29.1 All metallic and moving parts shall be bonded together and to the equipment grounding terminal.

29.2 A noncurrent-carrying metal part that is not likely to become energized, such as a nameplate, need not be bonded if an investigation shows one of the following:

a) After the part has been electrostatically charged, the accumulation is not sufficient to arc a grounded probe; or

b) There is insufficient flammable vapor available at the part.

29.3 Vessels which can be removed or disconnected from the solvent distillation unit during normal operation and usage shall be bonded using a bonding strap with a maximum resistance of 1 megohm. At least one strap shall be provided for each vessel, container, tank, or other device that is to be connected to, or used in the vicinity of, the solvent distillation unit. Straps shall be of uninsulated, flexible copper construction, minimum 14 AWG (2.1 mm^2), and shall be permanently connected to the solvent distillation unit at one end. The other end shall contain a battery clip or other similar device to connect to the collection container, tank, or device.

Exception No. 1: A separate bonding strap is not required for collection vessels that are already provided with a bonding means.

Exception No. 2: Bonding to a collection vessel is not required when:

a) The solvent or waste discharged to that vessel is discharged at a temperature below its flashpoint; and

b) The generation of a static charge sufficient to cause an ignition source is unlikely.

29.4 Means for permanently bonding a permanently-connected flow-through type solvent distillation unit to interconnected solvent utilization equipment shall be provided.

29.5 Casual contact between removable vessels, other devices, and the solvent distillation unit shall not be used in lieu of bonding.

29.6 A bonding method shall be provided for the collection vessel.

30 Pressure Vessels and Parts Subject to Pressure

30.1 Except as noted in 30.2, a pressure vessel having an inside diameter of more than 6 inches (152 mm) and subject to a pressure of more than 15 psi (103 kN/m^2) shall be certified by the National Board of Boiler and Pressure-Vessel Inspectors and marked in accordance with the appropriate boiler and pressure vessel code symbol ("H," "M," "S," or "U") of the American Society of Mechanical Engineers (ASME) for a working pressure not less than the pressure determined by applying 30.3.

30.2 If a pressure vessel, because of its application, is not covered under the inspection procedures of the ASME code, it shall be constructed so that it will comply with the requirements in 30.3.

30.3 Except as noted in 30.4 and 30.5, a part that is subject to air or vapor pressure, including the vapor pressure in a vessel containing only a superheated fluid, during normal or abnormal operation shall withstand without bursting or leaking a pressure equal to the highest of the following that is applicable:

a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the assembly, but not more than five times the marked maximum supply pressure from an external source and not more than five times the pressure setting of a pressure-relief device provided as part of the assembly.

b) Five times the marked maximum supply pressure from an external source, except as provided in (a).

c) Five times the pressure setting of a pressure-relief device provided as part of the assembly.

d) Five times the maximum pressure that can be developed by an air compressor that is part of the assembly, unless the pressure is limited by a pressure-relief device in accordance with item (a).

e) Five times the working pressure marked on the part.

30.4 A test need not be performed to determine whether a part complies with the requirement in 30.3 if study and analysis of the material and dimensions indicate that the part has the strength acceptable for the application – for example, copper or steel pipe of standard size provided with standard fittings might be considered to have the strength for the application.

30.5 A pressure vessel bearing the ASME code inspection symbol ("H," "M," "S," or "U") is considered to comply with the requirement in 30.3 if the vessel is marked with a value of working pressure not less than that to which it is subject during normal or abnormal operation.

30.6 If a test is necessary to determine whether a part complies with the requirement in 30.3, two samples of the part are to be subjected to a hydrostatic-strength test. Each sample is to be filled with water so as to exclude air and is to be connected to a hydraulic pump. The pressure is to be raised gradually to the specified test value and is to be held at that value for 1 minute. The results do not comply if either sample bursts or leaks, except as indicated in 30.7.

30.7 Leakage at a gasket during the hydrostatic-strength test is acceptable if it does not occur at a pressure 40 % or less of the required test value.

30.8 A means for relieving pressure shall be provided for all parts in which pressure might be generated in the event of fire.

30.9 Pressure-relief devices, see 30.15, fusible plugs, soldered joints, nonmetallic tubing, or other pressure-relief means may be used to comply with the requirements in 30.8.

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

30.11 A vessel having an inside diameter of more than 3.0 inches (76.2 mm) and subject to air or steam pressure generated or stored within the unit shall be protected by a pressure-relief device.

30.12 The start-to-discharge pressure setting of the pressure-relief device shall not be higher than the working pressure marked on the vessel. The discharge rate of the device shall be capable of relieving the pressure.

30.13 A pressure-relief device shall comply with all four of the following. It shall:

a) Be connected as close as possible to the pressure vessel or parts of the system that it is intended to protect.

b) Be installed so that it is readily accessible for inspection and repair and cannot be readily rendered inoperative.

c) Have its discharge opening located and directed so that the risk of scalding is reduced to a minimum.

d) Have its discharge opening located and directed so that operation of the device will not deposit moisture on bare live parts or on insulation or components affected by moisture.

30.14 A pressure-relief device having an adjustable setting shall be evaluated on the basis of its maximum setting unless the adjusting means is sealed at a lower setting.

30.15 A pressure-relief device is considered to be a pressure-actuated valve or rupture member constructed to relieve excessive pressures automatically.

31 Collection Vessels

31.1 If collection vessels are to be used with batch type solvent distillation units, but are not provided with the unit, the instruction manual shall describe the recommended type of vessel.

31.2 Vessels for collecting the decontaminated solvent and waste products shall be:

a) Constructed so that they can be installed, removed, and handled without spilling flammable or combustible liquids; and

b) Able to hold the contents of at least twice the volume of the distillation vessel.

32 Protection Against Injury to Persons

32.1 Materials used in the construction of the unit that reduce the risk of injury to persons shall be determined acceptable for the particular use. See 7.1 and 7.4.

32.2 All units, or any items furnished with the unit, shall have no sharp edges, burrs, points, or spikes inside or outside the unit, that may present a risk of injury to persons during use, including cleaning operations.

32.3 The temperature of a surface that is likely to be contacted by the user – other than a heating function surface and an adjacent surface known to be hot because of its proximity to a heating function surface – shall not be more than the value specified in Table 36.2 when measured in accordance with the applicable requirements in the Normal Temperature Test, Section 36.

Exception: Accessible surfaces, other than handles or knobs, may have temperatures that exceed those shown in Table 36.2 if marked in accordance with 49.16.

PERFORMANCE

33 General

33.1 Complete samples of solvent distillation units are to be subjected to the following tests. Unless noted otherwise, samples are to be installed and operated in accordance with the instruction manual. Any accessories, collection bags, or ancillary devices recommended for use with the unit shall be utilized as intended. The unit is to be connected to external sources of compressed air, steam, heated fluid, vacuum, cooling water, or other materials or supplies as recommended in the instruction manual.

33.2 Unless otherwise noted, samples are to be operated with the solvents recommended in the instruction manual. Solvents used during the following tests are to be selected to reflect the most stringent application of the test requirements.

33.3 A single model, or selected representative models may be tested to represent a series of similar units. Samples are to be selected to represent all of the construction and performance features provided in the series.

33.4 The manufacturer is to provide the solvents to be used for testing, and to retrieve or otherwise dispose of the solvents and hazardous wastes after the investigation is completed.

33.5 When the recommended ambient temperature by the manufacturer is at or below 104 °F (40 °C), then testing may be performed at 77 °F (25 °C). If the ambient temperature exceeds 40 °C, testing is also to be conducted at the maximum ambient temperature recommended by the manufacturer if it is determined that it may affect the results of the tests. The effect of the elevated ambient temperature on the LFL measurements, especially at the discharge tube and collection vessel is to be examined.

34 Power Input Test

34.1 The power input shall not be more than 105 % of its marked rating.

34.2 To determine whether a unit complies with the requirement in 34.1, the power input is to be measured with the unit at normal operating temperature under full-load conditions and while connected to a supply circuit adjusted to be the highest of the following:

a) The marked voltage rating; or

b) The highest voltage of the applicable range of voltages specified in 49.2 when the marked voltage is within one of the voltage ranges indicated in 49.2. When a unit uses a nonmetallic element, such as carbon, the power input is to be determined for a new element.

35 Leakage Current Test

35.1 The leakage current of a cord-connected unit rated for a nominal 120-, 208-, or 240-V supply when tested in accordance with 35.3 – 35.8 shall not be more than:

a) 0.5 mA for an ungrounded (2-wire) unit;

b) 0.5 mA for a grounded (3-wire) portable unit; and

c) 0.75 mA for a grounded (3-wire) unit intended to be fastened in place or located in a dedicated space and using a standard attachment plug rated 20 A or less.

Exception No. 1: During heat-up and cool-down, as defined in Table 1 of the Standard for Leakage Current for Appliances, UL 101, the leakage current of a unit using a sheath type heating element may exceed 0.5 mA or 0.75 mA, as applicable, but shall not exceed 2.5 mA during a period of 5 minutes beginning with the moment the leakage current exceeds 0.5 mA or 0.75 mA. At the end of the 5-minute period, the leakage current shall not be more than 0.5 mA or 0.75 mA, as applicable.

Exception No. 2: Equipment that is required to have primary circuit filtering to meet EMC (Electromagnetic Compatibility) regulations of the country in which it is intended for use may have leakage current at accessible parts of more than 0.5 mA. However, the leakage current shall not exceed 5.0 mA, and the equipment shall be provided with protective grounding in accordance with Grounding, Section 28.

35.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of a unit and ground or other exposed conductive surfaces of a unit.

35.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible and from one surface to another where simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure considered acceptable for protection against a risk of electric shock as defined in 7.1 – 7.15. Surfaces are considered to be simultaneously accessible when they can be contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltage levels that do not involve a risk of electric shock.

35.4 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 with an area of 4 by 8 inches (10 by 20 cm) in contact with surface. Where the surface is less than 4 by 8 inches, 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 unit.

35.5 A heated surface of insulating material is to be investigated concerning the leakage current available from the use of metal utensils.

35.6 The measurement circuit for leakage current is to be as shown in Figure 35.1. The ideal measurement instrument is defined in items (a) – (d). The meter which is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the ideal instrument. The meter used need not have all the attributes of the ideal instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 µF.

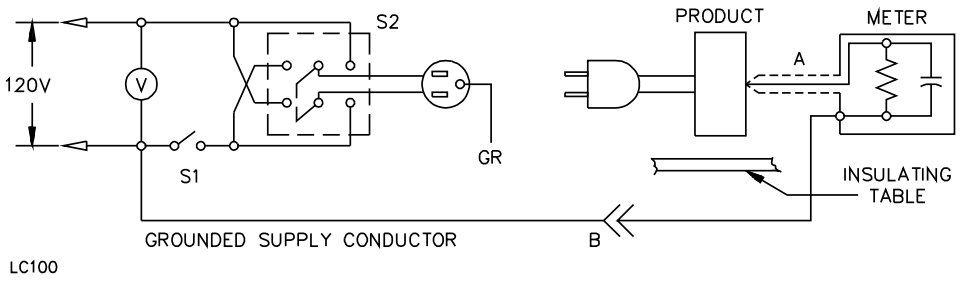
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kHz, 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 µF capacitor to 1500 ohms. At an indication of 0.5 or 0.75 mA, the measurement is to have an error of not more than 5 % at 60 Hz.

d) Unless the meter is being used to measure leakage from one part of a unit to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

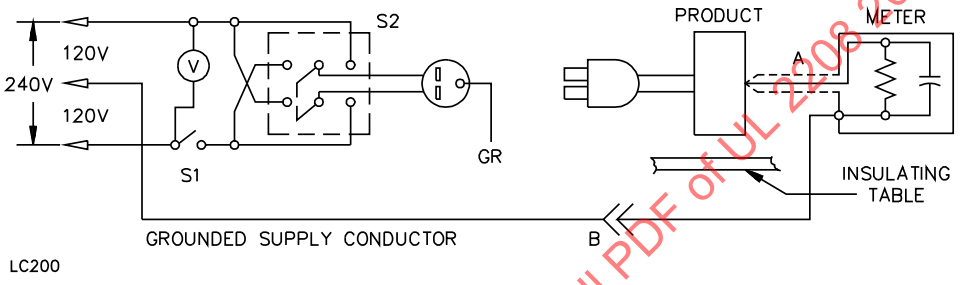
Figure 35.1

Leakage-Current Measurement Circuit



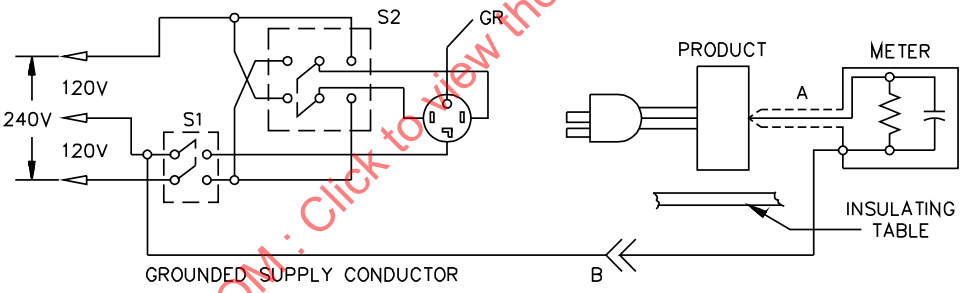
LC100

Unit intended for connection to a 120-V power supply.



LC200

2-wire unit intended for connection to a 30-wire, grounded neutral power supply, as illustrated above.



LC300

3-wire unit intended for connection to 3-wire, grounded neutral power supply, as illustrated above.

A – Probe with shielded lead.

B – Separated and used as clip when measured currents from one part of unit to another.

35.7 A sample of the unit is to be tested for leakage current starting with the as-received condition with all its switches and thermostats closed, but with its grounding conductor, if any, open at the attachment plug. The as-received condition is defined as being without prior energization, except as may occur as part of the production-line testing. The supply voltage is to be 120, 208, or 240 V depending on unit rating. The test sequence, with reference to the measuring circuit, Figure 35.1, is to be as follows:

a) With switch S1 open, the unit is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2.

b) Switch S1 is then to be closed, energizing the unit, and within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the unit operated at the maximum heat setting of controls.

c) Leakage current is to be monitored from the time the unit is energized until the unit reaches thermal stabilization. Both positions of switch S2 are to be used. The equivalent of thermal stabilization is considered to be obtained as in the normal temperature test. If any thermostat does not cycle at the maximum heat setting, it is to be adjusted until it does cycle before the final measurements are taken. Measurements are to be made with the thermostat, if any, open and closed. Upon evidence of stabilizing readings, intervals between measurements may be increased.

d) Monitoring of leakage current is to continue until the leakage current stabilizes or decreases after the unit is turned off.

35.8 A sample will be carried through the complete leakage-current test program as covered by 35.7, without interruption for other tests. However, with the concurrence of those concerned, the leakage-current tests may be interrupted for the purpose of conducting other nondestructive tests.

35.9 If intended for permanent connection to the power supply, a unit of the electrode type and a unit in which live parts of the heating element are in contact with the liquid shall not have a leakage current to ground in excess of 0.5 A with current flowing through the element or with one side of the line open as explained in 35.10.

35.10 To determine whether a unit complies with the requirement in 35.9, the unit is to be connected to a grounded supply circuit having full rated voltage between the ungrounded side of the line and ground. The case is to be mounted so that it will be insulated from ground, and the liquid is to be supplied by means of a rubber tube. The unit is to be filled as intended with a representative solvent. An ammeter is to be placed between the pipe connections on the heater and the water pipe or other ground, and leakage readings are to be observed under all conditions representing an open fuse or fuses. In the case of a heater constructed and marked for use with a solid (unfused) and grounded neutral, the grounded conductor need not be disconnected.

35.11 The greatest leakage current is usually noted with the maximum water temperature that, in the case of an instantaneous or faucet heater, may be obtained by reducing the flow of water to a minimum.

35.12 The leakage current of a cord-connected liquid-heating unit of the electrode type, or a unit in which live parts of the heating element are in contact with the liquid, shall be investigated with reference to the inherent leakage current occurring during conditions of normal and abnormal use.

36 Normal Temperature Test

36.1 A unit, when tested under the conditions described in 36.2 – 36.20, shall comply with all of the following conditions:

a) The unit shall not attain at any point a temperature that would constitute a risk of fire or damage to any materials used in the unit.

b) At any time during the test, temperature rises at specific points shall not be greater than indicated in Table 36.1.

c) The unit shall comply with the requirement in 7.1.

d) The unit shall comply with the requirements in 32.3 (see Table 36.2).

e) The maximum surface temperature that can be exposed to flammable or combustible liquids, or ignitable mixtures shall not be within 18 °F (10 °C) of the autoignition temperature of any of the solvents investigated for use with the unit.

Table 36.1
Maximum Temperature Rises

Materials and component parts	°F	(°C)
1. Any point within a terminal box or wiring compartment of a permanently connected unit in which field-installed conductors are to be connected (including such conductors themselves) unless the unit is marked in accordance with 49.12.	63	(35)
2. Any point on a surface adjacent to a unit that is:		
a) Permanently connected electrically or	117	(65)
b) Cord-connected and intended to be fastened in place or located in a dedicated space – including the surface on which the unit is mounted, and specified points on test surfaces and enclosures at designated clearances from the unit.	117	(65)
3. Fuses	117	(65)
4. Fiber used as electrical insulation or as cord bushings	117	(65)
5. Wood or other combustible material that is part of a unit	117	(65)
6. Cotton or rayon braid of flexible cord	117[a]	(65[a])
7. Class 105 insulation systems on winding relays or solenoids and the like:		
Thermocouple method	117	(65)
Resistance method	153	(85)
8. Class A insulation systems on coil winding of a-c motors having a frame diameter of more than 7 inches (178 mm) and of d-c and universal motors[b,c]:		
A. In open motors:		
Thermocouple method	117	(65)
Resistance method	135	(75)
B. In totally enclosed motors:		
Thermocouple method	126	(70)
Resistance method	144	(80)
9. Class A Insulation systems on coil windings of a-c motors (not including universal motors) having a frame diameter of 7 inches (178 mm) or less and on vibrator coils – thermocouple or resistance method[b,c]:		
A. In open motors and on vibrator coils	135	(75)
B. In totally enclosed motors	144	(80)
10. Class 130 insulation systems on winding of relays, solenoids and the like:		
Thermocouple method[b]	153	(85)
Resistance method	189	(105)
11. Class B insulation systems on coil windings of a-c motors having a frame diameter of more than 7 inches (178 mm) and of d-c and universal motors[b,c]:		

Table 36.1 Continued on Next Page

Table 36.1 Continued

Materials and component parts	°F	(°C)
A. In open motors:		
Thermocouple method	153	(85)
Resistance method	171	(95)
B. In totally enclosed motors:		
Thermocouple method	162	(90)
Resistance method	180	(100)
12. Class B insulation systems on coil windings of a-c motors (not including universal motors) having a frame diameter of 7 inches (178 mm) or less and on vibrator coils – thermocouple or resistance method[b,c]:		
A. In open motors and on vibrator coils	171	(95)
B. In totally enclosed motors	180	(100)
13. Phenolic composition used as electrical insulation or where deterioration would result in risk of fire, electric shock, or injury to persons[d]	225	(125)
14. Points on surface supporting a cord-connected heater	225	(125)
15. Unit plug	315	(175)
16. Insulated wire or cord	45 °F (25 °C) less than its temperature rating[e]	45 °F (25 °C) less than its temperature rating[e]
17. Sealing compound	See footnote f	(See footnote f)
18. Copper conductors, bare or insulated, without a nickel coating or other protection	225	(125)
19. Termination of copper conductor and pressure terminal connector without being nickel coated or otherwise protected	225	(125)

[a] Inside a unit, the braid of a heater cord may be subjected to a greater rise if the insulation is held in place by other appropriate means.

[b] See 36.9 and 36.10.

[c] The frame diameter is the diameter, measured in the plane of the lamination of the circle circumscribing the stator frame, excluding lugs, boxes and the like used solely for motor mounting, assembly, or connection.

[d] The limitation on phenolic composition does not apply to a compound that has been investigated and determined to have special heat-resistant properties.

[e] Inside a unit, the temperature rise on a wire or cord may be greater than the specified maximum rise, provided that the insulation on each individual conductor is protected by supplementary insulation (such as braid, wrap, tape, or close-fitting tubing) that is appropriate for the temperature and the type of insulation involved.

[f] Unless a thermosetting material, the maximum sealing compound temperature, when corrected to a 77 °F (25 °C) ambient temperature, is 59 °F (15 °C) less than the softening point of the compound as determined by ASTM E28.

Table 36.2
Maximum Surface Temperatures

Location	Composition of surface,[a]	
	Metal	Nonmetallic
Handles or knobs that are grasped for lifting, carrying or holding	122 °F (50 °C)	140 °F (60 °C)
Handles or knobs that are contacted but do not involve lifting, carrying, or holding; and other surfaces subject to contact and user maintenance	140 °F (60 °C)	185 °F (85 °C)
Surfaces others than a heating function surface and known to be hot due to proximity to the heating function surface	158 °F (70 °C)	203 °F (95 °C)

Table 36.2 Continued on Next Page

Table 36.2 Continued

Location	Composition of surface,[a]	
	Metal	Nonmetallic
NOTE – If the test is conducted at a room temperature of other than 77 °F (25 °C), the results are to be corrected to that temperature.		
[a] A handle, knob, or the like, made of a material other than metal, that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is considered to be, and is evaluated as, a nonmetallic part.		

36.2 All values in Table 36.1 are based on an assumed room ambient temperature of 77 °F (25 °C), but a test may be conducted at any ambient temperature within the range of 50 – 104 °F (10 – 40 °C). However, if the operation of an automatic thermal control during the test limits the temperatures under observation, no temperature higher than 77 °F (25 °C) plus the specified maximum rise is acceptable.

36.3 The unit is to be operated continuously to distill solvents. Operation is to continue until maximum temperatures are reached. For batch type units, this may require processing multiple batches until temperature equilibrium is reached.

36.4 If the unit is capable of operating without solvent, the unit is to be operated dry until maximum temperatures are obtained.

36.5 Adjustable temperature controls, if provided, are to be adjusted to their maximum settings. Units that utilize external cooling liquids are to be tested with the minimum flow rate and maximum fluid temperature specified in the instruction manual. Units that utilize remotely provided heat sources are to be tested under conditions that result in the highest possible temperatures, as specified in the instruction manual.

36.6 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2), except that a coil temperature may be determined by the change-of-resistance method if the coil is inaccessible for mounting thermocouples. When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to use thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument, and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

36.7 For tests that are to be continued until constant temperatures are attained, thermal equilibrium is to be considered to exist only if three successive readings indicate no change when taken at the conclusion of each of three consecutive equal intervals of time, the duration of each interval being whichever of the following is longer:

a) 5 minutes; or

b) 10 % of the total test time elapsed previous to the start of the first interval.

36.8 A thermocouple junction and adjacent thermocouple lead wire are to be held securely in good thermal contact with the surface of the material whose temperature is being measured. In most cases, good thermal contact results from secure taping or cementing of the thermocouple in place. When a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

36.9 The temperature of a coil or winding is to be measured by means of thermocouples mounted on the outside of the coil wrap. If the coil is inaccessible for mounting thermocouples, for example, a coil immersed in sealing compound, or if the coil wrap includes thermal insulation, or more than 1/32 inch (0.8 mm) of cotton, paper, rayon, or similar insulation, the change-of-resistance method is to be used. For the thermocouple-measured temperature of a coil of an alternating-current motor, other than a universal

motor having a frame diameter of 7 inches (178 mm) or less (items 9 and 12 in Table 36.1), the thermocouple is to be mounted on the integrally applied insulation of the conductor.

36.10 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 means of a thermocouple may exceed the maximum temperature specified in Table 36.1 by the amount specified in Table 36.3. However, the temperature rise measured by the change-of-resistance method shall not exceed the values indicated in Table 36.1.

Table 36.3
Additional Thermocouple Rise

Item in Table 36.1	Temperature rise °F	(°C)
Item 7 and part A of item 8	27	(15)
part A of item 9	9	(5)
part A of item 11	36	(20)
part A of item 12	18	(10)

36.11 If the coil wrap does not exceed its temperature limitation by radiation from an external source, the temperature of the coil may be measured by means of a thermocouple on the integral insulation of the coil conductors.

36.12 To determine whether a unit complies with the requirements in 36.1, the unit is to be operated continuously until constant temperatures have been reached. The test voltage is to be the highest of the following:

a) The marked voltage rating; or

b) The highest voltage of the applicable range of voltages specified in 49.2 if the marked voltage is within one of the voltage ranges indicated in 49.2.

36.13 If a unit uses a motor in addition to a heating element, the voltage applied to an integrally connected motor is to be the test voltage specified in 36.12. A motor supplied from a separate circuit is to be connected to a test voltage derived from its marked rated voltage in accordance with 36.12.

36.14 In conducting a test to determine whether a unit complies with the temperature requirements, it is to be mounted or supported as in service and tested under conditions approximating those of normal operation, except as otherwise noted. Temperatures are to be observed on nearby surfaces, on the supporting surface, at points of support, on attachment plugs, and at other points determined to be necessary, including building wiring that may be located adjacent to or behind a permanently installed unit.

36.15 A unit intended to be permanently connected to the power supply or a unit that is cord-connected and that is intended to be fastened in place or located in a dedicated space is to be supported in the intended manner on black-painted wood not less than 3/8 inch (9.5 mm) thick. The unit is to be located in a corner – vertical walls meeting at a right angle – formed by two black-painted, vertical sheets of 3/8 inch plywood having such width and height that they extend not less than 2 feet (610 mm) beyond the physical limits of the unit. The unit is to be located as close to both walls of the corner as its construction permits. It is to be placed relative to the walls so that maximum heating of the walls will occur, except that it may be spaced away from the walls to limit the wall temperatures from rising more than 117 °F (65 °C) if the unit is marked as described in 49.17.

36.16 A cord-connected unit is to be supported on two layers of white tissue paper on a softwood surface.

36.17 An automatic temperature-regulating or -limiting control or other protective device is to be shunted out of the circuit, unless the control has been shown to be rugged, reliable in accordance with the endurance requirements in Table 43.1, and unlikely to be defeated by the user. The control is considered not likely to be defeated when tools are required to gain access to the control, or a positive stop is incorporated in the control.

36.18 If the unit is constructed so that heating of a liquid is a determining factor in the temperature attained, the intended duty of a unit is to be taken into consideration. However, normal operating conditions cannot be obtained when certain types of units are operated continuously and in a dry condition. Accordingly, in determining whether a unit complies with the requirements in 36.1, actual service conditions or an approximation are to be used. Unless otherwise specifically indicated:

a) When the unit is controlled by an adjustable thermostat, the thermostat is to be set to give maximum temperatures; and

b) When the unit is controlled by a nonadjustable thermostat, it is to operate at whatever temperature the thermostat permits.

In each case, operation is to be continued until temperatures are stabilized.

36.19 External thermal insulation, such as woven glass fiber or mineral wool, is to be removed before a unit is installed in the test enclosure unless the material is bonded or permanently attached to the unit. Rubber or other material similarly subject to deterioration is to be removed from feet or other supports if the removal of the material is likely to result in higher temperatures on the unit.

36.20 Wherever cheesecloth is mentioned in connection with either a temperature test or an abnormal test, the cloth is to be bleached cheesecloth running 14 – 15 yd/lb (approximately 28 – 30 m/kg) having what is known to the trade as a "count of 32 x 28" – for any square inch, 32 threads in one direction and 28 threads in the other direction (for the square centimeter, 13 threads in one direction and 11 threads in the other direction).

37 Test of Insulation Resistance and Leakage Current as a Result of Moisture

37.1 If a unit uses insulation material that is not resistant to moisture under conditions of intended use, the unit shall be conditioned for 48 hours in moist air having a relative humidity of 88 ±2 % at a temperature of 89.6 ±3.6 °F (32.0 ±2.0 °C). After the conditioning:

a) A cord-connected unit rated for a nominal 120-, 208-, or 240-V supply shall comply with the requirement in 35.1 in a repeat leakage-current test, except that the test shall be discontinued when leakage current stabilizes.

b) A unit, other than mentioned in (a), shall have an insulation resistance of not less than 50,000 ohms between live parts and interconnected dead metal parts.

37.2 The insulation resistance is to be measured by:

a) A magneto megohmmeter that has an open circuit output of 500 V;

b) A voltmeter having an internal resistance of at least 30,000 ohms and using a 250-V dc circuit; or

c) Comparable equipment.

38 Dielectric Voltage-Withstand Test

38.1 A unit shall be capable of withstanding for 1 minute without breakdown a 60 Hz essentially sinusoidal potential applied between primary live parts and dead metal parts, and between primary live parts and isolated secondary circuits, with the unit at its maximum normal operating temperature. The test potential (rms) is to be 1000 V plus twice the rated voltage.

38.2 To determine whether a unit complies with the requirement in 38.1, the unit is to be tested by means of a 500 VA or larger-capacity testing transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased gradually from zero until the required test value is reached, and held at that value for 1 minute. The increase in the applied potential is to be at a uniform rate and as rapid as consistent with its value being correctly indicated by the voltmeter.

38.3 An immersion-type heater in which the electrodes make contact with a liquid shall be capable of withstanding successfully, for a period of 1 minute, the application of a potential of 150 % of the maximum rated voltage of the unit across the supply connections, under any condition of intended operation of the unit.

39 Vapor Concentration Measurement Test

39.1 This test determines compliance with the applicable requirements referenced in Construction, General, Section 6. Vapor concentration measurements are to be made under any foreseeable conditions, including those in 39.2 – 39.6. Consideration is to be given to the effect of the ambient temperature on the solvent.

39.2 Solvent distillation units are to be operated as intended using one or more solvents recommended in the instruction manual. The solvents used are to be selected based on their propensity for producing an ignitable atmosphere during this test.

39.3 Measurements of ignitable vapors are to be made during the introduction of solvent to the solvent distillation unit by pouring, inserting a container, processing, removal of waste, and maintenance operations as described in the instruction manual. The unit is to be operated in a draft free room with no forced ventilation or air circulation. The unit is not to be powered while taking measurements during filling, removal of waste, and maintenance operations.

39.4 Ignitable vapor levels are to be measured using a calibrated meter that is recommended for use in detecting the vapors produced. The meter is to be sufficiently sensitive to measure concentrations as low as 10 % of the lower flammability limit.

39.5 Vapor concentration measurements are to be made:

a) At all electrical connections, components, and possible sources of ignition on or in the unit;

b) Within 3 inches (76.2 mm) from any inlet or outlet connection for solvent or residue;

c) Within 3 inches from any vent that is not intended to vent outdoors; and

d) At the distance around the unit specified by the manufacturer regarding potential external sources of ignition in accordance with 49.2(e).

39.6 Measurements of vapor concentration are also to be made under single fault conditions. Common examples of fault conditions are:

a) Improper setting or failure of a regulating control;