UL 1963

STANDARD FOR SAFETY

Refrigerant Recovery/Recycling Equipment

UL Standard for Safety for Refrigerant Recovery/Recycling Equipment, UL 1963

Fourth Edition, Dated June 1, 2011

Summary of Topics

This revision of ANSI/UL 1963 dated January 15, 2025 includes the replacement of a referenced standard which was withdrawn: 51.1.1

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated November 22, 2024.

No Text on This Page

JUNE 1, 2011
(Title Page Reprinted: January 15, 2025)

UL 1963

Standard for Refrigerant Recovery/Recycling Equipment

First Edition – October, 1989
Second Edition – October, 1995
Third Edition – September, 2005

Fourth Edition

June 1, 2011

This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through January 15, 2025.

The most recent designation of ANSI/UL 1963 as an American National Standard (ANSI) occurred on January 15, 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.

Our Standards for Safety are copyrighted by ULSE Inc. Neither a printed nor electronic copy of a Standard should be altered in any way. All of our Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of ULSE Inc.

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

ELECTRICAL COMPONENTS

SPACINGS

REFRIGERANT SYSTEM

PERFORMANCE

APPENDIX B – Operating and Protective ("Safety Critical") Control Functions (Normative)

No Text on This Page

INTRODUCTION

1 Scope

1.1 These requirements cover refrigerant recovery and recycling equipment to be employed in accordance with the National Electrical Code, NFPA 70 and include battery operated equipment.

1.2 These requirements apply to equipment intended for indoor or outdoor use or both.

1.3 These requirements do not cover equipment rated more than 600 volts or employing a universal motor rated more than 250 volts or intended for installation and use in a hazardous (classified) location.

1.3.1 These requirements cover recovery/recycling equipment intended for use with a flammable refrigerant when investigated to the requirements in Supplement SB.

1.4 Refrigerant recovery/recycling equipment intended for use with commercial refrigerant systems, other than automotive, is judged on the basis of compliance with the requirements in this standard, insofar as they are applicable, and further examination and test to determine whether the equipment is acceptable for the purpose.

2 General

2.1 Units of measurements

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

2.1.2 Unless indicated otherwise, all voltage and current values mentioned in this standard are rms.

2.2 References

2.2.1 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.

2.3 Terminology

2.3.1 The term “equipment” as used in these requirements refers to all refrigerant recovery/recycling and recovery (extraction) equipment or any part thereof covered by these requirements unless specifically noted otherwise.

3 Glossary

3.1 For the purpose of these requirements, the following definitions apply.

3.2 ACCESSORY – An optional electrical device or other component intended for installation in or connection to the equipment for the purpose of modifying or supplementing its functions. The accessory may be factory installed or intended for installation by the user or service personnel.

3.2.1 ADJUSTABLE SPEED DRIVE – A combination of power converter, inverter, motor, and motor-mounted auxiliary devices such as encoders, tachometers, thermal switches and detectors, air blowers, heaters, and vibration sensors.

3.2.2 ADJUSTABLE SPEED DRIVE SYSTEM – An interconnected combination of equipment that provides a means of adjusting the speed of a mechanical load coupled to a motor. A drive system typically consists of an adjustable speed drive and auxiliary electrical apparatus.

3.3 BARRIER, INSULATING – A partition for the isolation of high-voltage electrical components or circuits.

3.4 BARRIER, MECHANICAL – A rigid partition for the isolation of ignition sources, moving parts or protection of wiring.

3.5 CABINET – The part of the product that provides physical protection to insulated wiring, enclosures, moving parts, motors, enclosed electrical parts, refrigeration tubing or other parts that may cause a risk of injury to persons.

3.5.1 CAPACITOR, CLASS Y – Capacitor or resistor-capacitor unit of a type suitable for use in situations where failure of the capacitor could lead to danger of electric shock. (Examples would include capacitors connected across the primary and secondary circuits where electrical isolation is required to prevent an electric shock or between hazardous live parts and accessible parts.)

3.6 CAPILLARY TUBE – Device made of tubing with an outer diameter of less than 3/16 in. (4.7 mm) and used to reduce the pressure of the refrigerant between the condenser and evaporator. It also regulates the refrigerant flow.

3.7 CIRCUITS, ELECTRICAL –

a) Extra-Low-Voltage – A circuit supplied by:

1) An AC potential of not more than 42.2 volts peak (30 V rms) and power of 100 VA or less; or

2) A DC potential of 30 V supplied by a primary battery; or

3) A Class 2 transformer, as defined by the National Electrical Code, NFPA 70; or

4) A combination of an isolating transformer and fixed impedance which as a unit complies with all performance requirements for a Class 2 transformer.

b) High-Voltage – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of an extra low-voltage circuit.

3.8 COMPONENT – A device or fabricated part of the recovery/recycling equipment covered by the scope of a safety standard dedicated to that purpose. If incorporated in recovery/recycling equipment, a product that is otherwise typically field installed (e.g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as aluminum or copper, are not considered components. Generally, components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under specific, limited conditions, such as certain temperatures not exceeding specified limits.

3.9 COMPRESSOR – A refrigerant motor-compressor with the suction side (low side) intended to be connected to a system from which the refrigerant is being removed. The discharge side is connected to the refrigerant recovery tank.

3.10 CONTROL CIRCUIT – A circuit that carries electric signals directing the performance of a controller that in turn, governs power delivered to a motor or other load in the equipment. A control circuit does not carry main power current.

3.11 CONTROL CIRCUIT, DIRECT-CONNECTED HIGH-VOLTAGE – A circuit that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the equipment. It is not tapped from the load side of the overcurrent device(s) of the controlled circuit(s) within the equipment.

3.12 CONTROL CIRCUIT, TAPPED HIGH-VOLTAGE – A circuit that is tapped within the equipment from the load side of the overcurrent device for the controlled load.

3.12.1 CONTROL FUNCTION (CLASS A, B or C) – Actuation of an electrical or electronic device (or devices) that are part of the refrigerant recovery/recycling equipment. Software may be used in the actuation of the device(s). Class A is not intended to be relied upon to reduce the risk of electric shock, fire or injury to persons. Class B is intended to reduce the risk of electric shock, fire or injury to persons. Class C is intended to further reduce the risks involving special hazards, such as explosion. A device with Class A actuation is considered to be an operating control, whereas a device with Class B or Class C actuation is considered to be a protective control.

3.13 CONTROL, OPERATING – A device or assembly of devices, the operation of which starts or regulates the end product during normal operation. For example, a thermostat, the failure of which a thermal cutout/limiter or another layer of protection would mitigate the potential hazard, is considered an operating control. Operating controls are also referred to as “regulating controls”. Operating controls can also include other controlling devices such as switches, contactors, relays and similar devices. Appendix B specifies control functions that are not considered to result in a risk of fire, electric shock or injury to persons.

3.14 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of electric shock, fire or injury to persons during normal and reasonably anticipated abnormal operation of the product. For example, a thermal cutout/limiter, or any other control/circuit relied upon for normal and abnormal conditions, is considered a protective control. Protective controls are also referred to as “limiting controls” or “safety controls” and are investigated under normal and single-fault conditions. Appendix B specifies control functions that are considered to result in a risk of fire, electric shock or injury to persons. Such functions may also be known as “safety critical”.

3.15 CONTROL, TEMPERATURE-LIMITING – A control that serves to prevent excessive temperature.

3.16 DESIGN PRESSURE – The maximum acceptable working pressure for which the equipment or a specific part is designed.

3.16.1 ELECTRONIC COMPONENT – A part in which electrical conduction is achieved principally by electrons moving through a vacuum, gas or semiconductor. A Metal Oxide Varistor (MOV) is considered to be an electronic component, but neon indicators are not.

3.16.2 ELECTRONIC DISCONNECTION – The de-energizing of a load within a product by an electronic device of a circuit. No electro-mechanical component having an air gap, such as a switch, contactor or relay is used to de-energize the load.

3.17 ENCLOSURE – The part of the product that does one or more of the following:

a) Isolates ignition sources;

b) Renders inaccessible all or any parts of the equipment that may otherwise present a risk of electric shock; or

c) Retards propagation of flame initiated by electrical disturbances within.

3.18 FUNCTIONAL PART – A part of the product, other than an enclosure or cabinet, used to maintain the intended relative physical position of fixed or moving parts, or maintain the integrity of the structure.

3.18.0 GROUNDING, FUNCTIONAL – Grounding of a point in a product which is necessary for a purpose other than safety.

3.18.1 HOSE ASSEMBLY – A segment of flexible, usually nonmetallic, tubing and having a threaded fitting at each end for the purpose of connecting two components of a refrigeration system.

3.19 IGNITION SOURCE – Any high-voltage electrical component not located within an enclosure.

3.19.1 MAXIMUM OPERATING CURRENT (MOC) – The current resulting when an electric motor and adjustable speed drive or drive system are operated under any conditions such as maximum speed/maximum load, maximum speed/minimum load, minimum speed/minimum load, minimum speed/maximum load, including locked-rotor such that current to the motor/adjustable speed drive or drive system is at a maximum.

3.19.2 MAXIMUM RATED CURRENT (MRC) – The current resulting when a hermetic refrigerant motor-compressor and adjustable speed drive or drive system are operated under any conditions such as maximum speed/maximum load, maximum speed/minimum load, minimum speed/minimum load, minimum speed/maximum load, including locked-rotor such that current to the motor-compressor/adjustable speed drive or drive system is at a maximum.

3.20 MOTOR CONTROLLER – Any switch or device normally used to start and stop a motor by making and breaking the motor current directly.

3.21 NONFUNCTIONAL PART – A part of the product that does not perform a specific function.

3.22 NONFUNCTIONAL PART, SMALL – A nonfunctional part that does not occupy a volume greater than 0.12 in^3 (2 cm^3), does not have a dimension greater than 1.2 in (3 cm), is located so it cannot propagate flame from one area to another, and does not connect a possible source of ignition to other ignitable parts.

3.23 PIPING – Includes pipe, flanges, bolting, gaskets, valves, fittings, the pressure-containing parts of other components, such as strainers and devices that serve such purposes as mixing, separating, muffling, snubbing, distributing, metering, or controlling flow.

3.24 PRESSURE-LIMITING DEVICE – A pressure-responsive mechanism designed to automatically stop the operation of the pressure-imposing element at a predetermined pressure.

3.25 PRESSURE-RELIEF DEVICE – A pressure-actuated valve or rupture member designed to relieve excessive pressure automatically. The device is not temperature-actuated.

3.26 PRESSURE VESSEL – Any refrigerant-containing receptacle of a system other than evaporators [each separate section of which does not exceed 1/2 ft^3 (0.014 m^3) of refrigerant containing volume], evaporator coils, compressors, condenser coils, controls, headers, pumps, piping, filters and strainers.

Exception: A refrigerant-containing receptacle identified as an ASME pressure vessel in accordance with ASME Boiler and Pressure Vessel Code, Section VIII.

3.26.1 PROTECTIVE ELECTRONIC CIRCUIT (PEC) – An electronic circuit that prevents a risk of fire, electric shock or injury to persons under abnormal operating conditions.

3.27 RECOVERY EQUIPMENT – An appliance that transfers refrigerant in any condition from a product to an external container without necessarily testing or processing the refrigerant.

3.28 RECYCLING EQUIPMENT – An appliance that extracts refrigerant from a product and cleans the refrigerant for reuse.

3.28.1 SOFTWARE – Pre-loaded data which creates, affects, and/or modifies the functionality of the equipment except that this does not include any pre-loaded data programmed into an integrated circuit chip that requires physical access and removal of the chip for reprogramming.

3.28.2 SOFTWARE UPDATE – Occurs if a version of data (software) replaces or modifies the previous version of data. This could include replacing or re-installing a version of data with an identical version of data.

3.28.3 SWITCH MODE POWER SUPPLY UNIT – Electronic device incorporating transformer(s) and electronic circuitry(ies), that converts electrical power into single or multiple power outputs by rapidly switching a solid-state device on and off. It may also isolate the input circuit from the output circuit and regulate and/or convert the output voltage and current. The device may consist of one or more individual units with identical or different waveforms and frequencies including dc output.

3.28.4 THERMISTOR – A thermally sensitive semiconductor resistor, which shows over at least part of its resistance/temperature characteristic a significant non-linear change in its electrical resistance with a change in temperature. A thermistor may be either of the positive temperature coefficient (PTC) type or of the negative temperature coefficient (NTC) type.

3.29 ULTIMATE STRENGTH – The highest stress level that the refrigerant component or vessel can tolerate without rupture.

3.30 VOLTAGE FOLDBACK – A circuit design feature intended to protect the power supply output transistors. When overcurrent is drawn by the load, the supply reduces the output voltage and current to within the safe power dissipation limit of the output transistors.

CONSTRUCTION

4 General

4.1 Ferrous metal parts used to support or retain electrical components in position shall be protected against corrosion by metallic or nonmetallic coatings, such as plating or painting.

Exception: This requirement does not apply to parts, such as washers, screws, bolts, and similar parts, where corrosion of such unprotected parts would not affect compliance with the requirements of this standard.

4.2 Exposed unimpregnated asbestos material shall not be used. The unprotected edge of a gasket sandwiched between two parts is considered to be exposed.

4.3 Electrical insulating materials and systems used inside a hermetically sealed motor-compressor enclosure shall be compatible with the refrigerants and oils intended to be used in accordance with the Standard for Safety of Household and Similar Electrical Appliances, Part 1, General Requirements, UL 60335-1, together with the Standard for Household and Similar Electrical Appliances, Part 2: Particular Requirements for Motor-Compressors, UL 60335-2-34. They shall also be compatible with each other and with other materials used within the system.

4.4 Movable equipment employing carrying handles or straps shall be permanently marked according to 91.30.

4.5 All nonmetallic parts, excluding small nonfunctional parts shall comply with 5.1, 5.2, 5.3, and Table 52.1.

4.6 In addition to the requirement in 4.5, nonmetallic materials that serve as electrical insulation or that directly support live parts shall comply with the requirements for electrical insulation in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

4.7 A component shall:

a) Comply with the safety standard covering that component;

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;

d) Comply with the applicable requirements of this end product standard; and

e) Not contain mercury.

Exception: A component of a product covered by this standard is not required to comply with a specific component requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product; or

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

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

4.8 A component that is also required to perform other necessary 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) covering products that provide those functions.

4.9 A component made of drawn or machined brass and containing more than 15 percent zinc shall comply with the 10-Day Moist Ammonia Air Stress Cracking Test as specified in the Standard for Refrigerant-Containing Components and Accessories, Nonelectrical, UL 207.

5 Nonmetallic Material

5.1 Classification

5.1.1 Materials shall be classified with respect to flammability characteristics that are established by the tests specified in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

5.1.2 Materials shall be assigned flammability ratings based on greatest to least resistance to flame and are identified as: 5VA, 5VB, V-0, V-1, V-2, HF-1, HF-2, HB, and HBF.

5.1.3 In reference to 5.1.2, the assigned flammability rating shall be appropriate for the material-use application in accordance with 5.2 and Table 52.1.

5.2 Ignition sources

5.2.1 Parts formed from nonmetallic materials rated HB or HBF and positioned as shown in Figure 5.1 shall be separated from ignition sources by means of a mechanical barrier, extending at least to the boundary surface of the space if such parts are located:

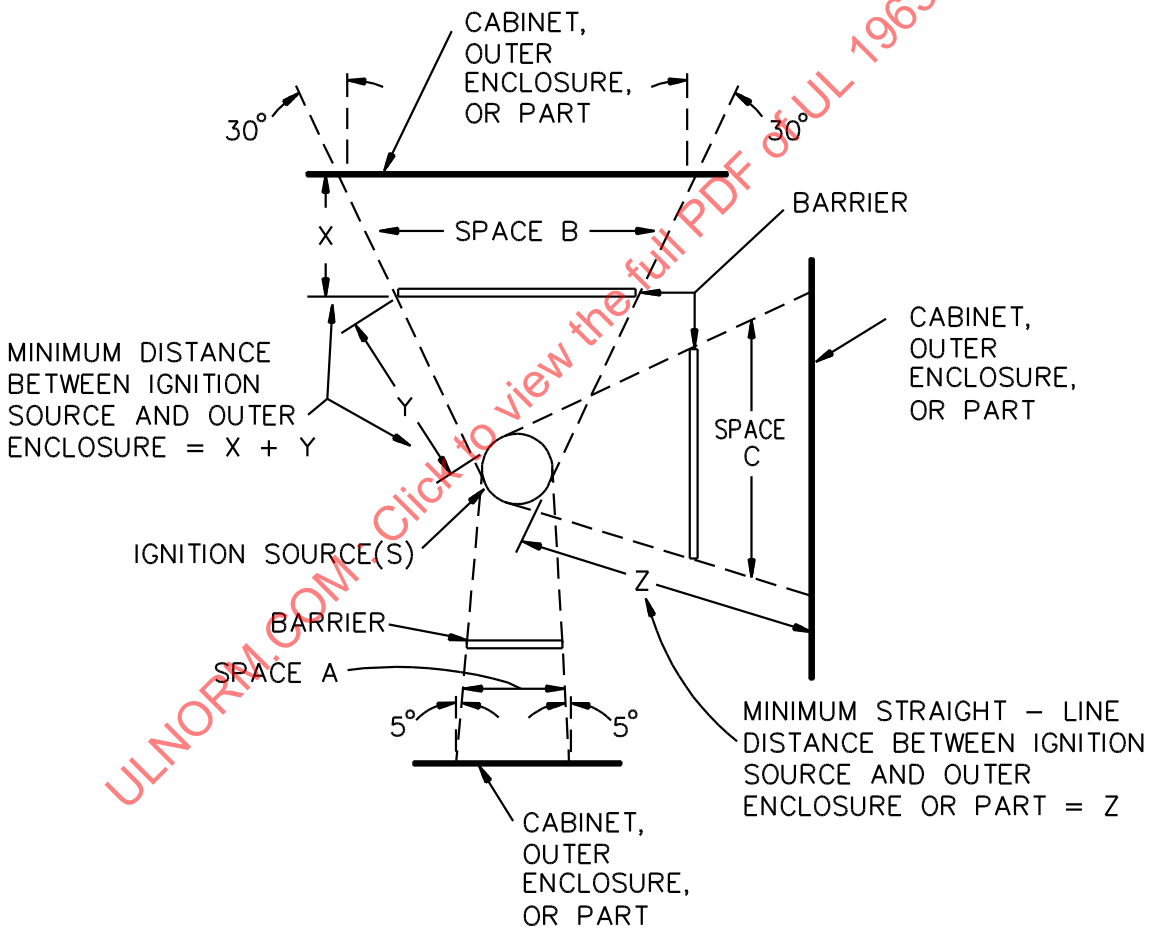
a) Below an ignition source and within Space A; and

b) Above an ignition source and within Space B; and

c) In the vertical plane relative to an ignition source and within Space C.

Figure 5.1

Separation of Ignition Sources from Nonmetallic Materials



Notes:

Space A – Represents the volume below the ignition source determined by a straight line that moves about the ignition source while remaining at the angle of 5 degrees from the vertical and is always so oriented that the volume is maximum.

Space B – Represents the volume above the ignition source determined in the same manner as Space A, except that the angle is 30 degrees from the vertical.

5.2.2 The HB or HBF materials referenced by 5.2.1 shall be located such that the distance between:

a) High-voltage wiring not employing VW-1 and the HB or HBF materials shall be a minimum of 2 in (51 mm), and

b) Any other ignition source and the HB or HBF materials shall be a minimum of 4 in (102 mm).

5.2.3 In reference to 5.2.2 and Figure 5.1, the minimum distance for materials located:

a) Above the ignition source shall be as shown in Distance X + Y; and

b) In the vertical plane relative to the ignition source shall be as shown in straight-line Distance Z.

5.3 Application and location

5.3.1 Nonmetallic fasteners used as a part of the enclosure, cabinet or functional part shall comply with the Fastener Strength Test,52.3.

5.3.1.1 In reference to 5.3.1, nonmetallic fasteners required to comply with 52.3 shall include:

a) Nonmetallic ultrasonic, solvent or heat welds;

b) Nonmetallic screws and/or nuts; and

c) Nonmetallic parts into which metal or nonmetallic screws will be threaded.

5.3.2 The combined total exposed surface area of all small, nonfunctional parts shall not exceed 144 in^2 (929 cm^2).

5.3.3 When thermal insulation is located between a cabinet and inner liner, the product shall comply with both (a) and (b) or it can comply only with item (c):

a) All holes within the cabinet and inner liner shall be closed;

b) The cabinet surfaces shall be securely fastened such that the maximum spacing between screws, spot welds, or other securement means does not exceed 6 in (152.4 mm);

c) The thermal insulation shall be rated HF-1.

6 Assembly

6.1 General

6.1.1 Refrigerant recovery and/or recycling equipment shall be provided with the necessary hoses for connection in the intended manner to the equipment being serviced. These hoses shall be no longer than 8 ft (2.44 m), shall be provided with shut-off devices within 12 in (0.3 m) of the ends, and shall be constructed in accordance with Section 46.

6.1.2 The shut-off devices mentioned in 6.1.1 shall prevent refrigerant flow when the hose is not connected.

6.1.3 The equipment shall be assembled so that removal and replacement of tanks and containers, and the like, will not result in damage to electrical components and wiring, or to refrigerant-containing components.

6.1.4 Equipment having provision for the storage of refrigerant cylinders or the like shall be provided with means for retaining the cylinders in position.

6.1.5 Electrical components shall be installed on the unit and wired as necessary for intended operation.

6.1.6 Pressure-limiting devices, when required, shall be installed on the assembly and connected to the high side of the system.

6.1.7 Except as specified in 6.1.8, refrigerant-containing parts shall be factory connected with tubing or piping.

6.1.8 In reference to 6.1.7 refrigerant-containing parts not factory connected with tubing or piping shall be:

a) Intended for installation in the field;

b) Intended for connection to the refrigeration system being serviced;

c) Be packaged with the recovery/recycling equipment; and

d) Comply with the requirements in this standard.

6.1.9 In reference to 6.1.7, if flexibility is needed, a hose assembly used within recovery/recycling equipment in place of metal tubing or piping shall comply with 46.2.1. In addition, the hose assembly shall not:

a) Exceed 36 in. (0.91 m) in length; and

b) Be connected to another hose assembly located within the recovery/recycling equipment.

6.2 Mechanical protection

6.2.1 Horizontally-hinged doors that provide access to the storage compartments that may cause injury to persons upon unintentional closing shall be counterweighted, spring loaded, or provided with an automatic latch to retain them in the open position. Action members, such as springs and latches that may cause injury to persons due to pinching or the like, shall be enclosed or guarded.

6.2.2 A slideout component, such as a drawer or shelf, shall be restrained to prevent it from being unintentionally pulled free of its supporting means. Compliance shall be determined in accordance with the Component Restraint Test, Section 82.

6.2.3 With the equipment installed in its intended manner as specified in the Installation and Operating Instructions, Section 94, openings in the equipment shall be constructed or located to reduce the risk of injury to persons due to unintentional contact with:

a) Moving parts, such as fan blades, blower wheels, gears, and belts, and

b) Surfaces that exceed the temperatures permitted by subitems 2 and 3 of item D of Table 57.1.

6.2.3.1 Except as specified in 6.2.3.2, in evaluating openings, parts of the cabinet or enclosure, such as covers, panels, grilles, and guards shall be removed unless tools are required for their removal.

6.2.3.2 If a cover, panel, grille or guard can be removed without the use of a tool to expose a moving part, the moving part shall be made inoperative through the use of an interlocking mechanism complying with 9.2.1.

6.2.3.3 Except as specified in 6.2.3.4, the minor dimension of any opening shall not exceed 3 in (76.2 mm).

6.2.3.4 In reference to 6.2.3.3, equipment having an opening with a minor dimension larger than 3 in (76.2 mm) shall be provided with fixed components located to reduce the likelihood of contact with a moving part. Fixed components could include baffles, refrigerant tubing, and the like.

6.2.4 *Deleted*

6.2.5 Except as specified in 6.2.5.2, a fan blade employing a guard with openings having a minor dimension sized:

a) Less than 1 in (25.4 mm) shall be guarded such that the probe illustrated in Figure 6.1 cannot contact any part of the fan blade.

b) One inch (25.4 mm) or larger shall be guarded such that the distance from the opening to the fan blade complies with Table 6.1.

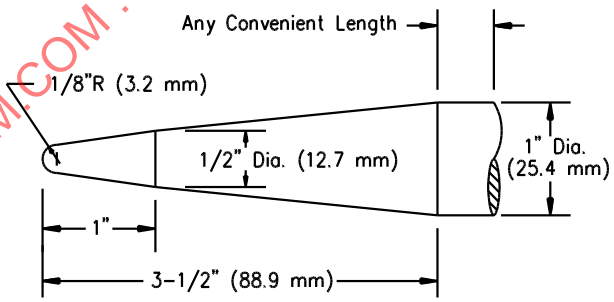
6.2.5.1 In reference to 6.2.5, the probe shall be inserted through openings in the guard with a force of not more than 2.5 lb (11.1 N).

6.2.5.2 In reference to 6.2.5, if the probe illustrated in Figure 6.1 contacts the fan blade, it shall not contact any part other than the trailing edge of the fan blade. Also, the relationship between weight (w) in pounds, radius (r) in inches and speed (n) in revolutions per minute of the fan blade shall be such that k in the following equation is less than 100:

$$k = 6 \times 10^{-7} (wr^2 n^2)$$

Figure 6.1

Probe for fan blades



PA 160

6.2.6 Except as specified in 6.2.6.1, a moving part other than a fan blade shall be guarded such that the distance from an opening to the moving part is in accordance with Table 6.1.

Table 6.1
Clearance from openings

Minor dimension of opening[a,d]		Minimum distance from opening to moving part[c]	
in	(mm)	in	(mm)
1/4	(6.4)	3/8	(9.5)
3/8	(9.5)	1-1/4	(31.8)
1/2	(12.7)	2	(50.8)
3/4	(19.1)	3-5/8	(92.1)
1	(25.4)	5-1/4	(133.4)
1-1/2	(38.1)	8-3/8	(212.7)
2	(50.8)	11-5/8	(295.3)
Over 2[b]	(Over 50.8)	30	(762.0)

[a] Openings less than 1/4 in (6.4 mm) are not to be considered.

[b] But not more than 3 in (76.2 mm). See 6.2.3.3.

[c] Also applies to hot parts. See 6.2.3(b).

[d] For fan blade guards that have openings with minor dimensions less than 1 in (25.4 mm), see 6.2.5(a).

6.2.6.1 In reference to 6.2.5(b) and 6.2.6, if an opening has a minor dimension intermediate between two of the values shown in Table 6.1, the distance from the opening to the moving part shall not be less than that found by interpolating between the corresponding values in the right column of the table.

6.2.7 The minor dimension of the opening shall be determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of not more than 2.5 lbs (11.1 N).

6.2.8 *Deleted*

6.2.9 *Deleted*

6.3 Electrical protection

6.3.1 Louvers and other openings in the enclosure shall be constructed and located to reduce the risk of unintentional contact with uninsulated live parts. Parts of the enclosure, such as covers, panels, or grilles shall be removed unless:

a) Tools are required for their removal, or

b) An interlock complying with 9.2.1 is provided.

6.3.2 If an opening in the enclosure does not permit the entrance of a 3/4 in (19.1 mm) diameter rod, the probe illustrated in:

a) Figure 6.2 shall not be capable of touching any uninsulated live parts; and

b) Figure 6.3 shall not be capable of touching any film-coated insulated wire.

6.3.2.1 In reference to 6.3.2, the probes shall be inserted through any openings in grilles, screens, louvers, or the like, with a force of not more than 5.0 lbs (22.3 N).

Figure 6.2

Probe

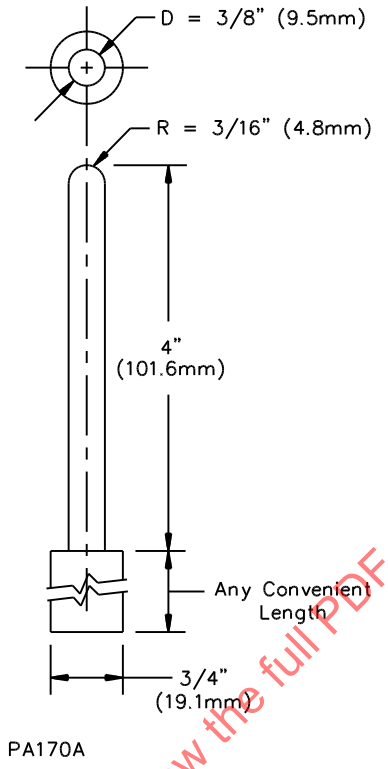
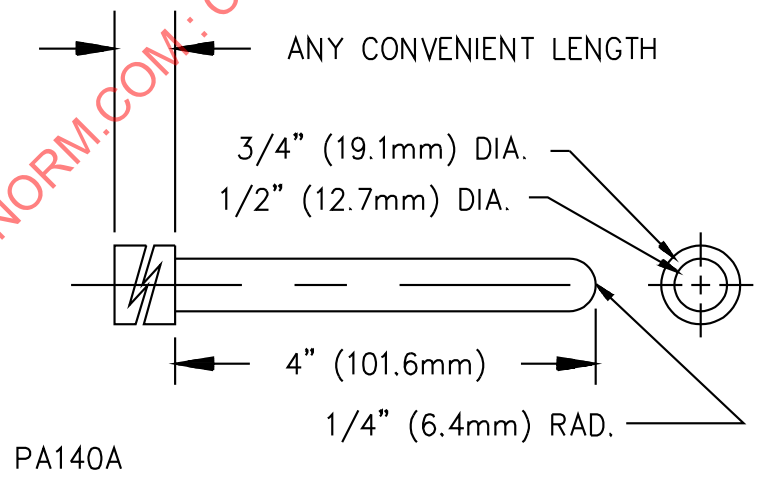


Figure 6.3

Probe



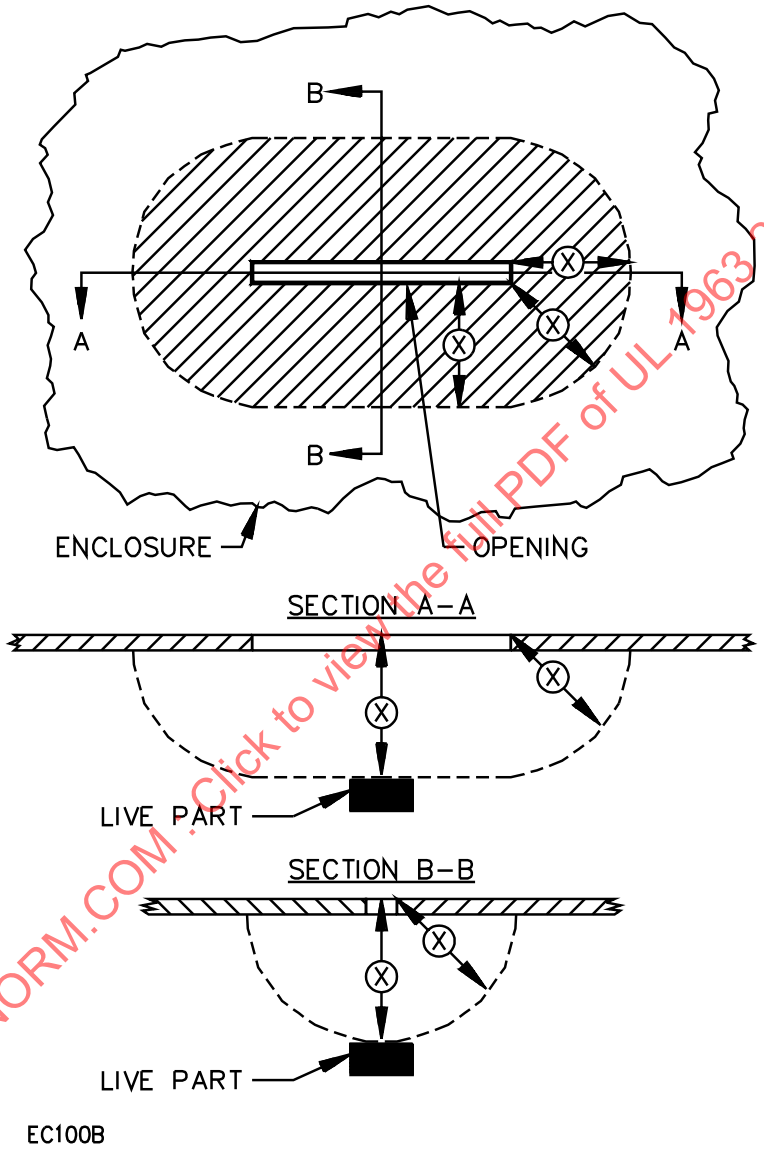
6.3.3 When an opening in the enclosure permits the entrance of a 3/4 in (19.1 mm) diameter rod, the conditions described in Figure 6.4 shall be used to determine compliance with the requirements. The minor dimension of the opening shall not exceed 1 in (25 mm) in any case.

6.3.4 In addition to the requirements of 6.3.2 and 6.3.3, uninsulated live parts located inside the enclosure that are likely to be contacted by persons performing operations, such as replacing fuses,

resetting manual-reset devices, oiling motors, or other such service operations shall be located, guarded or enclosed to prevent unintentional contact, unless tools are required to expose the live part.

Figure 6.4

Opening in enclosure



The opening is acceptable when, within the enclosure, there is no uninsulated live part or film-coated insulated wire (1) less than X in (mm) from the perimeter of the opening, as well as (2) within the volume generated by projecting the perimeter X inches normal to the plane. X equals five times the diameter of the largest diameter rod that can be inserted through the opening, but not less than 4 in (102 mm).

6.3.5 Except as specified in 6.3.5.2 and 6.3.5.4, a switch, lampholder, an attachment-plug receptacle, or similar component shall be secured in position and shall be prevented from turning. The means for preventing rotation shall consist of more than friction between surfaces.

6.3.5.1 In reference to 6.3.5, a stem-mounted switch or other similar device intended for mounting within a single-hole shall be prevented from rotating by either a:

a) Toothed lock washer; or

b) An interference lock, such as by a notch in the stem of the device.

6.3.5.2 In reference to 6.3.5, a switch that is not prevented from rotating shall:

a) Be operated by mechanical means rather than direct contact by persons;

b) Be of a plunger or other type that does not tend to rotate when operated;

c) Be mounted such that operating the switch is unlikely to loosen it;

d) Not cause electrical spacings to be reduced below the minimum required values specified in Sections 41 – 43 if the switch rotates.

6.3.5.3 In reference to 6.3.5.2(b), a toggle switch shall not be used since such a switch is subjected to forces that tend to rotate the switch during its operation.

6.3.5.4 In reference to 6.3.5, a lampholder that is not prevented from rotating shall:

a) Be of a type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel; and

b) Not cause electrical spacings to be reduced below the minimum required values specified in Sections 41 – 43 if the lampholder rotates.

6.3.6 *Deleted*

6.3.7 An uninsulated current-carrying part, or a part that supports a live part, shall not rely solely upon friction between surfaces and shall be positively secured:

a) To the base or mounting surface so that it will be prevented from turning or shifting in position if such motion results in a reduction of electrical spacings below the minimum required values specified in Sections 41 – 43; or

b) By a toothed lock washer or an interference lock as specified in 6.3.5.1.

6.3.8 *Deleted*

7 Barriers

7.1 A mechanical barrier shall be secured to the mounting surface such that tools are required for its removal and shall be formed from one or more of the following:

a) Metal, minimum 0.026 in (0.66 mm) thick,

b) A nonmetallic material which shall be considered a part of the cabinet and which shall comply with the cabinet requirements of Table 52.1,

c) A finned coil in which the coil is located in the:

1) Vertical plane such that a 2 in long by 1/4 in diameter (51 by 6.4 mm) rod cannot contact the part or material being protected from the opposite side of the finned coil; or

2) Horizontal plane if the coil employs flat plate fins with a minimum of 12 fins per inch (12 fins per 25.4 mm) and having at least two rows of tubing in depth.

d) Any other material or construction determined to be equivalent to (a) – (c).

7.1.1 An insulating barrier shall:

a) Be constructed to withstand the most severe condition anticipated in service;

b) Comply with 7.2 and with the requirements for mechanical barriers in 7.1 if exposed or otherwise subjected to mechanical damage; and

c) Be reliably held in place.

7.2 Except as specified in 7.2.1, an insulating barrier shall be formed from one or more of the following:

a) Vulcanized fiber or varnished cloth not less than 0.028 inch (0.71 mm) thick,

b) Fiberglass, minimum 0.5 in (12.7 mm) thick,

c) A nonmetallic that complies with 5.1 – 5.3 and the functional parts requirements of Table 52.1 together with the requirements for electrical insulation in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C,

d) Any other material or construction determined to be equivalent to (a) to (c).

7.2.1 An insulating barrier not complying with 7.2 shall be used only for extra-low-voltage circuits that do not contain a protective control.

7.3 In reference to 7.2, a rigid backing or a mechanical barrier shall be provided behind these materials unless the materials are determined to be suitably rigid.

7.4 *Deleted*

8 Accessories

8.1 Equipment having provisions for the use of electrical accessories to be attached in the field shall be constructed so that the use of these accessories will not introduce a risk of fire, electric shock, or injury to persons. See 91.18 and 91.20.

8.2 The equipment shall comply with all requirements of this standard with or without the accessory installed.

8.3 Installation of accessories by the user shall be restricted to an arrangement that can be accomplished by means of receptacles and plug-in connectors.

8.4 Installation of accessories by service personnel shall be by means of receptacles, plug-in connectors, insulated wire connectors, or by connection to existing wiring terminals.

8.5 Accessories intended for connection to a source of field supply independent of that of the unit shall:

a) Comply with the requirements specified in Section 10 when intended to be a permanently connected accessory.

b) Comply with the requirements specified in Section 11 when intended to be a cord-connected accessory.

In no case shall a permanently connected accessory be used with supply cord connected equipment.

8.6 When an accessory is powered from a source of supply separate from that supplying the unit, disconnection of any one supply shall automatically cause de-energization of all circuits within the unit and accessory.

Exception: Automatic de-energization may be omitted when the unit and accessory are marked in accordance with 91.36.

8.7 Installation of accessories shall not require the cutting of wiring or the soldering of connections by the installer. Installation shall not require cutting, drilling, or welding either in electrical enclosures, or other areas where such operations may result in damage to electrical or refrigeration components and wiring within the enclosure.

8.8 Strain-relief means shall be provided for the wiring in the accessory when there is a possibility of transmitting stress to the terminal connections during installation. See Strain Relief Test, Section 64.

8.9 All terminals and wiring intended to be field connected shall be identified on the:

a) Accessory,

b) Equipment when connections are to be made between the accessory and the equipment, and

c) Wiring diagram(s).

8.10 The mounting location of the accessory shall be indicated on the equipment.

Exception: When the mounting location is fixed due to the function of the accessory and arrangement of the equipment, and instructions are provided covering the installation and location for the accessory, the mounting location of the accessory need not be indicated.

8.11 As part of the investigation, accessories are to be trial-installed to determine that their installation is feasible, the instructions are detailed and correct, and the use of the accessories does not introduce a risk of fire, electric shock, and injury to persons.

9 Enclosures

9.1 General

9.1.1 An enclosure shall be formed and assembled so that it will have the strength and rigidity necessary to resist the conditions of intended use without increasing the risk of fire or injury to persons due to total or partial collapse and the resulting reduction of spacings, loosening or displacement of parts, or other defects. Enclosures for individual electrical components, outer enclosures, and combinations of the two are to be considered in determining compliance with this requirement.

9.1.2 Among the factors that are to be taken into consideration when judging the acceptability of an enclosure are:

a) Mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Flame resistance,

e) Resistance to distortion at temperatures to which the material may be subjected under conditions of use, and

f) Resistance to corrosion.

For a nonmetallic enclosure or part of an enclosure, all of these factors, including the effect of exposure to weathering when for outdoor use, are to be considered with respect to aging.

9.1.3 The enclosure of the equipment shall reduce the risk of mechanical damage to wiring, electrical components, and refrigerant tubing.

9.1.4 The enclosure shall reduce the risk of emission of molten metal, burning insulation, flaming particles, or the like, through openings onto flammable material, including the surface over which the equipment is mounted.

9.1.5 Electrical components, such as controls, solenoids, starting relays, and switches, shall be individually enclosed except terminals unless it can be determined that failure of a component will not result in a risk of fire. See Burnout Tests – Electromagnetic Components, Section 65.

9.1.6 Electrical parts, see 9.1.5, within the outer cabinet need not be individually enclosed when the assembly complies with (a) – (c):

a) Their construction and location with respect to openings in the outer cabinet will not result in the emission of flame or molten metal through openings in the cabinet, or it can be shown that failure of the component would not result in a risk of fire,

b) There are no openings in the bottom of the compartment in which the part is located that would permit dropping of molten metal, and the like, on flammable material, and

c) The part is not in proximity to flammable material other than electrical insulation.

9.1.7 A sheet metal enclosure is to be judged for acceptability with respect to its size, shape, metal thickness, and use in a particular application. Sheet steel shall be not less than 0.026 in (0.66 mm) thick when uncoated or 0.029 in (0.74 mm) when galvanized, and nonferrous sheet metal shall be not less than 0.036 in (0.91 mm), except for relatively small areas or for surfaces which are curved or otherwise reinforced.

9.1.8 Sheet metal to which a wiring system is to be connected in the field shall be not less than 0.032 in (0.081 mm) thick when uncoated steel, not less than 0.034 in (0.86 mm) thick when galvanized steel, and not less than 0.045 in (1.14 mm) thick when nonferrous.

9.1.9 When threads for the connection of conduit are tapped through a hole in an enclosure wall, or when an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal, and the construction shall permit a conduit bushing to be attached. When threads for the connection of conduit are not tapped through a hole in an enclosure wall, conduit hub, or the like, there shall be no less than 3-1/2 threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductor equivalent to that provided by a standard conduit

bushing and have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

9.1.10 A knockout in a sheet metal enclosure shall be secured in place, but shall be capable of being removed without deformation of the enclosure that would result in damage to electrical components, reduction in electrical spacings, or both. See 9.1.12.

9.1.11 A knockout shall remain in place when a force of 10 lb (44.5 N) is applied at right angles to the knockout by a 1/4 in (6.4 mm) diameter mandrel with a flat end. The mandrel shall be applied at the point most likely to cause movement of the knockout.

9.1.12 A knockout shall be provided with a flat surrounding surface for seating of a conduit bushing and shall be located so that installation of a bushing at any knockout likely to be used during installation will not reduce spacings between uninsulated live parts and the bushing to less than those required.

9.1.13 In measuring a spacing between an uninsulated live part and a bushing installed in a knockout, it is to be assumed that a bushing having the dimensions indicated in Table 9.1 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

9.1.14 Steel enclosures shall be protected against corrosion by metallic or nonmetallic coatings, such as plating or painting. See 9.3.1 – 9.3.6.

Table 9.1
Knockout or hole sizes and dimensions of bushings

Trade size of conduit, in (mm OD)		Knockout or hole diameter, in (mm)		Bushing dimensions			
				Diameter, in (mm)		Overall height, in (mm)	
1/2	(21.3)	7/8	(22.2)	1	(25.4)	3/8	(9.5)
3/4	(26.7)	1-3/32	(27.8)	1-15/64	(31.4)	27/64	(10.7)
1	(33.4)	1-23/64	(34.5)	1-19/32	(40.5)	33/64	(13.1)
1-1/4	(42.3)	1-23/32	(43.7)	1-15/16	(49.2)	9/16	(14.3)
1-1/2	(48.3)	1-31/32	(50.0)	2-13/64	(56.0)	19/32	(15.1)
2	(60.3)	2-15/32	(62.7)	2-45/64	(68.7)	5/8	(15.9)

9.2 Doors and covers

9.2.1 In reference to 6.2.3.2 or 6.3.1 a required interlocking mechanism shall comply with the relevant requirements in 17.8 – 17.16.3 and 17.17 – 17.17.1 and shall:

a) Be engaged with the cover in the closed position before parts are energized, and

b) Secure the cover in the closed position when engaged.

9.2.2 A hinged or pivoted panel or cover shall be positioned or arranged so that when it is in an open position falling or swinging due to gravity or vibration will not cause injury to persons from:

a) The panel or cover,

b) Moving parts, or

c) Uninsulated live parts that can cause a risk of electric shock.

9.2.3 The assembly shall be arranged so that an overcurrent protective device, such as a fuse, can be replaced and manual-reset devices can be reset:

a) Without removing parts other than a service cover(s) or panel(s), and

b) By opening the cover or door enclosing the device.

9.2.4 A required protective device shall not be accessible from outside the enclosure without opening a door or cover.

Exception: The operating handle of a circuit breaker, the reset button of a manually resettable motor protector, the reset button of a manually resettable pressure switch, and similar parts may project outside the enclosure, provided that the clearance between the control member and the edge of the opening in the outer enclosure is not more than 1/8 in (3.2 mm) for any setting or position of the control member.

9.2.5 Covers for enclosures of fuses in high-voltage circuits shall be hinged. Covers for manual-reset overload protective device enclosures shall be hinged if it is required to open the cover to reset the device.

Exception: A hinged cover is not required when the only fuses enclosed are:

a) Supplementary type control circuit fuses, provided that the fuses and control circuit loads (other than a fixed control circuit load such as a pilot lamp) are within the same enclosure; or

b) Supplementary type fuses of 2 amp or less for small auxiliary resistance heaters, such as crankcase heaters, with a maximum rating of 100 W; or

c) Extractor-type fuses with their own enclosure; or

d) Fuses in extra-low-voltage circuits.

9.2.6 A cover required to be hinged shall not depend solely upon screws or other similar means to hold it closed, but shall be provided with a latch or the equivalent.

9.2.7 With reference to the requirements of 9.2.6, a spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the cover closed and will require some effort on the user's part to open is acceptable. When provided as the sole means for securing the cover an interlocking mechanism as described in 9.2.1 is also acceptable.

9.2.8 A door or cover giving direct access to fuses in other than extra-low-voltage circuits shall shut closely against a 1/4 in (6.4 mm) rabbet or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the wall of the box and shall overlap the edges of the box by not less than 1/2 in (12.7 mm). A construction, such as a fuse enclosure, located within an outer enclosure, or a flange and rabbet combination that affords the equivalent protection is acceptable.

9.2.9 Strips used to provide rabbets, or angle strips fastened to the edges of a door shall be secured at not less than two points, not more than 1-1/2 in (38 mm) from each end of each strip and at points between these end fastenings, not more than 6 in (152 mm) apart.

Table 9.2
Corrosion protection means

Type of cabinet and enclosure	Thickness 0.053 in (1.35 mm) and heavier as specified by	Thickness less than 0.053 in (1.35 mm) as specified by
Outer cabinets which protect motors, wiring or enclosed current-carrying parts	9.3.2	9.3.3
Inside enclosures which protect current-carrying parts other than motors	9.3.2	9.3.3
Outer cabinets which are the sole enclosure of current-carrying parts	9.3.3	9.3.3

9.3 Enclosures exposed to weather

9.3.1 Sheet steel cabinets and electrical enclosures exposed to the effects of weathering shall be protected against corrosion by the means specified in Table 9.2 or by other metallic or nonmetallic coatings that provide equivalent protection.

Exception: These requirements are not applicable to a metal part, such as a decorative grille, that is not required for conformance with this standard.

9.3.2 To comply with the requirements of 9.3.1, one of the following coatings shall be used:

a) Hot-dipped mill-galvanized sheet steel conforming with the Coating Designation G60 or A60 in Table 1 of the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in the ASTM Specification. The weight of zinc coating may be determined by any recognized method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method For Weight [Mass] Of Coating On Iron And Steel Articles With Zinc Or Zinc-Alloy Coatings, ASTM A90/A90M. An A60 (alloyed) coating shall also comply with 9.3.4.

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 in (0.0104 mm) on each surface with a minimum thickness of 0.00034 in (0.0086 mm). The thickness of the coating shall be established by the Metallic-Coating Thickness Test, Section 86. An annealed coating shall also comply with 9.3.4.

c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on both surfaces. Unless acceptability of the paint can be determined by consideration of its composition, corrosion tests are required.

9.3.3 To comply with 9.3.1, one of the following coatings shall be used:

a) Hot-dipped mill-galvanized sheet steel conforming with the Coating Designation G90 in Table 1 of the Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirements in that ASTM Specification. The weight of zinc coating may be determined by any recognized method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method For Weight [Mass] Of Coating On Iron And Steel Articles With Zinc Or Zinc-Alloy Coatings, ASTM A90/A90M.

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 in (0.0155 mm) on each surface with a

minimum thickness of 0.00054 in (0.0137 mm). The thickness of the coating shall be established by the Metallic-Coating Thickness Test, Section 86. An annealed coating shall also comply with 9.3.4.

c) A cadmium coating of not less than 0.001 in (0.025 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the Metallic-Coating Thickness Test, Section 86.

d) A zinc coating conforming with 9.3.2 (a) or (b) with one coat of outdoor paint as specified in 9.3.2(c).

e) A cadmium coating of not less than 0.00075 in (0.0191 mm) thick on both surfaces with one coat of outdoor paint on both surfaces or not less than 0.0005 in (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established in accordance with the Metallic-Coating Thickness Test, Section 86, and the paint shall be as specified in 9.3.2(c).

9.3.4 An annealed zinc coating that is bent or similarly formed after annealing shall be painted in the bent or formed area if the bending or forming process has damaged the zinc coating, as evidenced by flaking or cracking of the zinc coating at the outside radius of the bent or formed section visible at 25 power magnification.

9.3.5 With reference to the requirements of 9.3.7, simple sheared or cut edges and punched holes are not considered to be formed, but extruded and rolled edges and holes shall comply with 9.3.4.

9.3.6 With reference to the requirements of 9.3.1, other finishes, including paints, special metallic finishes, and combinations of the two, are acceptable when comparative tests with galvanized sheet steel without annealing, wiping, or other surface treatment complying with 9.3.2(a) or 9.3.3(a), as applicable, indicate that they provide equivalent protection. Among the factors to be taken into consideration when judging the acceptability of such coating systems are exposure to salt spray, to moist carbon dioxide-sulphur dioxide-air mixtures, to moist hydrogen sulphide-air mixtures, and to ultraviolet light and water.

9.3.7 Nonferrous enclosures may be employed without special corrosion protection. See 9.1.2.

9.3.8 Gaskets required to seal electrical enclosures against the entrance of rain and condensate shall comply with 83.1 – 83.4.2 or with the Standard for Gaskets and Seals, UL 157 if the gasket physical properties are equivalent to those specified in 83.1 – 83.4.2. In addition, each gasket shall:

a) Be held in place by mechanical fasteners, adhesives, or as indicated in 9.3.9; and

b) Be neoprene, rubber, or thermoplastic or other materials with equivalent properties.

9.3.9 Sealing compounds required to seal electrical enclosures shall comply with 83.5.

9.3.10 Adhesives required to secure gaskets shall comply with 83.6.

9.3.11 In reference to 9.3.8(b), gaskets that are not held in place by mechanical fasteners or adhesives but are intended to be retained in the correct position by some other means shall be prevented from displacement either:

a) Due to their location within the equipment; or

b) By the placement of other components in the enclosure so that if the equipment cover is removed, the gasket will be reengaged in the intended manner when the cover is replaced.

10 Field Supply Connections

10.1 General

10.1.1 Equipment of the following types shall have provision for permanent connection to the power supply in accordance with the National Electrical Code, ANSI/NFPA 70:

a) Equipment rated in excess of 250 V.

b) Polyphase equipment.

c) Equipment employing a water-cooled condenser.

d) Except as indicated in 11.10 equipment in which the sum of the load currents exceed 16 amperes. The largest sum of concurrent load currents shown on the nameplate shall be used to determine the rating.

e) Equipment other than of the self-contained type.

10.1.2 As used in 10.2.1 – 10.2.10, field-wiring terminals are considered to be the terminals to which power supply, control, or equipment grounding connections will be made in the field when the equipment is installed.

10.1.3 A knockout for connection of a field-wiring system to a field-wiring compartment shall accommodate conduit of the trade size determined by applying Table 10.1.

10.1.4 Space shall be provided in the field-wiring compartment or outlet box for installation of conductors of the number and size required by 10.1.7. The space provided shall permit the required number and size of at least 6-in (150-mm) lengths of Type TW or THW wire brought into the wiring compartment. When required, a trial installation is to be made.

Exception: Conductors other than Type TW or THW may be used if specified in the installation instructions.

10.1.5 The location of a terminal box or compartment in which power supply connections are to be made shall permit these connections to be inspected after the equipment is installed. The connections are to be accessible without removing parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made.

10.1.6 A terminal compartment intended for the connection of a supply raceway shall be secured in position and shall be prevented from turning.

10.1.7 The equipment shall be provided with field-wiring terminals or leads for the connection of conductors having an ampacity of not less than that indicated in 92.11. It is to be assumed that branch circuit conductors rated 140°F (60°C) will be used when the required circuit ampacity is 100 amp or less and that conductors rated 167°F (75°C) will be used when the required ampacity is more than 100 amp.

10.2 Terminals

Table 10.1
Trade size of conduit in inches (mm OD)

Wire size		Number of wires									
AWG	(mm^2)	2		3		4		5		6	
14	(2.1)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)
12	(3.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
10	(5.3)	1/2	(21.3)	1/2	(21.3)	1/2	(21.3)	3/4	(26.7)	3/4	(26.7)
8	(8.4)	3/4	(26.7)	3/4	(26.7)	1	(33.4)	1	(33.4)	1-1/4	(42.3)
6	(13.3	3/4	(26.7)	1	(33.4)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)
4	(21.2)	1	(33.4)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)
3	(26.7)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)	1-1/2	(48.3)
2	(33.6)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)	2	(60.3)
1	(42.4)	1-1/4	(42.3)	1-1/4	(42.3)	1-1/2	(48.3)	2	(60.3)	2	(60.3)

Note – This table is based on the assumption that all conductors will be of the same size and there will be no more than six conductors involved or when all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of Type THW wire.

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

10.2.2 For field-wiring terminals intended for 8 AWG (8.4 mm^2) and larger conductors, pressure wire connectors shall be used. For field-wiring terminals intended for 10 AWG (5.3 mm^2) and smaller conductors, the parts to which wiring connections are to be made may consist of clamps or wire binding screws with cupped washers, terminal plates, or the equivalent to hold the wire in position.

10.2.3 A wire binding screw at a field-wiring terminal shall not be smaller than No. 10 (4.8 mm diameter), except that a No. 8 (4.2 mm diameter) screw may be used for the connection of a conductor no larger than 14 AWG (2.1 mm^2) and a No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 or 18 AWG (1.2 or 0.8 mm^2) control circuit conductor.

10.2.4 It should be noted that according to the National Electrical Code, ANSI/NFPA 70, 14 AWG (2.1 mm^2) is the smallest conductor that the installer may use for branch circuit wiring and thus is the smallest conductor that may be anticipated at a terminal for the connection of a power supply wire.

10.2.5 A terminal plate for a wire binding screw shall be of metal not less than 0.030 in (0.76 mm) thick for a 14 AWG (2.1 mm^2) or smaller wire and not less than 0.050 in (1.27 mm) thick for a wire larger than 14 AWG. In either case, there shall be not less than two full threads in the metal.

10.2.6 A terminal plate formed from stock having the minimum required thickness may have the metal extruded at the hole tapped for the binding screw to provide two full threads.

Exception: Two full threads are not required if a lesser number of threads results in a connection in which the threads will not strip when tightened in accordance with the torques indicated in the Standard for Wire Connectors, UL 486A-486B.

10.2.7 Upturned lugs or a cupped washer shall retain a conductor of the size mentioned in 10.1.7, but no smaller than 14 AWG (2.1 mm^2), under the head of the screw or the washer.

10.2.8 Wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with 10.2.1, 10.2.3, 10.2.5, 10.2.6, 10.2.9, and 10.2.10 or with the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

10.2.9 A wire binding screw shall thread into metal.

10.2.10 A field-wiring terminal intended for the connection of a grounded conductor shall be of a metal, or plated with a metal, substantially white in color and shall be readily distinguishable from the other terminals, or identification of that terminal shall be shown in some other manner, such as on an attached wiring diagram.

10.3 Leads

10.3.1 Leads intended for connection to any external high-voltage circuit or to an external extra-low-voltage circuit that contain one or more of the components specified in 42.3 shall comply with all of the following:

a) Be one of the types of wiring specified in 12.1.3;

b) Be 6 inches (152 mm) or more in length, as measured from the lead end to the strain relief means, unless the use of a shorter lead is required to prevent damage to the lead insulation;

c) Be provided with strain relief if stress on the lead may be transmitted to terminals, splices, or internal wiring. In such cases, leads shall comply with the Strain Relief Test, Section 64;

d) Not be connected to wire binding screws or pressure wire connectors located in the same compartment as the lead ends (that are intended for spliced connections to the field-wiring) unless the screws or connectors are rendered unusable for field-wiring connections or the lead ends are insulated; and

e) Be insulated at the free end, if the lead will not be used in every installation and if the end can reduce spacings below the minimum acceptable values specified in Section 41 for high-voltage circuits or Section 42 for extra-low-voltage circuits.

10.3.2 A lead intended for the connection of a grounded conductor shall be finished to show a white or gray color, shall be distinguishable from other leads, and no other lead shall be so identified.:

10.4 Grounding

10.4.1 Equipment shall have an equipment grounding terminal or lead.

10.4.2 A terminal intended solely for connection of an equipment grounding conductor shall be capable of securing a conductor of the size required by the National Electrical Code, ANSI/NFPA 70.

10.4.3 A soldering lug, a push-in connector, a screwless connector, or a quick connect or similar friction fit connector shall not be used for the grounding terminal.

10.4.4 A wire binding screw intended for the connection of an equipment grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. Except as indicated in 10.4.5, a pressure wire connector intended for connection of such a conductor shall be plainly identified such as by being marked “G,” “GR,” “GROUND,” or “GROUNDING,” or by a marking on a wiring diagram provided on the equipment. The wire binding screw or pressure wire connector shall be secured to the frame or enclosure

of the equipment and shall be located so that it is unlikely to be removed during service operations, such as replacing fuses, resetting manual-reset devices, or oiling motors.

10.4.5 When a pressure wire connector intended for grounding is located where it could be mistaken for the neutral conductor of a grounded supply, it shall be identified by a marking “EQUIPMENT GROUND”, by a green color identification, or by both.

10.4.6 The surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be finished in a continuous green color or a continuous green color with one or more yellow stripes, and no other lead shall be so identified.

10.4.7 Functional grounding shall not be relied upon for equipment grounding.

11 Supply Connections – Cord-Connected Equipment

11.1 Cord-connected equipment shall be provided with:

a) A non-detachable power supply cord for connection to the supply by means of a plug; or

b) An appliance coupler and inlet (motor attachment plug) for connection of a detachable power supply cord and either a detachable power supply cord or instructions for selection of a suitable detachable power supply cord.

11.2 In reference to 11.1, a power supply cord and plug or appliance coupler shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817. An inlet shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

11.3 Cord connected equipment consisting of two separate units joined together or two of the same units in a single structure may be provided with more than one power supply cord if all of the following conditions are met:

a) Not more than two cords are provided;

b) Each cord is of the type, size and rating required or permitted for the type of equipment and the load supplied to each unit;

c) Each attachment plug cap is sized based on the load supplied to each unit;

d) The total marked nameplate equipment load in amperes (current through both cords) is not more than 24 amperes;

e) If both cords provide power to the same control enclosure or electrical panel that could result in an electrical shock, fire hazard or injury to persons, the equipment shall be provided with a mechanical or electrical interlock system that results in all ungrounded conductors of the supply being disconnected in the event that either cord is disconnected;

f) The markings in 93.3 (a) and (c) are provided; and

g) The instructions contain information as indicated in 94.9.

11.4 In reference to 11.3, where the rated current input to both units exceeds 80 percent of the branch circuit to which the equipment will be connected, the unit with the highest rated current input shall be marked adjacent to its cord in accordance with 93.3 (b).

11.5 The rating marked on the equipment in accordance with 93.1 shall not exceed 80 percent of the attachment plug rating.

11.6 Except as indicated in 11.7, cord-connected equipment shall employ a grounding-type attachment plug that complies with the ANSI designation specified in Table 11.1 based on the equipment voltage and ampere rating.

Table 11.1
Attachment plugs

Nameplate rating			Attachment plug	
Volts	Phase	Amperes[a]	Rating	ANSI designation[b]
110– 120	1	12.0	15 amperes, 125 volts	5-15P
110 – 120	1	16.0	20 amperes, 125 volts	5-20P
110 – 120	1	24.0	30 amperes, 125 volts	5-30P
110 – 120	1	40.0	50 amperes, 125 volts	5-50P
200 – 240	1	12.0	15 amperes, 250 volts	6-15P
200 – 240	1	16.0	20 amperes, 250 volts	6-20P
200 – 240	1	24.0	30 amperes, 250 volts[c]	6-30P
200 – 240	1	40.0	50 amperes, 250 volts[c]	6-50P
110 – 120/200 – 240	1	12.0	15 amperes, 125/250 volts	14-15P
110 – 120/200 – 240	1	16.0	20 amperes, 125/250 volts	14-20P
110 – 120/200 – 240	1	24.0	30 amperes, 125/250 volts[c]	14-30P
110 – 120/200 – 240	1	40.0	50 amperes, 125/250 volts[c]	14-50P
200 – 240	3	12.0	15 amperes, 250 volts	15-15P
200 – 240	3	16.0	20 amperes, 250 volts	15-20P
200 – 240	3	24.0	30 amperes, 250 volts[c]	15-30P
200 – 240	3	40.0	50 amperes, 250 volts[c]	15-50P

[a] Ampere rating is maximum permitted to be marked on equipment nameplate for attachment plug indicated. See 11.5.

[b] Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD6.

[c] 30 and 50 amp attachment plugs permitted only on equipment intended to be moved from place to place in normal service for cleaning as specified in 11.10.

11.7 In reference to 11.6, if the grounding-type attachment plug does not comply with the ANSI designation specified in Table 11.1, then the equipment shall be rated 250 V or less and shall be intended for connection to circuits rated for other than:

a) 60 Hz; and/or

b) The voltages specified in the first column of Table 53.1.

11.8 The power supply cord shall be provided with an equipment grounding conductor terminating within the equipment. The supply cord equipment grounding conductor shall be:

a) Finished with a continuous green color or with a continuous green color with one or more yellow stripes, and no other conductor shall be so identified;

b) Secured to the frame or enclosure of the equipment by a positive means that is not likely to be removed during any servicing operation not involving the power supply cord. A sheet metal screw or quick-connect terminal shall not be used; and

c) Connected to the grounding blade of the attachment plug.

11.9 Cord connected equipment shall employ Type SEO, SO, SOO, STO, STOO, SJEO, SJO, SJOO, SJTO, or SJTOO power supply cord rated for use at a voltage not less than the rated voltage of the equipment. The ampacity of the cord as given in the National Electric Code, ANSI/NFPA 70, shall be not less than that required by the ampere input measured in the Temperature and Pressure Test, Section 57. The ampere input value shall include the loads for convenience outlets and the current drawn by accessories intended for use with the equipment. See 91.11 and 91.12.

11.10 In reference to 10.1.1 (d), cord-connected equipment that exceeds 16 amperes shall comply with all of the following:

a) Be intended to be moved from place to place in normal service;

b) Be self-contained;

c) Not require connection to water lines, or the like;

d) Be permanently equipped with casters;

e) Have an electrical rating not exceeding 40 amp, 250 V, single phase.

11.11 The ampacity of a power supply cord on equipment intended for connection to a branch circuit which exceeds the limitations specified in 19.3.2(a) shall be not less than 80 percent of the maximum continuous current of the compressor motor determined in accordance with Protective Devices – Maximum Continuous Current Test, Section 75, plus the sum of all other loads, including accessories, which may operate concurrently.

Exception: The ampacity of the power supply cord need not be greater than the ampere rating of the attachment plug.

11.12 A power supply cord for outdoor use equipment shall be one of the types specified in 11.9 and identified by the letter “W” following the cord type designation marked on the jacket.

11.13 The length of a power supply cord shall be not less than 6 feet (1.8 m) nor more than 10 feet (3.0 m) as measured between the attachment plug and any point at which the cord exits the equipment cabinet or the last strain relief, whichever is shorter.

11.14 The power supply cord shall be provided with strain relief means so that a stress on the cord will not be transmitted to terminals, splices, or internal wiring. The strain relief means shall comply with the Strain Relief Test, Section 64.

11.15 Moving a power supply cord inward shall not result in either:

a) Cord damage; or

a) A metallic strain relief being able to contact uninsulated live parts. Spacings in accordance with Sections 41, 42 or 43 shall be maintained.

11.16 The edges of the entry hole for the power supply cord, including the cord entry hole in a bushing, shall be smooth and rounded without burrs, fins, or sharp edges that might damage the cord insulation. The power supply cord shall be routed to prevent damage to the cord insulation.

12 Internal Wiring and Wiring Methods

12.1 General

12.1.1 All wires and cords shall be routed and supported to reduce the risk of damage due to:

a) Sharp edges,

b) Surfaces and parts that operate at temperatures in excess of that for which the wire insulation is rated,

c) Moving parts, and

d) Parts that can be expected to vibrate, such as motors, compressor motors, refrigerant lines, and the like.

Clamping means shall have smooth, rounded surfaces.

Exception: Wires and cords may contact a vibrating part provided that:

a) The wiring is securely fastened to the part at the point of contact so as to restrict movement;

b) The part does not have burrs, fins, or sharp edges, that might abrade the insulation; and

c) Vibration does not place a strain on the wiring or wiring connections.

12.1.2 Wiring shall have insulation rated for the potential involved and the temperatures to which it may be subjected. Compliance shall be determined in accordance with any of the following:

a) Wiring temperatures shall be judged on the basis of the temperatures measured during the applicable temperature test specified in 57.1;

b) Other than motor wiring, all wiring shall:

1) Have an ampacity of the conductors in accordance with Table 12.1, and

2) Not be exposed to heat from radiating sources or heated components.

c) Motor wiring shall have an ampacity not less than 125 percent of the motor full load or maximum operating current rating in addition to complying with item (b).

Table 12.1
Wiring material ampacities

Wire size		
AWG	(mm^2)	Ampacity
22	(0.41)	4
20	(0.66)	7
18	(0.82)	10
16	(1.3)	13
14	(2.1)	18
12	(3.3)	25

Table 12.1 Continued on Next Page

Table 12.1 Continued

Wire size		
AWG	**(mm^2)**	**Ampacity**
10	(5.3)	30
8	(8.4)	40
6	(13.3)	55
4	(21.2)	70
2	(33.6)	95
1	(42.4)	110

Note – The ampacities shown apply to appliance wiring materials with insulation rated not less than 194°F (90°C).

For types of wires other than appliance wiring materials, the ampacity shall be determined from Tables 1 through 4 and Table 12 in the Canadian Electrical Code, Part I, CSA Standard C22.1 and Tables 310-16 and 310-17 in the National Electrical Code, ANSI/NFPA 70, for the type of wire employed. The correction factors of the referenced tables need not be applied.

12.1.3 Wiring shall comply with one of the following:

a) Standard for Appliance Wiring Material, UL 758;

b) Standard for Thermoset-Insulated Wires and Cables, UL 44;

c) Standard for Flexible Cords and Cables, UL 62; or

d) Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

12.1.4 Wire positioning devices shall comply with the Standard for Positioning Devices, UL 1565.

12.1.5 Wiring that is green or green with one or more yellow stripes shall be used only for grounding conductors, and wiring used for other purposes shall not be so identified.

12.1.6 All wires and cords shall be routed and supported so that they will not be immersed in water unless the insulation is specifically intended for this purpose. Wiring shall be arranged to prevent water caused by condensation, defrosting, or if intended for outdoor use, rain exposure, from entering wiring enclosures and electrical enclosures.

Exception: Water may enter an enclosure when:

a) The point of entrance is not in proximity to live electrical parts, and

b) The live parts are not wetted.

12.1.7 Parallel conductor appliance wiring material of the integral type shall not be ripped more than 3 in (76 mm) unless the minimum wall thickness of the conductor insulation after ripping is at least 0.058 in (1.47 mm). If the material has conductor insulation not less than 0.028 in (0.71 mm) after ripping and is within a separate metal enclosure, conduit, electrical metallic tubing, or metal raceway, the length of rip is not limited.

12.1.8 When cords or appliance wiring material are employed in the machine user accessible compartment, such wiring shall be of a type as indicated by Group B of Table 12.2 and shall be located or protected so as not to be damaged by refrigerant containers, removable shelves, or similar items.

Table 12.2
Typical wiring materials

Group	Type of wire, cord, or cable[a]	Wire size		Insulation thickness	
		AWG	(mm^2)	in	(mm)
A	Thermoplastic appliance wiring material[b], with insulation thicknesses shown at the right corresponding to wire sizes indicated, or type ACHH, ACTH, ACTHH, FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RHH, RHW, THW, XHHW, MTW, THWN, PF, PGF, PFF, PGFF, TW	10 and smaller	(5.3)	2/64	(0.8)
		8	(8.4)	3/64	(1.2)
		6	(13.3)	4/64	(1.6)
		4	(21.2)	4/64	(1.6)
		3	(26.7)	4/64	(1.6)
		2	(33.6)	4/64	(1.6)
		1	(42.4)	5/64	(2.0)
		1/0	(54.0)	5/64	(2.0)
		2/0	(67.0)	5/64	(2.0)
		3/0	(85.0)	5/64	(2.0)
		4/0	(107.2)	5/64	(2.0)
B	Appliance wiring material[b] having thermoplastic, or neoprene insulation, with insulation thicknesses shown at right corresponding to the wire sizes indicated; or cord Type S, SE, SO SOO, ST, STO, STOO; SJ, SJE, SJO, SJOO, SJT, SJTO, SJTOO; SP-3, SPE-3, SPT-3	18	(0.82)	4/64	(1.6)
		16	(1.3)	4/64	(1.6)
		14	(2.1)	5/64	(2.0)
		12	(3.3)	5/64	(2.0)
		10	(5.3)	5/64	(2.0)
		8	(8.4)	6/64	(2.4)
		6	(13.3)	8/64	(3.2)
		4	(21.2)	9/64	(3.6)
		2	(33.6)	10/64	(4.0)
C	Rubber appliance wiring material[b], with insulation thickness shown at the right corresponding to wire sizes indicated, or Type S, SJ, SP-3	Same as for Group B			

[a] The designated cord or cable or types of wire other than appliance wiring material may be used without regard to the values specified in this table.

[b] Appliance wiring material acceptable for refrigeration use.

12.1.9 If wiring extends from the cabinet to a hinged door, or is subject to movement during service operations such as routine maintenance, flexible conductors shall be employed. The wiring shall be routed or protected to reduce the risk of damage to the insulation. If the wiring is exposed to the user, the wiring shall be one of the S series of cord specified in Group B of Table 12.2 and shall be provided with strain relief so that stress will not be transmitted to terminals or splices. See Strain Relief Test, Section 64.

12.1.10 With reference to 12.1.9, wiring that is subject to movement shall comply with the Wiring Endurance Test, Section 82A.

12.1.11 Conductors supplying general purpose receptacles are considered as complying with the temperature requirement of 12.1.2 if the conductors are sized according to Table 12.3. See 57.6.

Table 12.3
Conductors supplying receptacles

Marked rating, amp[a]	Conductor size, AWG (mm^2)
7.0 or less	18 (0.82)
10.0 or less	16 (1.3)
15.0 or less	14 (2.1)
20.0 or less	12 (3.3)

[a] As marked on the equipment. See 91.11 and 91.12.

12.1.12 The insulation of wires or cords connected to fan motors and other auxiliary motors shall be of an oil resistant type, such as Type SJO, SJT, SPT-3, or appliance wiring materials having oil resistant insulation.

12.1.13 If any failure of extra-low-voltage wiring may cause malfunctioning of a limiting device, motor overload protective device, or any other protective device, such wire shall be:

a) Enclosed as specified in 12.1.25;

b) Type SPT-2 or SP-2 cord; or

c) One of the types specified in Group B or C of Table 12.2.

Wires of types specified in Group A of Table 12.2, or wires having equivalent characteristics may be used if such wiring is located in a cavity or compartment of the equipment and is shielded from damage.

12.1.14 All splices and connections shall be mechanically secured and electrically bonded. A soldered connection shall be made mechanically secure before being soldered.

12.1.15 Splices shall be located within the equipment enclosure. They shall be secured in position or located in a separate enclosure so that they are not subject to flexing, motion, or vibration due to air movement, and the like. Strain relief shall be provided on the conductors if the wiring may be moved during servicing operations, such as replacing fuses, resetting manual-reset devices, or oiling motors.

12.1.16 A splice shall be provided with electrical insulation equivalent to that of the conductor insulation if permanence of spacing between the splice and other metal parts is not maintained. Thermoplastic tape wrapped over the sharp ends of conductors is not acceptable.

12.1.17 Splicing devices, such as pressure-type wire connectors, shall comply with the Standard for Wire Connectors, UL 486A-486B or the Standard for Splicing Wire Connectors, UL 486C.

12.1.18 A quick-connecting assembly shall:

a) Comply with the Standard for Electrical Quick-Connect Terminals, UL 310; or

b) Form a secure electrical connection, such as by detents in the mating parts, and shall be acceptable for carrying the current involved during the Temperature and Pressure Test, Section 57. Securement of connections may be determined by engagement/disengagement tests as specified in the Standard for Electrical Quick-Connect Terminals, UL 310.

12.1.19 Wire binding screws shall thread into metal. At terminals, stranded conductors shall be secured by soldered or pressure-type terminal connectors or the conductors shall be soldered or otherwise

assembled to prevent loose strands after assembly. Soldered connections shall be made mechanically secure before being soldered.

12.1.20 Open-slot type connectors shall not be used unless they are constructed to prevent disconnection resulting from loosening of the clamping means. If required spacings may be reduced below the minimum acceptable values by movement of the connector, the shanks of terminal connectors shall be protected by electrical insulation secured in position and not less than 0.028 in (0.71 mm) thick, except as permitted by 41.9.

12.1.21 Holes for passage of wires and cords through rigid partitions, such as walls, panels, or barriers shall have one of the following:

a) Smooth, rounded surfaces;

b) Be provided with smoothly rounded bushings fabricated from materials, such as ceramic, phenolic, cold-molded composition, or fiber; or

c) Be provided with wire insulating bushings that comply with the Standard for Insulating Bushings, UL 635.

12.1.22 A wiring enclosure formed between the cabinet shell, liner, molding, trim strips, or the like shall be constructed of metal or of nonmetallic material, see 9.1.3, and shall provide a smooth wireway with no sharp edges or sharp projecting screws that might damage the wire insulation. Wood framing may be employed in the cabinet-wireway enclosure, but other flammable thermal insulating material may not be in direct contact with the wiring unless it can be shown that a risk of fire is not introduced.

12.1.23 A printed wiring board for high-voltage circuits shall have a minimum flammability level of V-1 when tested according to the method outlined in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

12.1.24 Wiring shall be of the types indicated in Table 12.2 as follows:

a) Group A or B, or

b) Group C if the compartment enclosing the wiring:

1) Contains no openings other than for conduit or piping, and

2) Contains no flammable material other than electrical insulation.

12.1.25 Wiring not enclosed by means of conduit, electrical metallic tubing, metal raceways, or enclosures shall be enclosed according to 12.1.26 – 12.1.32.

12.1.26 No openings shall be located in the top of the compartment unless mechanical barriers or baffles are placed between the wiring and the openings.

12.1.27 No openings shall be located in the bottom of the compartment unless mechanical barriers or baffles are located under the wiring.

12.1.28 Louvers or openings located on the sides and top of the assembly shall not permit entrance of a 1/2 in (12.7 mm) diameter rod.

12.1.29 Openings shall not be located closer than 1/4 in (6.4 mm) to the wiring unless mechanical barriers or baffles are placed between the wiring and the openings.

12.1.30 Other than electrical insulation, wiring shall be separated from HB and HBF materials in accordance with 5.2.1, 5.2.2, or 5.2.3.

12.1.31 Group A wiring shall be cabled, routed, located or secured to reduce the risk of damage to the wiring when replacing fuses, adjusting control settings and other similar servicing.

12.1.32 Conductors of motor circuits having two or more thermal- or overcurrent-protected motors wired for connection to one supply line shall comply with one or more of the following:

a) A conductor shall have an ampacity of not less than one-third the ampacity of the branch circuit conductors as determined in 10.2.8;

b) A conductor shall be:

1) Size 18 AWG (0.82 mm^2) or larger,

2) Not more than 4 ft (1.2 m) in length, and

3) Protected by a fuse or equivalent overcurrent protective device rated not more than 60 amp.

c) A conductor shall serve as a jumper lead between controls and shall:

1) Not exceed 3 in (76.2 mm) in length, or

2) Be located in an electrical control enclosure.

d) A conductor shall withstand the Limited Short-Circuit Test, Section 73.

13 Separation of Circuits

13.1 Unless provided with insulation rated for the highest voltage involved, insulated conductors of different circuits, (internal wiring including wires in a wiring compartment) shall be separated by insulating barriers or shall be segregated, and shall, in any case, be so separated or segregated from uninsulated live parts connected to different circuits.

13.2 Segregation of insulated conductors may be accomplished by clamping, routing, or other means that maintains permanent separation from insulated or uninsulated live parts of a different circuit.

13.3 Field-installed conductors of any circuit shall be segregated or separated by insulating barriers from field- 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.

13.4 Except for wiring terminals, field-installed conductors of a high-voltage circuit or an extra-low-voltage circuit with National Electrical Code, ANSI/NFPA 70, Class 1 wiring shall be segregated or separated by insulating barriers as specified in (a) and (b):

a) From uninsulated live parts connected to a different circuit, other than wiring terminals, and

b) From any uninsulated live parts of electrical components, such as a pressure-limiting device, motor overload protective device, or other protective device, where short-circuiting or grounding may result in a risk of fire, electric shock, or injury to persons.

13.4.1 In reference to 13.4, Sections 41 – 43 specify the requirements for wiring terminals.

13.5 Field-installed conductors of an extra-low-voltage circuit with National Electrical Code, ANSI/NFPA 70, Class 2 wiring shall be segregated or separated by insulating barrier(s) from:

a) Uninsulated live parts a protective control which is part of an connected to a high-voltage circuit, and

b) Wiring terminals and any other uninsulated live parts of a protective control which is part of an extra-low-voltage circuit.

13.6 *Deleted*

14 Bonding for Grounding

14.1 Equipment shall have provision for the grounding of all exposed or accessible noncurrent carrying metal parts that are likely to become energized and that may be contacted by the user or by service personnel during service operations likely to be performed when the equipment is energized.

14.2 Except as specified in 14.2.1, uninsulated metal parts of the equipment, such as cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, heater element sheaths, capacitors and other electrical components, interconnecting tubing and piping, valves, and gauges, and refrigerant-containing parts shall be bonded for grounding if they are likely to become energized and are exposed to contact by the user or service personnel.

14.2.1 Metal parts that are not bonded in accordance with 14.2 shall be:

a) Adhesive-attached metal-foil markings, screws, handles, and the like, that are located on the outside of enclosures or cabinets and isolated from electrical components or wiring by grounded metal parts so that they are not likely to become energized;

b) Isolated metal parts, such as motor controller magnet frames and armatures or small assembly screws that are positively separated from wiring and uninsulated live parts;

c) Cabinets, panels, and covers that do not enclose uninsulated live parts if wiring is positively separated from the cabinet, panel, or cover so that such parts are not likely to become energized; or

d) Panels and covers that are insulated from electrical components and wiring by an insulating barrier.

14.3 Metal-to-metal hinge bearing members for a door or cover are acceptable as a means for bonding a door or cover for grounding if a multiple-bearing pin-type hinge(s) is employed.

14.4 An internal connection for bonding internal parts of the enclosure for grounding, but not for a field-installed grounding conductor or for the grounding wire in a power supply cord, may employ a quick connect terminal of the specified dimensions, provided that the connector is not likely to be displaced and the component is limited to use on a circuit having a branch circuit protective device rated as shown in Table 14.2.

Table 14.1
Bonding wire conductor size

Rating of device, amp	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	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

[a] Or equivalent cross-sectional area.

14.5 A separate component bonding conductor shall be of copper, a copper alloy, or other material acceptable for use as an electrical conductor. Ferrous metal parts in grounding path shall be protected against corrosion by metallic or nonmetallic coatings, such as enameling, galvanizing, or plating. A separate bonding conductor or strap shall be protected from mechanical damage or be located within the confines of the outer enclosure or frame, and not be secured by a removable fastener used for any purpose other than bonding for grounding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

14.6 The bonding shall be by a positive means, such as clamping, riveting, bolted or screwed connection, welding, or soldering and brazing materials having a softening or melting point greater than 850°F (455°C). The bonding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel. Bonding around a resilient mount shall not depend on the clamping action of rubber or other nonmetallic material except as indicated in 14.8.

14.7 With reference to 14.6, a bolted or screwed connection that incorporates a star washer under the screwhead or a serrated screwhead is acceptable for penetrating nonconductive coatings. If the bonding means depends upon screw threads, two or more screws or two full threads of a single screw shall engage the metal.

14.8 A connection that depends upon the clamping action exerted by rubber or other nonmetallic material is acceptable provided that it compiles with the requirements of the Current Overload Test, Section 71, and the Limited Short-Circuit Test, Section 73, under any normal degree of compression permitted by a variable clamping device and after exposure to the effects of oil, grease, moisture, and thermal degradation that may occur in service. Also, a clamping device is to be investigated to verify the likelihood of its being disassembled and reassembled in the intended fashion.

14.9 On cord connected equipment, a bonding conductor or strap shall have a cross-sectional area no less than that of the grounding conductor of the supply cord except as permitted by 14.12 and 14.13.

14.10 On permanently connected equipment, the size of a conductor employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch circuit overcurrent device to which the equipment will be connected. Except as indicated in 14.12 and 14.13, the size of the conductor or strap shall be in accordance with Table 14.1.

14.11 A conductor, such as a clamp or strap, used in place of a separate wire conductor as indicated in 14.10, is acceptable provided that the minimum cross-sectional conducting area is equivalent to the wire sizes indicated in Table 14.1.

14.12 A smaller conductor may be used if the bonding conductor and connection comply with the provisions of the Current Overload Test, Section 71, and the Limited Short-Circuit Test, Section 73.

14.13 The size of a bonding conductor to a motor or other electrical component need not be larger than the size of the motor-circuit conductors or the conductors supplying the component. See 12.1.2 and 12.1.32.

14.14 Splices shall not be employed in wire conductors used to bond electrical enclosures, motor frames, or other electrical components.

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

14.16 Functional grounding shall not be relied upon for equipment bonding.

Table 14.2
Internal terminal connections for bonding

Terminal dimensions, in (mm)	Rating of protective device, amp
0.020 by 0.187 by 0.250 (0.51 by 4.75 by 6.4)	20 or less
0.032 by 0.187 by 0.250 (0.81 by 4.75 by 6.4)	20 or less
0.032 by 0.205 by 0.250 (0.81 by 5.2 by 6.4)	20 or less
0.032 by 0.250 by 0.312 (0.81 by 6.4 by 7.9)	60 or less

ELECTRICAL COMPONENTS

15 Current-Carrying Parts

15.1 All current-carrying parts shall be of silver, copper, a copper alloy, or other material inherently resistant to corrosion and acceptable for use as an electrical conductor.

Exception: Multimetallic thermal elements and heater elements of a thermal protector need not be inherently resistant to corrosion.

15.2 Aluminum may be used as a current-carrying part if treated to resist oxidation and corrosion.

15.3 Iron or steel shall not be used for current-carrying parts.

Exception: Iron or steel, if provided with a corrosion resistant coating, or stainless steel may be used for a current-carrying part if used in inherent construction of a component such as within a motor.

16 Insulating Material

16.1 Material for the mounting of uninsulated live parts shall be porcelain, phenolic composition, or other material having equivalent electrical and mechanical properties.

16.2 If vulcanized fiber is used for insulating bushings, washers, separators, and insulating barriers, it shall not be the sole support for uninsulated live parts if shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock. Nonmetallic materials used for the sole support of uninsulated live parts shall comply with the insulating barrier requirements in 7.2(c).

17 Switches and Controllers

17.1 Except as specified in 17.3, a motor controller(s) used for controlling the loads involved shall be provided for all equipment incorporating two or more motors, or a motor(s) and other load(s) intended for connection to the same power supply.

17.2 In reference to 17.1, if the attachment plug and receptacle serve as the controller on a cord connected product, then the marked ampere rating of the product shall not exceed the values shown in Table 17.1 for the voltage indicated.

Table 17.1
Ampere rating

Amperes	Voltage
7.2	115
4.0	208
3.6	230

17.3 In reference to 17.1, if a motor controller is not provided, the product shall be intended for permanent connection to the supply circuit such that:

a) The supply circuit supplies one or more motors and other loads;

b) The product is marked to specify that the maximum size of the supply circuit overcurrent protective device for that circuit shall not exceed 20 amperes at 125 V or less or 15 amperes at 600 V or less;

c) The rating of any motor in the circuit shall not exceed 1 horsepower (746 W); and

d) The motor full load or maximum operating current rating shall not exceed 6 amperes.

17.4 A single-pole switching device, including an automatic control having a marked “off” position, shall not be connected to the identified grounded conductor.

17.5 Cord connected equipment shall be provided with a manually operable switch that will shut off the complete equipment or will shut off any motor load exceeding the values shown in 17.2. Such switches shall have a marked “off” position and, if the switch does not control the complete equipment, shall indicate which load it controls, such as compressor, fan motor, or the like. The switch shall be accessible without the use of tools.

Exception: The off position of the switching devices or the main disconnect switch on equipment, may be identified by the “off” symbol illustrated in Figure 17.1.

17.6 A switching device that interrupts the main power supply circuit to a heater of permanently connected equipment shall disconnect all ungrounded conductors of the power supply circuit if the switching device or the pilot device that controls the switching device has a marked “on” or “off” position.

Exception: Both the on and off positions of the switching devices or the main disconnect switch on equipment, may be identified by the symbols illustrated in Figure 17.1.

Figure 17.1

On and off symbols

IEC Publication 417, Symbols 5007 and 5008

17.7 Motor controllers shall be arranged so that they will simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

Exception: This requirement does not apply to crankcase heating arrangements where the circuit is arranged to permit current flow through a capacitor in series with the start winding of single-phase motors with the motor not operating.

17.8 Switching devices shall be housed within an enclosure that will protect coils and contacts against mechanical damage, dirt, and moisture. The enclosure of the switching device may be provided by its method of mounting within the equipment enclosure, by inherent construction of the component, or by means of a separate enclosure.

17.9 *Deleted*

17.10 The current rating of a switch or other control device shall comply with 17.11 – 17.13, as applicable.

17.11 Except as specified in 17.11.1, a manually operated switch with a marked off position that controls a hermetic refrigerant motor-compressor with or without other loads shall have a current rating that is at least 115 percent of the sum of:

a) The rated load, maximum rated current or branch-circuit selection current of the motor-compressor, whichever is greater, and

b) The rated current for other controlled loads.

17.11.1 If a motor controller does not have a current rating sized at least 115 percent of the loads as specified in 17.11, then:

a) The controller shall not be a manually operated switch;

b) The equipment shall be marked with a branch-circuit selection current; and

c) The controller shall have a current rating that is not less than the sum of the branch-circuit selection current plus any additional loads controlled.

17.12 A switch provided for the control of an inductive load, such as a transformer, shall have a voltage rating of not less than the potential of the circuit in which it is used and a current rating of not less than:

a) The total marked current ratings of the inductive loads that it controls if an ac general-use snap switch is used; or

b) Twice the total marked current ratings of the inductive loads that it controls if a switch other than an ac general-use snap switch controls the inductive load.

17.13 The current interrupting capacity of a switching device that controls a motor load, such as a motor-compressor, shall equal the locked-rotor current, maximum operating current or maximum rated current of the largest motor load plus the full load or maximum operating current of any other loads controlled by the switch.

17.14 Except as specified in 17.11 – 17.13, a switch or other control device shall be rated for the load which it controls as determined by the Temperature and Pressure Test, Section 47. Items to consider in determining the device rating could include the voltage, current, power factor, control device ambient temperature and other similar parameters. Power factor requirements for each specific load type are specified in 69A.5.

17.14.1 A speed-control switch shall be provided as part of a product that employs a variable-speed or multispeed motor.

17.15 A protective control, other than a motor or motor-compressor overload protective device (covered in Section 19), shall comply with one of the following:

a) Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6. The endurance cycle requirements in Table AA.1DV of UL 60730-2-6 for cut-outs shall be applied.

b) Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9. The endurance cycle requirements in Table CC.2 of UL 60730-2-9 for cut-outs shall be applied.

c) Standard for Industrial Control Equipment, UL 508.

d) Standard for Nonindustrial Photoelectric Switches for Lighting Control, UL 773A;

e) Standard for Fan Speed Controls, UL 1917;

f) Standard for Clock-Operated Switches, UL 917;

g) Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1; or

h) Paragraph 17.18.8 and the protective electronic circuits tests in Section 85A.

17.16 In reference to 17.15 (c) – (h), the endurance cycle requirements in Table CC.2 of UL 60730-2-9 for cut-outs shall be applied to such controls.

17.16.1 In reference to 17.15 (a), (b), and (h), when determining the acceptability of a protective control, the control pollution degree shall be as specified in 43.4 – 43.7.

17.16.2 If the protective control has a protective electronic circuit, the relevant factors outlined in Table 19.2 shall be applied.

17.16.3 Software, including that which can be updated by a remote operation and which is a required part of a protective electronic circuit, shall comply with one of the following:

a) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, as well as the specific applicable Part 2 and with the requirements for a Class B or C control function;

b) Annex R, Software Evaluation, of the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, and also comply with the relevant requirements within Annex H.11.12, Controls Using Software, of UL 60730-1 for a software Class B or C control function; or

c) Not create any risk of fire, electric shock, or injury to persons under abnormal conditions with the software rendered ineffective, e.g., use of independent redundant protective devices.

17.16.4 In reference to 17.16.3, a remote software update shall occur while the equipment is energized but only if the various loads (motor-compressor, fans, etc.) are de-energized. Software enforcing de-energizing of the loads shall have at least a Class A control function, or equivalent.

17.16.5 In reference to 17.5, a device providing motor overload protection shall comply with the requirements in Section 19.

17.16.6 The cutout calibration temperature of a heater protective (temperature-limiting) control shall be ±10°F (±6°C) of its maximum marked set-point temperature.

17.16.7 The cutout calibration pressure of a pressure protective (limiting) control shall not exceed 105 percent of its maximum marked setting.

17.17 A protective control shall:

a) Be an integral part of the equipment; and

b) Control the load(s) directly except as specified in 17.17.1.

17.17.1 If a protective control indirectly controls the load through a switching device, the switching device shall comply with the endurance cycle requirements in 17.15 or 17.16. The switching device shall be an integral part of the equipment.

17.18 Except as specified in 17.18.1, an operating control, including of the electronic type, shall comply with:

a) One of the standards specified in 17.15;

b) Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1; or,

c) The requirements in this Standard as far as they reasonably apply.

17.18.1 An operating control not complying with 17.18 shall comply with 17.18.2(a) if the control is electronic and in addition:

a) Shall be powered entirely by no more than one low-voltage circuit; comply with the Limiting Impedance Test in UL 508; or, comply with the low-power circuit requirement determined as specified in 19.11.1 of the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1; and

b) If used to control a motor-compressor or electric heater, shall comply with the endurance cycle requirements in:

1) UL 60730-2-9, Table CC.2, for air conditioning and refrigeration applications; or

2) The Overload and Endurance Test for Operating Controls, Section 69A.

17.18.2 An operating control that complies with 17.18 shall also comply with all the following:

a) For electronic controls – Installation Class 2 for electromagnetic compatibility (EMC) shall be in accordance with the voltage surge testing in 85A.3.6 and comply with the results specified in 85A.3.2;

b) Category II shall be the overvoltage category;

c) Insulating materials shall have a minimum comparative tracking index (CTI) of 100 (Material Group III);

d) The applicable pollution degree shall be as specified in 43.4 – 43.7;

e) The operating control cycle requirements specified by one of the following:

1) For other than a self-resetting motor-compressor or electric heater operating control, Table CC.2 of UL 60730-2-9, with the operating control (temperature limiters) endurance cycle requirements for other than air-conditioning and refrigeration applications being applied;

2) For a self-resetting motor-compressor or electric heater operating control – Table CC.2 of UL 60730-2-9, with the operating control (temperature limiters) cycle requirements for self-resetting controls for air conditioning and refrigeration applications being applied; or

3) The Overload and Endurance Test for Operating Controls, Section 69A.

17.18.3 If an operating control complying with 17.18 indirectly controls a load through a switching device, the operating control endurance cycle requirements in 17.18.2(e) shall be applied to the switching device.

17.18.4 If an operating control as referenced in 17.18.1 indirectly controls a motor-compressor or electric heater through a switching device, the operating control endurance cycle requirements in 17.18.1(b) shall be applied to the switching device.

17.18.5 Operating and Protective ("Safety Critical") Control Functions, Appendix B, shall be referenced to determine whether a control function is considered to result in a risk of fire, electrical shock or injury to persons.

17.18.6 If a control can be used to reduce the risk of fire, electric shock or injury to persons under abnormal operating conditions of the product, but a redundant control (of similar or different design) operates to perform the identical function, the circuit shall be evaluated to determine which control will be relied upon as the protective control. The control determined to be the protective control shall comply with the protective control requirements in 17.15. The control determined to be the operating control is not required to comply with the protective control requirements but shall comply with the operating control requirements 17.18.1, or with 17.18 and 17.18.2.

17.18.7 A thermistor shall comply with Annex J of UL 60730-1 or the Standard for Thermistor-Type Devices, UL 1434. The calibration shall be as specified in 17.16.6. If a thermistor is used:

a) To reduce the risk of fire, electric shock or injury to persons under abnormal operating conditions of the product, the minimum number of endurance cycles shall be 100,000.

b) In other sensing applications of the product, the minimum number of endurance cycles shall be 6,000.

17.18.8 A protective control as referenced in 17.15(h) and having a protective electronic circuit:

a) In which electronic disconnection of the circuit could fail, shall have at least two components whose combined operation provides the load disconnection;

b) Shall prevent a risk of fire, electric shock or injury to persons under the relevant fault conditions specified in 85A.2;

c) In which an overcurrent protective device opens during application of any of the fault conditions specified in 85A.2, shall utilize an overcurrent protective device complying with the requirements applicable to that component. The fault condition causing the overcurrent protective device to open shall be repeated and the overcurrent protective device shall again open the protective electronic circuit. If the overcurrent protective device complies with IEC 60127-1 Standard for Miniature Fuses: Part 1, Definitions for Miniature Fuses and General Requirements for Miniature Fuse-Links as well as an applicable Part 2, then the protective device shall additionally comply with the Fuse-Link Test in 85A.5;

d) In which a conductor of the printed wiring board becomes open-circuited during the fault conditions test in 85A.2, then:

1) The printed wiring board shall comply with the Needle-Flame Test in Annex E of Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1 or have a minimum flammability rating of V-0 when tested in accordance with the vertical flame test described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94;

2) Any loosened conductor shall not reduce spacings below the values specified in the relevant Sections 41 – 43; and

3) The specific test in which the printed wiring became open-circuited shall be repeated a second time. There shall be no risk of fire, electric shock or injury to persons and spacings shall not be reduced below the values specified in the relevant Sections 41 – 43;

e) Shall maintain its required functions when subjected to the EMC related stresses specified in the Electromagnetic Compatibility (EMC) Tests, 85A.3; and

f) That relies upon a programmable component for one or more of its safety functions shall be subjected to the Programmable Component Reduced Supply Voltage Test, 85A.4, unless restarting at any point in the operating cycle after interruption of operation due to a supply voltage dip will not result in a risk of fire, electric shock or injury to persons. The test shall be carried out after removal of all batteries and other components intended to maintain the programmable component supply voltage during supply source (mains) voltage dips, interruptions and variations.

17.19 A general-use snap switch shall comply with the Standard for General-Use Snap Switches, UL 20.

17.19.1 A thermal cutoff shall comply with the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

17.20 Female devices (such as receptacles, appliance couplers, and connectors) that are intended, or that may be used, to interrupt current, shall be suitably rated for current interruption of the specific type of load, when evaluated with its mating plug or connector. For example, an appliance coupler that can be used to interrupt the current of a motor load shall have a suitable horsepower rating when tested with its mating plug.

17A Remotely Operated Equipment

17A.1 Any function of a product enabled in response to external communication or data signals shall be considered when determining normal and abnormal conditions of the product.

17A.2 Except as specified in 17A.3, a manual control shall be provided on a product such that actuation of the control is required before the product can be operated in any mode that permits remote operation, external communication or receiving/sending data signals.

17A.3 In reference to 17A.2, a product not provided with a manual control for actuating remote operation, external communication or receiving/sending data signals shall be:

a) Capable of remote operation, external communication or receiving/sending data signals only within line-of-sight; or

b) Limited only to monitoring external communication or data signals.

17A.4 A product shall include a means to manually disconnect, disable or override any remote operation commands, external communication or data signals. If the product attachment plug and receptacle serve as the manual means to disconnect data signals or remote operation commands, the product shall comply with 94.13.

17A.5 A control that operates in response to remote operation commands, external communication or data signals shall not introduce an operating condition or state that could lead to a risk of fire, electric shock or injury to persons. In addition, such a control shall not:

a) Render inoperative any protective control or protective control function within the product;

b) Alter the order of control response such as by forcing a protective control to operate instead of another control that would normally be intended to respond;

c) Reset any protective manual reset feature;

d) Supersede the response of any protective control; or

e) Alter the response to or expected performance of:

1) User actuation of controls, movement of doors, covers, grills, filters or the like; or

2) User interaction with any parts of the product that could result in exposure of hazardous electrical parts, moving parts, hot parts or radiation.

17A.6 Compliance with 17A.5 shall be determined by one of the following:

a) Using methods appropriate for determining the performance and reliability of protective control functions in accordance with Section 17, Switches and Controllers; or

b) Examining the product circuit diagram(s) to determine that a control which operates in response to remote operation commands, external communication or data signals operates wholly independent of the protective controls of the product and therefore is incapable of adversely affecting the operation of any protective controls.

18 Motors

18.1 Nonhermetic motors shall comply with the requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

18.2 Motors having openings in the enclosure or frame shall be arranged to reduce the risk of particles falling out of the motor onto flammable material within or under the assembly.

18.3 The requirement in 18.2 will necessitate the use of a mechanical barrier under an open-type motor unless:

a) The structural parts of the motor or of the equipment, such as the bottom closure, provide the equivalent of such a barrier, or

b) The motor overload protective device provided with the motor is such that no burning insulation or molten material falls to the surface that supports the equipment when the motor is energized under each of the following fault conditions applicable to the motor type:

1) Open main winding,

2) Open starting winding,

3) Starting switch short-circuited,

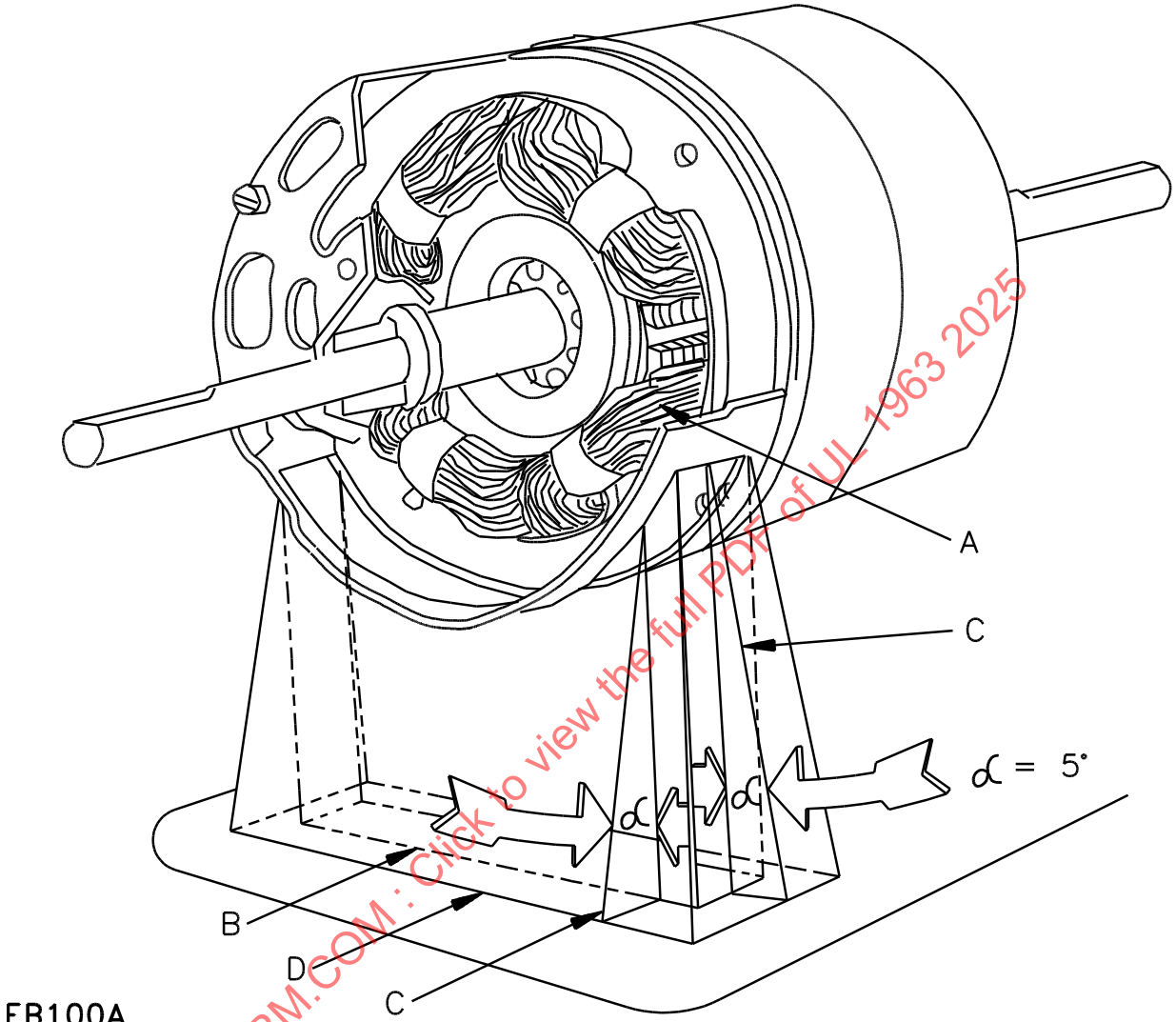
4) Capacitor shorted (permanent split capacitor type), or

c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will prevent the temperature of the motor windings from exceeding 257°F (125°C) under the maximum load under which the motor will run without causing the protector to cycle and 302°F (150°C) with the rotor of the motor locked.

18.4 The mechanical barrier mentioned in 18.3 shall be horizontal, shall be located and have an area not less than that described in Figure 18.1. If openings for drainage, ventilation, and the like, are employed in the barrier, such openings shall not permit molten metal, burning insulation, or the like, to fall onto flammable material that is part of or located underneath the refrigerant recovery/recycling equipment.

Figure 18.1

Location and extent of barrier



A – Motor winding to be shielded by barrier. This is to consist of the entire motor winding when it is not otherwise shielded, and is to consist of the unshielded portion of a motor winding which is partially shielded by the motor enclosure or equivalent.

B – Projection of outline of motor winding on horizontal plane.

C – Inclined line which traces out minimum area of the barrier. When moving, the line is to be always (1) tangent to the motor winding, (2) five degrees from the vertical, and (3) so oriented that the area traced out on a horizontal plane is maximum.

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

19 Motor Overload Protection

19.1 General

19.1.1 A fuse shall not be used as a motor protective device unless the motor is protected by the largest size fuse that can be inserted into the fuseholder.

19.1.2 Equipment shall start and operate as intended when a fuse or circuit breaker provides the required motor protection.

19.1.3 Overcurrent protective devices and thermal protective devices for motors shall comply with applicable short-circuit requirements for the class of protective device and shall, in addition, comply with the requirements of the Limited Short-Circuit Test, Section 73.

19.2 Protection of single-phase nonhermetic motors

19.2.1 All single-phase motors other than a hermetic refrigerant motor-compressor shall be protected by one or more of the following:

a) A separate device responsive to motor current and rated or set to trip at not more than the percentage of the motor nameplate full-load or maximum operating current rating as specified in Table 19.1.

b) A separate overload device which combines the functions of overload and overcurrent protection and is responsive to motor current. Such a device shall be set at values not greater than the percentages of the motor nameplate full-load or maximum operating current rating as specified Table 19.1.

c) Impedance protection complying with the Standard for Impedance Protected Motors, UL 1004-2.

d) A protective device integral with the motor that complies with the Standard for Thermally Protected Motors, UL 1004-3.

e) Protective electronic circuits integral to the motor that comply with the Standard for Electronically Protected Motors, UL 1004-7 or with the requirements in Section 17 applying to protective electronic circuits.

f) Other protection that is shown by test to be equivalent to the protection specified in (a) to (e).

19.2.1.1 In reference to 19.2.1 (d) and (e), a motor that moves air by means of a fan that is not integrally attached, keyed, or otherwise fixed directly to the motor shaft shall be evaluated for running heating protection.

19.2.2 In reference to 19.2.1 (a) and (b), if the percentage protection specified in Column A of Table 19.1 does not correspond to the percentage value of an overload device of a standard size, the device of the next higher size may be used. However, the device of the next higher size shall provide protection no higher than that indicated in Column B of Table 19.1.

Table 19.1
Overload relay size

Motor	Maximum percentage protection	
	A	B
Motor with a marked service factor no less than 1.15	125	140
Motor with a marked temperature rise no more than 72°F (40°C)	125	140
Any other motor	115	130

19.2.3 *Deleted*

19.2.4 With reference to 19.2.1(e), the relevant factors outlined in Table 19.2 shall be applied if evaluating the acceptability of a protective electronic circuit.

Table 19.2
Factors to apply if evaluating protective electronic circuits

1	Conducting failure-mode and effect analysis (FMEA) for the protective circuits and functions.
2	Electrical supervision of critical components resulting in the control becoming permanently inoperative and disconnecting power.
3	Temperature ranges as follows: Indoor Equipment 32.0 ±3.6°F (0.0 ±2°C) and 104 ±3.6°F (40.0 ±2°C) Outdoor Equipment minus 31.0 ±3.6°F (minus 35.0 ±2°C) and 104 ±3.6°F (40.0 ±2°C)
4	Cycling test duration: 14 days
5	Endurance test duration: 100,000 cycles
6	Radio-frequency electromagnetic field immunity: A. To conducted disturbances – test level 3 B. To radiated electromagnetic fields Evaluate in accordance with 85A.3.4 and 85A.3.2.
7	Humidity exposure: Indoor Equipment 70 – 80°F (21.1 – 26.7°C) and minimum 50 percent relative humidity Outdoor Equipment Same as indoor equipment except minimum 98 percent relative humidity
8	Electrical fast transient/burst immunity: Outdoor Equipment Test level 4 All Other Equipment Test level 3
9	Surge immunity: Outdoor Equipment Installation Class 4 All Other Equipment Installation Class 3
10	Electrostatic Discharge with a Severity Level of 3 having contact discharge at 6 kV to accessible metal parts and Air discharge at 8 kV to accessible parts of insulating material.
11	Voltage Dips and Interruptions: Evaluate in accordance with 85A.3.8 and 85A.3.2.
12	Harmonics and Interharmonics: Evaluate in accordance with 85A.3.9 and 85A.3.2.
13	Calibration (deviation and drift): Evaluate in accordance with 17.16.6 for a temperature protective control or 17.16.7 for a pressure protective control.

19.3 Protection of single-phase hermetic refrigerant motor-compressors

19.3.1 Single-phase hermetic refrigerant motor-compressors shall be protected by one or more of the following:

a) A separate overload relay that is responsive to motor compressor current and will trip at not more than 140 percent of the rated load or maximum rated current of the motor compressor;

b) A thermal protector integral with the motor compressor or a protective system that complies with the applicable requirements in the Standard for Safety of Household and Similar Electrical Appliances – Part 1: General Requirements, UL 60335-1, together with the Standard for Safety of Household and Similar Electrical Appliances – Part 2: Particular Requirements for Motor-Compressors, UL 60335-2-34; or

c) An overcurrent device, such as a fuse or circuit breaker, responsive to motor current, and rated at no more than 125 percent of the motor-compressor rated-load or maximum rated current.

19.3.2 In reference to 19.3.1 (b), a motor-compressor protector or protective system shall not permit a continuous current in excess of 156 percent of the motor-compressor rated load current or branch-circuit selection current (if the latter is marked), unless:

a) The equipment is intended for connection to a 15- or 20-amperes, 120 volt or a 15-ampere, 208- or 240 volt, single phase branch circuit; or

b) The motor-compressor protector or protective system is provided by an adjustable speed drive system.

19.3.2.1 Each component of the protective system specified in 19.3.1(b) or 19.3.2(b) shall be provided as part of the equipment.

19.3.3 The values of rated-load current and branch-circuit-selection current specified in 19.3.2 shall be the values marked on the equipment nameplate. For equipment marked with a single-ampere rating, the rated load current as specified in 19.3.2 shall be the current drawn by the motor-compressor during the Temperature and Pressure Test, Section 57.

19.4 Protection of three-phase motors

19.4.1 Three-phase motors shall be protected by:

a) Three properly rated overcurrent units, each complying with 19.2 or 19.3; or

b) Other protective methods if the methods provide protection under primary single-phase failure conditions. Equipment with such protective methods shall be marked as described in 92.21.

20 Fuseholders

20.1 Except as specified in 20.1.1, a fuseholder shall be installed, or protected so that uninsulated high-voltage live parts located within 4 in (102 mm) from the insulating body of a fuse, are not exposed to contact by persons removing or replacing fuses. An insulationg barrier employed as a guard for uninsulated high-voltage live parts shall comply with 7.1.1 – 7.3.

20.1.1 In reference to 20.1, uninsulated high-voltage live parts not complying with 20.1 shall be:

a) The screw shell of a plug fuseholder;

b) Cartridge fuse clips; or

c) Wiring terminals to the fuseholder.

20.2 Fuseholders shall either comply with the Standard for Fuseholders, UL 512, or with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, in conjunction with any of the associated Standards tabulated below, as applicable for the class of fuseholder:

a) Standard for Fuseholders – Part 4: Class CC, UL 4248-4; or

b) Standard for Fuseholders – Part 5: Class G, UL 4248-5; or

c) Standard for Fuseholders – Part 8: Class J, UL 4248-8; or

d) Standard for Fuseholders – Part 9: Class K, UL 4248-9; or

e) Standard for Fuseholders – Part 11: Type C (Edison Base) and Type S Plug Fuse, UL 4248-11; or

f) Standard for Fuseholders – Part 12: Class R, UL 4248-12; or

g) Standard for Fuseholders – Part 15: Class T, UL 4248-15.

20.3 The screw shell of a plug fuseholder used in a high-voltage circuit shall be connected toward the load.

20.4 A plug fuseholder of the Edison-base type shall be provided with an adapter designed for Type S fuses.

21 Receptacles

21.1 Unless intended to be connected to a power supply separate from that supplying other loads, a receptacle intended for general use shall be rated at 15 or 20 amp, 125 or 250 V. All general use receptacles shall be of the grounding type.

21.2 Receptacles shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

21.3 Special purpose receptacles shall be of the grounding type.

21.4 Receptacles shall be located so that liquid due to overflow, splashing, leakage, and cleaning will not enter the receptacle. This will require the face of the receptacle to be mounted not less than 60 degrees from the horizontal.

22 Receptacle Overcurrent Protection

22.1 Overcurrent protection shall be provided as part of the equipment for each receptacle included in the equipment.

Exception No. 1: Overcurrent protection is not required if the receptacle is intended to be connected to a power supply separate from that supplying the equipment. See 92.23.

Exception No. 2: Overcurrent protection is not required if the equipment can be connected to a branch circuit rated at not more than 20 amp in accordance with the National Electrical Code, ANSI/NFPA 70, and is not marked as specified in 91.12.

22.2 The overcurrent protection specified in 22.1 shall be provided by a circuit breaker(s) or fuse(s) acceptable for branch circuit use. A 15 amp protective device shall be provided if a single 15 amp

receptacle outlet is furnished. Two or more 15 amp receptacles (two separate receptacles or a duplex receptacle) shall be protected by either a 15 or 20 amp protective device. A 20 amp receptacle or a combination 15 and 20 amp receptacle shall be protected by a 20 amp protective device.

Exception: A receptacle circuit may be protected by an overcurrent protective device rated less than indicated above provided the rating equals the receptacle load which is marked on the equipment. See 91.12. If the equipment is intended for connection to a branch circuit rated at not more than 20 amp, the overcurrent protective device provided for the receptacle circuit may be of the supplementary type.

23 Valves and Solenoids

23.1 An electrically operated valve or solenoid shall comply with the Standard for Electrically Operated Valves, UL 429 or comply with the requirements of the Burnout Test, Section 65.

24 Capacitors

24.1 A motor start or run capacitor shall comply with the Standard for Capacitors, UL 810 or shall:

a) Be housed within a cabinet, enclosure or other similar container which will protect the plates against mechanical damage and which will prevent the emission of flame or molten material resulting from failure of the capacitor.

b) Have a capacitor container that is protected against corrosion as specified in 9.3.1 if a ferrous metal capacitor container is exposed to the effects of weathering, and be:

1) Made of coated or uncoated sheet steel having a thickness of not less than 0.020 inch (0.51 mm); or

2) Mounted within the equipment cabinet or enclosure if the sheet steel is thinner than 0.020 inch (0.51 mm) or if materials other than metal are used as the capacitor container.

c) Be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions as specified in the Limited Short-Circuit Test, Section 73. The conditions for the Limited Short-Circuit Test shall be based on:

1) The circuit on which the capacitor is used;

2) Not less than the current specified in Table 73.1; or

3) Not less than the current established by dividing the circuit voltage by the impedance of the other component(s), if the available fault current is limited by other components in the circuit, such as a motor start winding.

24.2 *Deleted*

24.3 *Deleted*

24.4 If the container of an electrolytic capacitor is metal, the container shall be considered as a live part and shall be provided with moisture-resistant electrical insulation to isolate it from dead metal parts and to prevent contact during servicing operations. The insulating material shall be not less than 1/32 in (0.8 mm) thick except as indicated in 41.9.

24.5 *Deleted*

24.6 Across-the-line capacitors, antenna-coupling components, line-bypass components and fixed capacitors for use in electronic equipment shall comply with the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14 and shall have specifications as follows:

a) Operating voltage – Not less than 110 percent of the equipment rated voltage.

b) For capacitors connected across the line (phase-to-phase) – Subclass X1 (≤ 4.0 kV) or X2 (≤ 2.5 kV) for impulse voltage (based on minimum Overvoltage Category of II).

c) For capacitors connected from line to ground – Subclass Y1 or Y2 for any equipment having a rated voltage not exceeding 500 volts; or as an alternate, subclass Y4 if the equipment has a rated voltage not exceeding 150 volts.

d) Upper category temperature – Based on the maximum capacitor surface temperature measured during the Temperature and Pressure Test in Section 57, but not less than 185ºF (85ºC).

e) Lower category temperature – Based on the minimum surface temperature for which the capacitor has been designed to operate when installed within equipment as intended, but not greater than 14ºF (-10ºC).

f) Duration of the damp-heat steady-state test – Not less than 21 days.

g) Passive flammability category B or C. As an alternate, a polymeric capacitor case shall have a V-0 flame rating as described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

24.7 In reference to 24.6, a capacitor shall consist of a single Class Y1 capacitor or two Class Y2 capacitors connected in series if it is connected between:

a) Two line conductors in a primary circuit;

b) One line conductor and the neutral conductor;

c) Primary and accessible secondary circuits; or

d) The primary circuit and protective earth (equipment grounding conductor connection).

25 Transformer Protection

25.1 High-voltage transformer

25.1.1 General

25.1.1.1 A transformer (including an autotransformer), other than one as described in 25.1.3.4, is considered to be a high-voltage transformer and shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2. Except as indicated in 25.1.1.2, the transformer shall also:

a) Be provided with thermal overload protection in accordance with the requirements in 25.1.2.1, or

b) Be protected by an overcurrent device in accordance with the requirements in 25.1.3, or

c) Comply with the Burnout Test – High-Voltage Transformers, Section 66.

25.1.1.2 A transformer not complying with (a), (b) or (c) of 25.1.1.1 shall be:

a) Used only to energize a control and not loads such as motors or heaters;

b) Rated less than 50 VA;

c) Supplied as an integral part of a motor-controller; and

d) Located within the motor-controller enclosure.

25.1.2 Thermal protection

25.1.2.1 If a high-voltage transformer is provided with a thermal overload protective device, the device shall be arranged to interrupt primary current and shall limit temperatures of the transformer windings, under overload conditions, to that permitted for the class of insulation employed in the windings. See Overload Test – High-Voltage Transformers, Section 69.

Exception: If the thermal overload protective device provided is a nonrenewable thermal cutoff, a burnout test is to be conducted in place of the overload test. See Burnout Test – High-Voltage Transformers, Section 66.

25.1.2.2 A manual or automatic resetting thermal protector for a high-voltage transformer shall have an endurance rating of not less than 6000 cycles and shall have a cutout calibration temperature that is within ±10°F (±6°C) of its maximum marked set-point temperature.

25.1.3 Overcurrent protection

25.1.3.1 When a high-voltage transformer is protected by an overcurrent device, such protection shall comply with the requirements specified in 25.1.3.2, 25.1.3.3 and 25.2.1 – 25.2.3.

25.1.3.2 Except as noted in 25.1.3.3, a high-voltage transformer shall be protected by an overcurrent device(s) located in the primary circuit and rated or set as indicated in Table 25.1. See 25.2.1.

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

25.1.3.3 When the circuit supplying a transformer other than an autotransformer is provided with overcurrent protection rated or set at not more than 250 percent of the rated primary current of the transformer, additional overcurrent protection is not required in the primary circuit provided the secondary circuit is protected at not more than 125 percent of the rated secondary current of the transformer. See 25.2.2.

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

Exception No. 2: When the rated secondary current of the transformer is less than 9 amp, the overcurrent device(s) in the secondary circuit may be rated or set at not more than 167 percent of the rated secondary current.

Table 25.1
Rating of overcurrent devices

Related primary current, amp		Maximum rating of overcurrent device, percent of transformer primary current rating
Transformer other than an autotransformer	Autotransformer	
Less than 2	–	300[a]
2 or more, less than 9	Less than 9	167
9 or more	9 or more	125

[a] May be increased to 500 percent if transformer supplies a motor control circuit.

25.1.3.4 A transformer that directly supplies a National Electrical Code, ANSI/NFPA 70, Class 2 circuit (see 3.7) shall, in accordance with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, either limit the output current (inherently limited transformer) or be equipped with an overcurrent device (not inherently limited transformer).

25.2 Overcurrent protective device

25.2.1 Overcurrent protection in the primary circuit of a transformer, as described in 25.1.3.2, need not be provided as part of the equipment if, based on the marked rating or ratings of the equipment, the rating of the branch circuit overcurrent protective device or devices does not exceed the values specified in 25.1.3.2.

25.2.2 Overcurrent protection in the secondary circuit of a transformer, as required by 25.1.3.3, shall be provided as part of the equipment.

25.2.3 A required transformer overcurrent protective device(s) provided as part of the equipment shall:

a) Be provided for all ungrounded conductors,

b) Be sized in accordance with requirements in 25.1.3.2 and 25.1.3.3, as applicable, and

c) Have a voltage rating not less than the circuit in which it is used.

The device(s) shall be a circuit breaker acceptable for branch circuit protection or a fuse acceptable for branch circuit protection, such as a Class CC, G, J, K, L, R, or T cartridge fuse or Type S plug fuse. See 91.17.

Exception: If a transformer supply is tapped from a circuit supplying other loads in the equipment, a device used for overcurrent protection may be of the supplementary type provided it has a short-circuit rating acceptable for the circuit in which it is used. See Table 73.1. If the supplementary type device used is a fuse, the equipment shall be marked in accordance with the requirements in the Exception to 91.17.

25.2.4 In reference to 25.2.3, Class H fuses shall not be used.

25.3 Secondary circuits – general

25.3.1 Requirements for high-voltage circuits shall be used in evaluating a secondary circuit unless the secondary circuit:

a) Is not relied upon to reduce a risk of fire, electrical shock, or injury to persons, and

b) Complies with the requirements for an extra-low-voltage electrical circuit in 25.4.

25.3.2 A wiring compartment or the equivalent for field-wiring terminals for a secondary circuit shall be separate from a wiring compartment for other terminals. The use of a barrier or partition to separate the secondary circuit from the other terminals is acceptable.

25.3.3 Except as specified in 25.3.3.1, a secondary circuit shall not be connected to the frame of the product at more than one point.

25.3.3.1 In reference to 25.3.3, if a grounding bus is connected to the frame at more than one point and used as the return path for a secondary circuit, the bus shall be sized for the ampacity of the secondary circuit.

25.3.4 The frame shall not be used as the return path for an extra-low-voltage circuit.

25.3.5 If any secondary circuit having an open circuit potential of more than 42.4 V peak is connected to the frame of a product, all dead metal parts that may become energized and are exposed or are within the enclosure and can be touched by a person during operator servicing shall be permanently connected together.

25.3.6 A power supply having an output that is other than extra-low-voltage shall comply with one of the following:

a) Standard for Power Units Other Than Class 2, UL 1012;

b) Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1; or

c) Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

25.4 Extra-low-voltage electrical circuits

25.4.1 An extra-low-voltage electrical circuit shall be supplied from:

a) A Class 2 transformer; or

b) A Class 2 power supply complying with the Standard for Class 2 Power Units, UL 1310;

c) A power supply complying with the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, with an output marked “Class 2” or that complies with the limited power source (LPS) requirements and is marked “LPS”;

d) A power supply complying with the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1 and with the limited power source requirements and is marked “LPS”; or

e) An isolating transformer having an open circuit sinusoidal potential of 30 V rms (42.4 V peak) or less, and that includes at least one of the following means, that limits the power available to the levels specified for a Class 2 transformer.

1) A fixed impedance

2) A noninterchangeable fuse – the largest fuse that fits in the fuseholder provided – or a marking for fuse replacement adjacent to the fuseholder in accordance with 91.27.

3) A nonadjustable manually reset circuit protector; or

4) A regulating network.

25.4.1.1 A switch mode power supply unit not complying with 25.3.6 or 25.4.1 shall comply with the relevant requirements in this Standard, including the Switch Mode Power Supply Units – Overload Test, Section 69B.

25.4.2 With reference to 25.4.1(e)(1) and (4), if the performance of a fixed impedance or regulating network may be adversely affected by the short circuit or open circuit of any single component in the network, the likelihood of such malfunction occurring shall be determined by investigation of that component.

25.4.3 The impedance, the fuse, the protector, or the regulating network, and the wiring between it and the isolating transformer mentioned in 25.4.1 shall be judged as if it were part of a line-voltage circuit.

25.4.4 A fuse or a circuit protector used to limit the power as specified in 25.4.1 shall be rated or set at not more than 3.2 amp for a circuit operating between 15 and 30 V, and at not more than 5.0 amp for a circuit operating at 15 V or less.

25.4.5 An impedance or a regulating network that is used to limit the current as specified in 25.4.1 shall:

a) Limit the current under short circuit conditions to not more than 8.0 amperes measured after 2 minutes; or

b) Be powered by an extra-low-voltage transformer that complies with Section 68.

25.4.6 The performance of a regulating network used to limit the power in accordance with 25.4.1 shall not be adversely affected by either short circuit or open circuit between any two terminals of any single rectifier, capacitor, transistor, or similar component in the network.

25.4.7 The wiring in an extra-low-voltage circuit shall be:

a) Routed away from the wiring and uninsulated live components of other circuits or shall be provided with insulation that is rated for use at the highest of the voltages in the other circuits; and

b) Provided with strain relief if stress on the wiring would cause the extra-low-voltage circuit to contact an uninsulated live part of another circuit.

25.4.8 *Deleted*

25.4.9 *Deleted*

26 Electric Heaters

26.1 Electric resistance heating elements shall comply 26.2 – 26.9 or with the construction requirements of the:.

a) Standard for Electric Heating Appliances, UL 499; or

b) Standard for Sheathed Heating Elements, UL 1030.

26.2 An electric heater shall be an encased assembly constructed of materials that will not be damaged by the temperature to which they will be subjected in the unit.

26.3 Metal tubing forming a heater element enclosure shall be constructed of corrosion resistant material or shall be plated, dipped, or coated to resist external corrosion and shall be acceptable for the temperatures to which it is subjected. See 26.5.

26.4 A heater element, installed in the complete unit, shall be protected against mechanical damage. The heater is considered to be protected if it (1) employs a copper or steel sheath that is at least 0.016 in (0.41 mm) thick, or (2) cannot be contacted when the probe illustrated in Figure 6.1 is inserted with a force of 5 lb (22.2 N).

26.5 Uncoated copper tubing can be used for temperatures of 392°F (200°C) and lower; metallic coated copper tubing can be used for temperatures below the melting temperature of the coating. Uncoated or oxide-coated steel tubing is not to be used as a heater sheath. Plated steel tubing can be employed if the coating is corrosion resistant and will withstand the temperatures to which it may be subjected. Aluminum tubing can be employed if the alloy withstands the Burnout Test – Electric Heater, Section 67, without melting or other malfunction. Stainless steel tubing of the austenitic grades, such as ASTM Type 304, can be employed for heater sheaths.

26.6 Insulating materials, such as washers and bushings, that are integral parts of a heating element shall be of a moisture-resistant material that will not be damaged by the temperatures to which they will be subjected in the unit.

26.7 Insulating material employed in a heating element shall be used as the sole support of live parts. Materials, such as magnesium oxide, may be used in conjunction with other insulating materials if located and protected so that mechanical damage is prevented and if not subjected to the absorption of moisture. When conducting the investigation of an insulating material, consideration is to be given to its mechanical strength, dielectric strength, insulation resistance (see 72.2), heat resistant qualities, the degree to which it is enclosed or protected, and any other features involved that can result in a risk of fire and unintended contact in conjunction with conditions of service. All of these factors are to be considered with respect to thermal aging.

26.8 A heater case or a terminal seal of rubber, neoprene, or thermoplastic materials shall comply with the Accelerated Aging Test – Electric Heaters, Section 84.

26.9 An electric heater assembly shall be sealed to prevent entrance of moisture. See Insulation Resistance Test, Section 72. Molded seal caps, vulcanized to the heater leads and heater sheath, shall have a wall thickness equivalent to that required for the heater leads.

27 Electric Heater Control

27.1 If malfunction could result in risk of a fire or electric shock, electric heaters shall:

a) Be provided with a thermal protective device complying with protective control requirements in Section 17;

b) Be provided with a replaceable thermal cutoff; or

c) Comply with the Burnout Test – Electric Heater, Section 67.

27.2 *Deleted*

27.3 *Deleted*

27.4 *Deleted*

27.5 In reference to 27.1(b), a thermal cutoff shall be secured in place and located so that it will be accessible for replacement without damaging other connections or internal wiring.

27.6 Replacement of a thermal cutoff shall not necessitate the removal of a heater element from its installation unless the heater element is intended to be removable.

27.7 Wiring connected to a thermal cutoff shall be secured so that replacement of the thermal cutoff will not result in displacement or disturbance of internal wiring other than leads to either the cutoff or to a heating element assembly on which the cutoff is mounted.

28 High-Voltage Control Circuit Conductor Overcurrent Protection

28.1 General

28.1.1 If a control-circuit is supplied through a transformer provided as part of the equipment, see Transformer Protection, Section 25, for additional requirements.

28.2 Direct-connected high-voltage control circuit

28.2.1 A direct-connected high-voltage control circuit shall be marked as specified in 92.24. See 3.11.

28.3 Tapped high-voltage control circuit

28.3.1 A tapped high-voltage control circuit conductor shall be provided with overcurrent protection (see 3.12). The rating of the overcurrent protective device or devices shall not exceed the applicable value specified in Table 28.1.

Exception No. 1: An 18, 16, and 14 AWG (0.81, 1.3, and 2.1 mm^2) conductor that does not exceed 4 ft (1.2 m) in length between points of opposite polarity may be protected by a fuse or circuit breaker rated 60 amp or less.

Exception No. 2: An overcurrent protective device of a higher rating may be used if the conductors withstand short-circuiting when tested as specified in the Limited Short-Circuit Test, Section 73.

Exception No. 3: A lead 12 in (305 mm) or less in length need not be provided with overcurrent protection.

Exception No. 4: A control-circuit conductor, supplied from the secondary of a single-phase transformer that is connected so that only a 2-wire (single voltage) secondary is used, may be protected by an overcurrent device(s) located on the primary side of the transformer provided this protection is in accordance with requirements specified in Transformer Protection, Section 25, and the rating of the device does not exceed the applicable value specified in Table 28.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

Exception No. 5: A control circuit conductor that is tapped from the main power circuit at a point outside of the control equipment enclosure shall be protected as specified in Column A of Table 430-72(b) of the National Electrical Code, ANSI/NFPA 70.

Table 28.1
Overcurrent protective device rating for control circuit conductors

Trapped control-circuit conductor size, AWG	Maximum rating of overcurrent protective device, amp			
	Conductors contained in control equipment enclosure		Conductors extending beyond control equipment enclosure	
	Copper	Aluminum[a]	Copper	Aluminum[a]
18	25	–	7	–
16	40	–	10	–
14	100	–	45	–
12	120	100	60	45
10	160	140	90	75
Larger than 10	b	b	c	c

[a] Includes copper-clad aluminum

[b] 400 percent of value specified for 60°C conductors in Table 310-17 of National Electrical Code, ANSI/NFPA 70.

[c] 300 percent of value specified for 60°C conductors in Table 310-16 of National Electrical Code, ANSI/NFPA 70.

28.4 Overcurrent protective device

28.4.1 Overcurrent protection for a tapped high-voltage control circuit conductor, as required by 28.3.1 shall be provided as part of the equipment.

Exception: The overcurrent device(s) need not be provided as part of the equipment if, based on the marked rating(s) of the equipment, the rating of the branch circuit overcurrent protective device(s) does not exceed the values specified in Table 28.1.

28.4.2 A control circuit overcurrent protective device(s) shall:

a) Be provided for all ungrounded conductors,

b) Be sized in accordance with requirements in 28.3.1, and

c) Have a voltage rating not less than the circuit in which it is used.

The device(s) shall be a circuit breaker acceptable for branch circuit protection, or a fuse acceptable for branch circuit protection, such as a Class CC, G, J, K, L, R, or T cartridge fuse or Type S plug fuse. See 91.17.

Exception: If the control-circuit is tapped from a circuit supplying other loads in the equipment, a device used for overcurrent protection may be of the supplementary type provided it has a short-circuit rating acceptable for the circuit in which it is used. See Table 73.1. If the supplementary type device used is a fuse, the equipment shall be marked in accordance with the Exception to 91.17.

28.4.3 In reference to 28.4.2, Class H fuses shall not be used.

29 Circuit Breakers, Fusing Resistors and Supplementary Protectors

29.1 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489. In addition, circuit breakers used in telecommunications circuitry shall comply with the Standard for Circuit Breakers For Use in Communications Equipment, UL 489A.

29.2 Circuit breakers used to protect circuits having more than one ungrounded conductor and no grounded neutral shall be of the multipole common trip type arranged to open all ungrounded conductors. The use of external handle ties does not in itself constitute a common trip mechanism.

29.3 Fusing resistors shall comply with the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances, UL 1412.

29.4 Supplementary Protectors shall comply with the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077.

29.5 A fusing resistor or supplementary protector shall not be used in place of a circuit breaker or protective control.

30 Connectors

30.1 Single and multipole connectors for use in data, signal, control and power applications within and between electrical equipment, and that are intended for factory assembly to copper or copper alloy conductors, or for factory assembly to printed wiring boards, shall comply with the Standard for Component Connectors for Data, Signal, Control and Power Applications, UL 1977.

31 Electrical Cable, Conduit and Tubing

31.1 Aluminum or steel armored cable shall comply with the Standard for Armored Cable, UL 4. Nonmetallic sheathed cables shall comply with the Standard for Nonmetallic Sheathed Cables, UL 719.

31.2 Flexible metal conduit shall comply with the Standard for Flexible Metal Conduit, UL 1. Rigid steel conduit shall comply with the Standard for Electrical Rigid Metal Conduit - Steel, UL 6.

31.3 Electrical steel tubing shall comply with the Standard for Electrical Metallic Tubing – Steel, UL 797.

32 Electrical Insulation Systems

32.1 Film-coated wire or materials used in an insulation system that operates at or above Class 105 (Class A) shall comply with the Standard for Systems of Insulating Materials – General, UL 1446. The requirements for film-coated wire or materials used in insulation systems that operate below Class 105 (Class A) are unspecified.

32.2 Insulating tape shall comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510.

32.3 Insulating sleeving shall comply with the Standard for Coated Electrical Sleeving, UL 1441.

32.4 Insulating tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

33 Electromagnetic Interference Filters

33.1 Electromagnetic interference filters shall comply with the:.

a) Standard for Electromagnetic Interference Filters, UL 1283; or

b) Standard for Passive Filter Units for Electromagnetic Interference Suppression – Part 3: Passive Filter Units for Which Safety Tests are Appropriate, UL 60939-3.

34 Fuses

34.1 Unless otherwise specified, fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, in conjunction with any of the associated standards tabulated below, as applicable for the class of fuse:

a) Standard for Low-Voltage Fuses – Part 4: Class CC Fuses, UL 248-4; or

b) Standard for Low-Voltage Fuses – Part 5: Class G Fuses, UL 248-5; or

c) Standard for Low-Voltage Fuses – Part 8: Class J Fuses, UL 248-8; or

d) Standard for Low-Voltage Fuses – Part 9: Class K Fuses, UL 248-9; or

e) Standard for Low-Voltage Fuses – Part 10: Class L Fuses, UL 248-10; or

f) Standard for Low-Voltage Fuses – Part 11: Plug Fuses, UL 248-11; or

g) Standard for Low-Voltage Fuses – Part 12: Class R Fuses, UL 248-12; or

h) Standard for Low-Voltage Fuses – Part 15: Class T Fuses, UL 248-15.

34.2 If a supplementary fuse is permitted in accordance with the requirements in this Standard, such a fuse shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, in conjunction with the Standard for Low-Voltage Fuses – Part 14: Supplemental Fuses, UL 248-14.

35 Lighting Systems

35.1 Lampholders and indicating lamps shall comply with the Standard for Lampholders, UL 496.

35.2 Lighting ballasts shall comply with one of the following:

a) Standard for Fluorescent-Lamp Ballasts, UL 935; or

b) Standard for High-Intensity-Discharge Lamp Ballasts, UL 1029.

35.3 Light Emitting Diode (LED) light sources shall comply with the Standard for Light Emitting Diode (LED) Equipment For Use in Lighting Products, UL 8750.

36 Optical Isolators and Semiconductor Devices

36.1 An optical isolator shall comply with the Standard for Optical Isolators, UL 1577 if it is relied upon to provide isolation between:

a) Primary and secondary circuits;

b) Extra-low-voltage safety circuits; or

c) Other high-voltage circuits

36.1.1 In addition to complying with 36.1, an optical isolator relied upon to provide feedback between primary and secondary circuits of a switch mode power supply unit shall have a minimum isolation voltage of 1500V.

36.2 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. If the switching

semiconductor is used as part of a switch mode power supply unit, it shall have a minimum isolation voltage of 1500V.

36A Information Technology Equipment

36A.1 Information technology equipment such as a printer, visual display unit, router, communication connectors/data ports or computer shall comply with the:

a) Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1; or

b) Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

37 Outlet Boxes

37.1 Outlet boxes shall comply with UL 514A for Metallic Outlet Boxes or UL 514C for Nonmetallic Outlet Boxes, Flush Device Boxes, and Covers. Fittings shall comply with UL 514B for Conduit, Tubing, and Cable Fittings. Cover plates shall comply with UL 514D for Cover Plates for Flush-Mounted Wiring Devices.

38 Terminal Blocks

38.1 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059, and, if applicable, be suitably rated for field wiring.

38.2 In reference to 38.1, if a fabricated part performs the function of a terminal block, the part shall comply with 10.2 (Terminals), 15 (Current-Carrying Parts), 16 (Insulating Material), and the spacings requirements as applicable to the type of circuit as specified below:

a) High-voltage circuit spacings (Section 41); or

b) Extra-low voltage circuit spacings (Section 42).

38.3 If a fabricated terminal block complies with the alternate spacings requirements in Section 43, but not with the spacings requirements in Section 41, the terminal block shall not be used for field wiring.

39 Batteries and Battery Chargers

39.1 A lithium ion (Li-On) single cell battery shall comply with the requirements for secondary lithium cells in the Standard for Lithium Batteries, UL 1642. A lithium ion multiple cell battery, and a lithium ion battery pack, shall comply with the applicable requirements for secondary lithium cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

39.2 Rechargeable nickel cadmium (Ni-Cad) and nickel metal-hydride (Ni-MH) battery cells and packs shall comply with the requirements in this Standard and with the applicable requirements for secondary cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

39.3 A battery charger that is other than Class 2 shall comply with 25.3.6. A Class 2 battery charger shall comply with 25.4.1.

40 Wireways, Auxiliary Gutters and Associated Fittings

40.1 Wireways, Auxiliary Gutters and Associated Fittings shall comply with the Standard for Wireways, Auxiliary Gutters and Associated Fittings, UL 870.

SPACINGS

41 High-Voltage Circuits

41.1 The following electrical spacing requirements apply only to high-voltage circuits, as defined in 3.7(a).

41.2 Unless specifically noted otherwise, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 41.1.

Table 41.1
Spacings other than in motors

Ratings		Minimum Spacings in (mm)					
VA	V	Through Air[c]		Over Surface[c]		To Enclosure[b]	
2000 or less	300 or less	1/8[a]	(3.2)	1/4	(6.4)	1/4	(6.4)
2000 or less	301 – 600	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)
More than 2000	150 or less	1/8[a]	(3.2)	1/4	(6.4)	1/2	(12.7)
	151 – 300	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)
	301 – 600	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)

[a] The spacings between wiring terminals of opposite polarity, or between a wiring terminal and ground shall be not less than 1/4 in (6.4 mm), except that if short-circuiting or grounding of such terminals will not result from projecting strands of wire, spacing need not be greater than that given in the above table. Wiring terminals are those connected in the field and not factory wired.

[b] Includes fittings for conduit or metal-clad cable.

[c] At points other than field-wiring terminals, the spacings for heater elements only may be as indicated below provided the elements are not subject to moisture, such as may result from condensation on cooled surfaces:

1/16 in (1.6 mm) Through Air and Over Surface for heaters rated 0 – 300 V.

1/4 in (6.4 mm) Through Air and Over Surface for heaters rated 301 – 600 V.

41.3 The “Through Air” and “Over Surface” spacings specified in Table 41.1 and Table 41.2 at an individual component part are to be based on the total volt-ampere consumption of the load or loads that the component controls. For example, the spacings at a component that controls only the compressor motor are based on the volt-amperes of the compressor motor. Spacings at a component that controls loads in addition to the compressor motor are to be based on the sum of the volt-amperes of the loads so controlled. Spacings at a component that independently controls separate loads are to be based on the volt-amperes of the largest load controlled. The volt-ampere values for loads are to be determined by the marked rating of the loads. For loads that are not required to have a marked rating, the measured input is to be used in determining the volt-ampere values.

41.4 All uninsulated live parts connected to different circuits shall be spaced from one another as though they were parts of opposite polarity in accordance with the requirements indicated in 41.2 and shall be based on the highest voltage involved.

41.5 With reference to 41.2 and 41.3, the “To Enclosure” spacings specified in Table 41.1 are not to be applied to an individual enclosure of a component part within an outer enclosure or cabinet.

41.6 The spacings indicated in Table 41.2 are applicable only to electrical components mounted in totally enclosed nonrefrigerated and/or nonair handling compartments which are free of moisture, including that caused by condensation. At wiring terminals and for circuits over 250 V or over 2000 VA, spacings in Table 41.1 apply.

Table 41.2
Spacings in non-refrigerated and/or non-air handling compartments

Ratings		Minimum Spacing in (mm)					
VA	V	Through Air		Over Surface		To Enclosure[a]	
0 – 2000	0 – 125	1/16	(1.6)	1/16	(1.6)	1/4	(6.4)
	125 – 250	3/32	(2.4)	3/32	(2.4)	1/4	(6.4)

NOTE – See 26.6.

[a] Includes fittings for conduit or metal-clad cable.

41.7 The spacings specified in 41.1 and 41.2 are not to apply to the inherent spacings of a component part of the equipment, such as a snap switch, controller, attachment plug, and the like, for which spacing requirements are given in a standard for the component. However, the electrical clearance resulting from the assembly of the components into the complete product, including clearance to dead metal or enclosures, shall be those indicated.

41.8 If higher than rated potential is developed in a motor circuit through the use of capacitors, the rated voltage of the system is to be employed in judging the required spacings:

Exception: If the developed steady-state potential as determined in the temperature and pressure test exceeds 500 V, the developed potential is to be used in determining the spacings for the parts affected.

41.9 An insulating barrier employed if spacings are less than the required values, shall comply with 7.1.1 – 7.3.

41.10 The spacing between uninsulated live terminals of the components in an electric-discharge lamp circuit and a dead metal part or enclosure shall be not less than 1/2 in (12.7 mm) if the potential is 600 V or less and not less than 3/4 in (19.1 mm) if the potential is 601 – 1000 V.

42 Extra-Low-Voltage Circuits

42.1 The following electrical spacing requirements apply to extra-low-voltage circuits, as defined in 3.7(b).

42.2 A circuit derived from a source of supply classified as a high-voltage circuit, by having resistance connected in series with the supply circuit as a means of limiting the voltage and current, is not considered to be an extra-low-voltage circuit.

42.3 The spacing for electrical components installed in an extra-low-voltage circuit that includes a protective control shall comply with (a) – (c):

a) The spacing between an uninsulated live part and the wall of a metal enclosure, including fittings for the connection of conduit or metal-clad cable, shall be not less than 1/8 in (3.2 mm).

b) The spacing between field wiring terminals regardless of polarity and between the wiring terminal and a dead metal part, including the enclosure and fittings for the connection of conduit, that may be grounded when the device is installed, shall be not less than 1/4 in (6.4 mm).

c) The spacing between uninsulated live parts regardless of polarity and between an uninsulated live part and a dead metal part, other than the enclosure, that may be grounded when the device is installed, shall be not less than 1/32 in (0.8 mm) provided that the construction of the parts maintains required spacings.

42.4 If spacings in an extra-low-voltage circuit are less than those specified in 42.3 a protective control shall not be provided within the circuit.

43 Alternate Spacings – Clearances and Creepage Distances

43.1 Except as indicated in 43.2, the spacings requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are applicable as an alternative to the specified spacings requirements in the following:

a) High-Voltage Circuits – Section 41; and

b) Extra-Low-Voltage Circuits – Section 42

43.2 The spacings requirements in UL 840 shall not be used for spacings between field wiring terminals or between uninsulated live parts and a metal enclosure.

43.3 The items outlined in 43.4 – 43.9 shall be considered when evaluating an appliance to the requirements in UL 840.

43.4 Hermetically sealed or encapsulated enclosures are identified as pollution degree 1.

43.5 Coated printed wiring boards are identified as pollution degree 1 if they comply with one of the following:

a) Printed wiring board coating performance test of UL 840; or

b) Conformal coating requirements as outlined in the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E.

43.6 Indoor use appliances are identified as pollution degree 2.

43.7 Outdoor use appliances are identified as pollution degree 3.

43.8 Category II is the overvoltage category.

43.9 Printed wiring boards are considered as having a minimum comparative tracking index (CTI) of 100 unless further investigated for a higher CTI index.

43.10 Clearance B (Controlled Overvoltage) clearances as specified in UL 840 shall be achieved by providing an overvoltage device or system as an integral part of the recovery/recycling equipment.

REFRIGERANT SYSTEM

44 Refrigerants

44.1 The equipment employing or intended for use with a refrigerant having a flammability safety group classification exceeding Class 1 as described by the Standard for Designation and Safety Classification of Refrigerants, ANSI/ASHRAE 34 shall comply with:

a) The relevant requirements in the body of this Standard; and

b) Supplement SB, Requirements for Refrigerant Recovery/Recycling Equipment Intended for Use with a Flammable Refrigerant.

44.2 Refrigerant recovery/recycling equipment shall not employ or be intended for use with a refrigerant with a toxicity safety group classification exceeding Class A as described by ANSI/ASHRAE 34.

44.3 The refrigerant employed in the system shall:

a) Have flammability characteristics that have been evaluated in accordance with the Standard for Refrigerants, UL 2182; or

b) Be subjected to a compositional analysis to confirm a composition consistent with a refrigerant specified in the Standard for Designation and Safety Classification of Refrigerants, ANSI/ASHRAE 34.

44.4 In reference to 44.3(b), the chemical composition of the refrigerant, including the nominal composition (types and percentages) of a blended refrigerant, shall be determined by analytical testing in accordance with Section 86A using:

a) Infrared analysis for single component refrigerants; or

b) Gas chromatography for blended refrigerants.

45 Refrigerant Recovery Capacity

45.1 Equipment shall have a storage section to receive refrigerant during a recovery operation. This storage section shall have an automatic means to cease the recovery operation when 80 percent of the volume of the storage section contains liquid refrigerant at 70°F (21.1°C). There shall be an automatic means, such as a shutoff, to limit migrating liquid refrigerant from occupying more than 80 percent of the volume of the storage section(s) at 70°F (21.1°C) upon termination of all recovery operation including all rapid liquid recovery methods.

Exception: Storage sections intended to contain low pressure refrigerants R11, R113, R123 shall have a means to cease the recovery operation when 90 percent of the storage volume contains liquid refrigerant at 70°F (21.1°C). There shall be means, such as a shutoff, to limit migrating liquid refrigerant from occupying more than 90 percent of the volume of the storage section(s) at 70°F (21.1°C) upon termination of all recovery operations.

45.2 All components such as switches, relays, and solid state control circuits used to cease refrigerant recovery operations shall have an endurance rating of 100,000 cycles and adequate electrical ratings to handle all given load conditions.

45.3 Solid state control circuits used to operate the refrigerant recovery operation shall be evaluated in accordance with 17.15.

45.4 All electrical and mechanical assemblies that are part of the control system used to cease refrigerant recovery operations shall be subjected to overvoltage/undervoltage (see Section 70), and strength tests (see Section 76) described in this standard.

46 Refrigerant Tubing and Hoses

46.1 Tubing

46.1.1 The wall thickness of copper or steel tubing used to connect components in the refrigerant systems shall be not less than indicated in Table 46.1.

Exception: Copper or steel capillary tubing that is protected against mechanical damage by the cabinet or assembly shall have a wall thickness not less than 0.020 in (0.51 mm).

46.1.2 Tubing shall be constructed of corrosion-resistant material such as copper, or shall be plated, dipped, coated, or equivalently treated to resist external corrosion. Aluminum may be used where the material is not subject to galvanic corrosion.

Table 46.1
Minimum wall thickness for copper, steel and aluminum tubing

Outside diameter,		Copper				Steel		Aluminum	
		Protected[a]		Unprotected		Protected or unprotected			
in	(mm)	in	(mm)	in	(mm)	in	(mm)	in	(mm)
3/16	(4.76)	0.0279	(0.71)	0.0299	(0.76)	0.0279	(0.71)	0.0350	(0.89)
1/4	(6.4)	0.0245	(0.622)	0.0265	(0.673)	0.025	(0.64)	0.0350	(0.89)
5/16	(7.9)	0.0245	(0.622)	0.0285	(0.724)	0.025	(0.64)	0.0350	(0.89)
3/8	(9.5)	0.0245	(0.622)	0.0285	(0.724)	0.025	(0.64)	0.0350	(0.89)
1/2	(12.7)	0.0245	(0.622)	0.0285	(0.724)	0.025	(0.64)	0.0350	(0.89)
5/8	(15.9)	0.0315	(0.800)	0.0315	(0.800)	0.032	(0.81)	0.0488	(1.24)
3/4	(19.1)	0.0315	(0.800)	0.0385	(0.978)	0.032	(0.81)	0.0488	(1.24)
7/8	(22.2)	0.0410	(1.041)	0.0410	(1.041)	0.046	(1.17)	0.0650	(1.65)
1	(25.4)	0.0460	(1.168)	0.0460	(1.168)	–	–	0.0720	(1.83)

NOTE – Nominal wall thickness of tubing will have to be greater than the thickness indicated to maintain the minimum wall thickness.

[a] Within the product.

46.1.3 Tubing forming part of components such as evaporators or condensers, where protection is afforded by inherent construction, shall be judged according to Strength Test – Pressure Containing Components, Section 76.

46.1.4 Special alloys or constructions used in components of the refrigerant system including tubing with a wall thickness less than indicated in 46.1.1 are acceptable, subject to an investigation that considers:

a) Resistance to mechanical abuse,

b) Strength against internal pressure,

c) Resistance to corrosion,

d) Protection against refrigerant contamination, and

e) Compliance with requirements of safety codes such as the Safety Standard for Refrigeration Systems, ASHRAE 15, as compared to tubing of the minimum wall thicknesses indicated in Table 46.1.

46.1.5 Tubing connections shall be made by means of flare-type fittings with steel or forged brass nuts, by soldering or brazing, or by equivalent means. Flare-type fittings shall comply with the Standard for Refrigeration Tube Fittings – General Specifications, SAE J513.

46.2 Hoses

46.2.1 A hose assembly provided for field connection of the recovery/recycling equipment to equipment being serviced or provided when flexibility is needed in accordance with 6.1.9 shall comply with Section 58. Such hose assemblies provided with equipment intended for outdoor use and marked in accordance with 91.22 shall be investigated with respect to the effects of outdoor exposure.

47 Refrigerant-Containing Parts

47.1 Parts of the equipment subjected to refrigerant pressure shall comply with one of the following:

a) Strength Tests – Pressure Containing Components, Section 76;

b) The Standard for Refrigerant-Containing Components and Accessories, Nonelectrical, UL 207; or

c) Section 50 for storage cylinders that do not comply with 47.8.

47.2 If a refrigerant containing part is subjected to the Fatigue Test in accordance with UL 207 as referenced in 47.1 (b), then the maximum abnormal or design pressures required for this test shall be based on the maximum refrigerant pressures obtained on the component during the tests of the refrigerant recovery/recycling equipment in accordance with this standard.

47.3 If the high-side design pressure marked on the equipment as described in 91.2 (e) equals or exceeds the critical pressure of the refrigerant, and if the Fatigue Test is conducted in accordance with 47.1(b), then the upper test pressure for the high-side parts of the:

a) First cycle shall be the higher of either the equipment maximum abnormal or marked design pressure; and

b) Remaining cycles shall be not less than 95 percent of the higher of either the equipment maximum abnormal or marked design pressure.

47.4 In reference to 47.3, the lower pressure for all cycles shall not be greater than the saturated vapor pressure of the refrigerant at 40°F (4.4°C). For R744, this value is 553 psig (3.8 MPa).

47.5 In reference to 47.3, the critical pressure of R744, this value is 1058 psig (7295 kPa).

47.6 In addition to the requirement of 47.1, parts of equipment subjected to refrigerant pressure shall be constructed of corrosion resistant material such as copper or stainless steel, or plated, dipped, coated, or equivalently treated to resist external corrosion.

47.7 The dial of a pressure gauge connected in the high side of the refrigerant system shall be graduated up to:

a) No less than two times the maximum operating pressure, or, if a pressure-limiting device is employed in the refrigerant system, no less than 1.2 times the setting of that device;

b) No less than 1.2 times the marked factory leakage test pressure; and

c) No less than 1.2 times the marked design pressure of high-side refrigerant-containing components.

The dial of a pressure gauge connected in the low side of refrigerant system shall be graduated up to no less than two times the maximum operating pressure, no less than 1.2 times the marked factory leakage test pressure, and no less than 1.2 times the marked design pressure of the low-side refrigerant-containing components.

47.8 Pressure vessels over 6 in (152 mm) inside diameter shall be constructed, tested, and stamped in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, for a working pressure in compliance with the applicable performance requirements of this standard.

Exception: Pressure vessels subjected to a gauge pressure not exceeding 15 psig (102 kPa) are not required to be constructed, tested and stamped in accordance with the ASME Boiler and Pressure Vessel Code.

47.9 Pressure vessels bearing the ASME Code "U" symbol complying with 47.8 are considered acceptable without tests.

47.10 Pressure vessels bearing the ASME Code "UM" symbol are to be tested to determine compliance with the Strength Tests– Pressure Containing Components, Section 76. The manufacturer shall submit evidence of compliance of these vessels with ASME Boiler and Pressure Vessel Code, Section VIII.

47.11 Valves employed on ASME marked pressure vessels that receive refrigerant during the recovery operation shall comply with the Standard for Cylinder Valves, UL 1769.

48 Pressure-Limiting Device

48.1 A pressure-limiting (protective) device designed to automatically stop the operation of the compressor shall:

a) Be installed on all equipment with a system containing more than 22 pounds-mass (10 kg) of refrigerant; and

b) Comply with the protective control requirements in Section 17.

48.2 The adjustable cutout pressure setting of a pressure-limiting (protective) device shall not exceed one-third the ultimate strength of high-side refrigerant-containing parts, provided this setting does not exceed ninety percent of the setting of the pressure-relief device.

48.3 There shall be no stop valves between the pressure-limiting device and the pressure imposing element of the hermetic compressor.

49 Pressure Relief

49.1 General

49.1.1 Equipment shall be constructed so that pressure due to fire, or other abnormal conditions, will be relieved. Pressure-relief devices, fusible plugs, or soldered or brazed tubing joints may be employed for this purpose.

Exception: Storage container assemblies intended to receive refrigerant during the recovery operation that comply with Section 50 are considered to comply with this section.

49.1.2 A pressure-relief device is a pressure-actuated valve or rupture member designed to relieve excessive pressures automatically.

49.1.3 Equipment with a pressure vessel over 3 in (76 mm) inside diameter, but not exceeding 3 ft^3 (0.08 m^3) internal gross volume, shall be protected by a pressure-relief device or fusible plug.

49.1.4 Equipment with a pressure vessel having an internal gross volume exceeding 3 ft^3 (0.08 m^3) but less than 10 ft^3 (0.28 m^3) shall be protected by a pressure-relief device.

49.1.5 There shall be no stop valve between the pressure-relief means and the parts or section of the system protected. A device other than a stop valve may be located between the pressure-relief means and the parts or sections being protected provided it allows the relief of these parts or sections as intended.

49.1.6 All pressure-relief devices shall be connected as close as practicable, or directly, to the pressure vessel or parts of the system protected. Pressure relief devices shall be connected above the liquid refrigerant level, installed so that they are accessible for inspection and repair, and arranged so that they cannot readily be rendered inoperative.

49.1.7 Fusible plugs may be located either above or below the liquid refrigerant level.

49.2 Relief valves

49.2.1 Pressure-relief valves shall comply with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII. Valves of 1/2 in iron pipe size and larger shall bear the authorized code “UV” symbol together with the set pressure and capacity. Valves of less than 1/2 in iron pipe size shall be similarly marked, except that where the size does not permit a nameplate, the code symbol may be omitted and the set pressure and capacity may be stamped on the valve or on a metal plate attached to it. Manufacturers of valves that do not bear the code symbol shall provide evidence of certification of the valve and its pressure and capacity rating by appropriate code authorities.

49.2.2 Pressure-relief valves shall be set to start to function at a pressure not to exceed the design pressure of the parts of the system protected.

49.2.3 The marked discharge capacity shall be not less than the minimum required discharge capacity specified in the Safety Standard for Refrigeration Systems, ASHRAE 15.

49.3 Fusible plugs or rupture members

49.3.1 Calculation of the minimum required discharge capacity and the rated discharge capacity of a rupture member or fusible plug shall be in accordance with the Safety Standard for Refrigeration Systems, ASHRAE 15.

49.3.2 Fusible plugs and rupture members shall comply with the applicable requirements in the Standard for Refrigerant-Containing Components and Accessories, Nonelectrical, UL 207.

49.3.3 Rupture members shall have a nominal rated rupture pressure not exceeding the design pressure of the parts of the system protected.

50 DOT Storage Cylinders

50.1 Removable storage cylinders, which are not ASME marked pressure vessels, that receive the refrigerant during the recovery operation shall comply with all of the following:

a) The storage cylinder shall comply with DOT specifications, 49CFR, and have a service pressure rating of at least 260 psig (1.79 MPa), but not less than 80 percent of the setting of the pressure limiting device.

b) The cylinder valve shall comply with the Standard for Cylinder Valves, UL 1769.

c) The pressure relief device shall comply with the Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases, Compressed Gas Association Standard S-1.1.

d) The storage cylinder shall be marked to indicate the first retest date, which shall be 5 years from date of manufacture. Also the marking shall indicate that retest must be performed every subsequent 5 years. The marking shall be in letters at least 1/4 in (6.4 mm) high . The storage cylinder shall also be marked with its service pressure.

e) Elastomeric materials employed on cylinder valves and relief devices that contact refrigerant shall comply with the tests specified in 78.2.1 – 78.4.1.

f) The storage cylinder shall withstand, without rupture, a pressure of four times the maximum adjustable setting of the pressure limiting devices.

PERFORMANCE

51 Instrumentation

51.1 Temperature measurements

51.1.1 Temperatures are to be measured by thermocouples, except that the change-in-resistance method may be used to measure the temperature of motor windings or of coils. See 57.4. The thermocouples are to consist of 24 – 30 AWG (0.21 – 0.05 mm^2) wires. The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to comply with the requirements in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ASTM E230/E230M.

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

51.1.3 When thermocouples are used in the determination of temperatures in connection with the heating of electrical equipment, thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer type of indicating instrument are to be used whenever referee temperature measurements by means of thermocouples are necessary.

51.1.4 When the temperature of a copper motor winding or coil is to be determined by the change-in-resistance method the following formula shall be used:

$$T = (R / r)(k + t) - k$$

In which:

T is the temperature to be determined.

t is the known temperature.

R is the resistance in ohms at the temperature to be determined.

r is the resistance in ohms at the known temperature.

k is 390.0 when using degrees F (234.5 when using degrees C).

51.1.5 When it is necessary to de-energize the winding before measuring R, the value of R at shutdown is to be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time is to be plotted and extrapolated to give the value of R at shutdown.

51.1.6 Except as specified in 51.1.7, during any test in which temperatures are measured, temperatures shall be monitored until maximum temperatures are attained. Thermal equilibrium is to be considered to exist when three successive readings indicate the same or decreasing temperatures. Readings shall be taken at the end of not less than three consecutive periods, the duration of each period being not less than 5 minutes.

51.1.7 In reference to 51.1.6, if temperatures on the component being monitored cycle between higher and lower temperatures due to the component cycling as part of the test (for example a load cycling on and off due to operation of a protective device), equilibrium is to be considered obtained when three successive peak temperatures indicate the same or decreasing temperatures.

51.1.8 In reference to 51.1.6 and 51.1.7, the recorded temperature shall be the highest of the three readings.

51.2 Pressure measurements

51.2.1 Pressure gauges are to be attached in a manner that prevents leakage. Special fittings for direct connection to the system or minimum lengths of 1/8 in (3.2 mm) outside diameter commercial capillary tubing may be employed for gauge connections. The volume of the pressure-measuring gauge and lines is to be held to a minimum. All joints in the gauge system are to be tested for leakage.

51.2.2 Opening of the gauge line valves shall not cause a significant change in the electrical input of the system.

52 Tests on Nonmetallic Materials

52.1 General

52.1.1 Nonmetallic materials are to be evaluated as indicated in Table 52.1.

Table 52.1
Tests On Nonmetallic Materials – Based on Nonmetallic Requirements in Section 5.1 and 5.2

Nonmetallic Component	Applicable Test Number
A part serving as an enclosure for ignition sources.	1[a], 2[a], 3[b] or 4[h], 5, 6[c], 7[d], 8, 9, 10, 11, 12, 13, 14
A part serving as a cabinet.	Minimum 4[h], 5, 6[c], 7[d], 8, 9, 10, 11, 12, 13, 14
A functional part.	Minimum 4[h], 5, 6[c], 7[d], 8, 9, 10, 11
A nonfunctional part.	Minimum 4[h], 8
APPLICABLE TESTS	

Table 52.1 Continued on Next Page

Table 52.1 Continued

Nonmetallic Component	Applicable Test Number
1. 5 in end product flame test.[e] 2. 5V rated material.[f] 3. V-0, V-1, V-2, HF-1, HF-2 rated materials[f], 3/4 in End Product Flame Test[e] or 12 mm End Product Flame Test.[e] 4. HB or HBF rated material[f] or a material with a flame spread rating of 25 or less and a smoke developed rating of 50 or less.[g] 5. Mold Stress-Relief Test.[e] 6. Fastener Strength Test, 52.3. 7. Adhesive Test.[e] 8. Radiant Panel or Surface Burning Characteristic Test[g] – A flame spread index (FSI) of not more than 200 applies only to parts forming portions of the equipment exterior surface, including any nonfunctional (e.g., decorative) part if the total area of all external parts exceeds 10 ft^2 (0.93 m^2). With respect to ASTM E162, if the Radiant Panel Test is conducted and any dripping of the part/material exceeds 10 drops during any 10 second period of time, the test shall not be considered invalid as long as sufficient material remains to enable calculating the flame spread index. 9. Volume Resistivity Test[e] – Applies only if electrical spacings between uninsulated live parts and the material are less than specified in line-voltage circuits, and extra-low voltage (Class 2) circuits, or if the part is used as indirect support of an uninsulated live part. 10. High Current Arc Resistance to Ignition Test[e] – Applies only if the material is used to enclose uninsulated live parts or to provide indirect support of uninsulated live parts. The test does not apply if uninsulated live parts are located a minimum of 1/32 inch (0.79 mm) from the part. If applicable, no ignition shall occur to: V-0 materials subjected to 15 arcs; V-1, V-2, or 5V materials subjected to 30 arcs, or to HB materials subjected to 60 arcs. 11. Hot Wire Ignition Test[e] – Applies only if the material is within 1/2 in (12.7 mm) of electrically-heated wires or resistors. If applicable, ignition shall not occur in less than: 10 s for V-0 materials, 15 s for V-1 or 5V materials, or 30 s for V-2 or HB materials. 12. Impact Tests[e] – 5 ft-lb (6.8 J) impact for enclosures containing uninsulated live and hot parts, 1.5 ft-lb (2.0 J) impact for enclosures containing moving parts. 13. Crush Resistance Test[e] – Only one sample needs to be tested. 14. UV Light Exposure Test[e] – Applies to equipment intended for outdoor locations and provided with a polymeric cabinet and/or enclosure that could be exposed to sunlight.	

[a] An enclosure provided with a mechanical barrier interposed between the material and an ignition source will be tested with the barrier in place.

[b] A material with a V-2 minimum rating is able to be used to enclose an ignition source if the ignition source is only energized as a result of a continuous action by an attending operator.

[c] Applies to an enclosure, cabinet or functional part having ultrasonic welds; heat welds; polymeric screws or nuts; metal screws threaded into a polymeric part, or other means where degradation of a polymeric material affects securement that could result in a risk of electric shock, fire or injury to persons.

[d] Applies only if the adhesive is relied on to maintain the integrity of an enclosure or functional part.

[e] Tested or rated as described in UL 746C.

[f] Tested or rated as described in UL 94.

[g] Tested or rated as described in ASTM E162 or UL 723.

[h] These materials are able to be used if ignition sources are separated or isolated in accordance with Section 5.2.

52.2 Burnout test – impedance protected motors

52.2.1 An impedance protected motor not provided within an enclosure and located adjacent to nonmetallic materials other than those rated 5V, shall comply with 52.2.2 or 52.2.7.

52.2.2 There shall be no ignition of cotton surrounding the motor when tested as described in 52.2.3 – 52.2.6.

52.2.3 One sample motor shall be arranged for testing as follows:

a) At least one thermocouple shall be secured to the winding for measurement of the winding temperature.

b) The rotor shall be locked.

c) The motor shall be mounted as intended in use.

d) The motor shall be completely wrapped in dry absorbent surgical cotton.

e) The motor shall be connected to a variable voltage source.

52.2.4 The motor shall be energized at rated voltage and operated until the winding temperature stabilizes.

52.2.5 The voltage shall be progressively increased in 5 V increments, allowing the winding temperature to stabilize after each increase in voltage.

52.2.6 Operation of the motor shall continue until burnout occurs.

52.2.7 There shall be no ignition of materials surrounding the motor when tested as described in 52.2.8.

52.2.8 The test shall be conducted as outlined in 52.2.3 – 52.2.6 with the difference that the motor shall not be wrapped in cotton and shall be mounted as intended within a complete unit.

52.3 Fastener strength test

52.3.1 *Deleted*

52.3.2 In reference to 5.3.1, the tightening torque and pull-off strength of nonmetallic fasteners used as part of an enclosure, cabinet or functional part shall be not less than 50 percent of the as-received value.

52.3.3 Three sets of samples, each set consisting of three specimens, shall be temperature conditioned as indicated in Table 52.2 and Table 52.3.

Table 52.2
Test Specifications

Sample Set	No. of Samples	Test Specifications
1	3	As-received (no conditioning).
2	3	Oven aging – 300 hours at the service temperature plus 18°F (10°C) but not less than 158°F (70°C). Service temperature is considered to be the temperature measured during the Temperature and Pressure Test, Section 57.
3	3	Heat cycling – 40 cycles of alternate heating and cooling at the temperatures specified in Table 52.3. Each cycle is to consist of 4 hours at the upper temperature followed by 4 hours at the lower temperature.

Table 52.3
Temperature Cycling Parameters

Location	Upper Temperature	Lower Temperature
Nonrefrigerated Areas	Service temperature plus 18°F (10°C) but not less than 158°F (70°C)	77°F (25°C)
Refrigerated Area	90°F (32°C)	32°F (0°C)
Low Temperature Area	90°F (32°C)	0°F (minus 17.8°C)

53 Test Voltage

53.1 Unless otherwise specified, all tests are conducted at 60 hz voltages maintained at the equipments supply connections in accordance with Table 53.1.

Exception: Equipment rated at other than 60 hz frequency is to be tested at its rated voltage(s) and frequency(s).

Table 53.1
Test voltages

Nameplate voltage rating	Normal test voltage[a]
110 to 120	120
200 to 208	208
220 to 240	240
254 to 277	277
440 to 480	480
550 to 600	600
Other	Rated

[a] These test voltages are nominal for the Condenser Fan Motor Failure Test, Section 60, and Condenser Water Failure Test, Section 61.

54 Leakage Current Test – Cord Connected Equipment

54.1 The leakage current of cord-connected equipment shall be no more than 0.75 milliampere when tested in accordance with requirements in 54.7 – 54.10.

54.2 Leakage current refers to all currents, including capacitively-coupled currents, that may be conveyed between exposed conductive surfaces of the equipment and ground or other exposed conductive surfaces.

54.3 All exposed conductive surfaces are to be tested for leakage currents. Leakage currents are to be measured between the grounded supply conductor and:

a) Each exposed surface individually,

b) All exposed surfaces collectively if the surfaces are simultaneously accessible.

Leakage currents also are to be measured between simultaneously accessible surfaces. Surfaces are considered exposed unless guarded by an enclosure providing protection in accordance with 6.3.2 and 6.3.3. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time.

Exception: These measurements do not apply to terminals operating at voltages that are considered to be extra-low-voltage.

54.4 When a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using metal foil having dimensions of 3.9 by 7.8 in (10 by 20 cm), in contact with the surface. When the surface is less than 3.9 by 7.8 in (10 by 20 cm), 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 equipment.

54.5 The measurement circuit for leakage current shall be as shown in Figure 54.1. The measurement instrument is defined in (a) – (c). The meter used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument and need not have all of the attributes of the defined instrument.

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

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

c) Over a frequency range of 0 – 100 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 microfarad capacitor to 1500 ohms. At an indication of 0.75 milliampere, the measurement is to have an error of not more than 5 percent.

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

54.7 The equipment is to be prepared and conditioned for leakage current measurement as follows:

a) The grounding conductor is to be open at the attachment plug and the equipment is to be isolated from the ground.

b) The sample is to be conditioned in an ambient temperature of 70 – 80°F (21.1 – 26.7°C) and 50 percent relative humidity for not less than 8 hours.

54.8 The test is to be conducted at the ambient conditions specified by 54.7(b).

54.9 The supply voltage is to be adjusted to the voltage indicated in Table 53.1.

54.10 With reference to the measuring circuit in Figure 54.1, the leakage current test sequence shall be as described in (a) – (d) below. If the compressor stalls during sequence (b) or (c) due to changing the position of switch S2, the sequence is to be conducted in its entirely in one position of switch S2 and then repeated in the second position of switch S2.

a) With switch S1 open, the unit is to be connected to the measuring circuit. The leakage current is to be measured using both positions of switch S2 and with manually operated unit switching devices successively placed in each mode (on, standby, and the like).

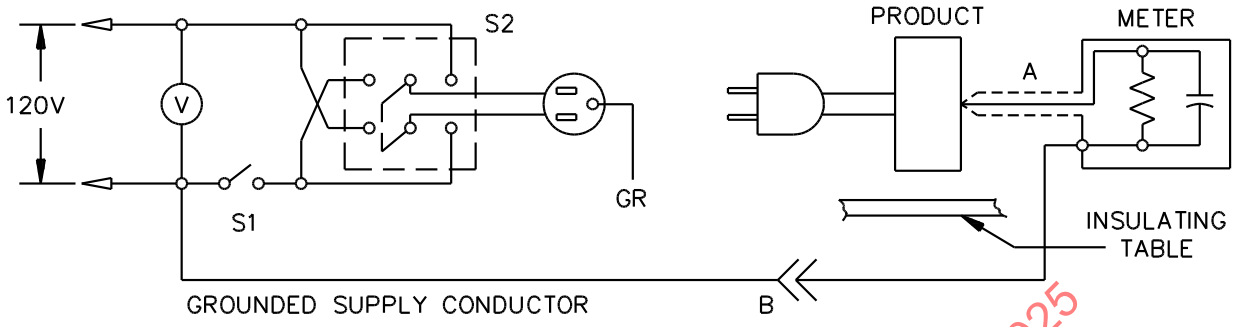
b) With controls set for maximum, switch S1 is to be closed to energize the unit. Within 5 seconds, leakage current is to be measured using both positions of switch S2. Following this and using both positions of switch S2, manual switching devices are to be operated as quickly as possible through all modes, but not in the OFF position, to determine the maximum leakage current condition.

c) With switching devices set at the position that causes the highest leakage current, the unit is to be operated continuously until the measured leakage current stabilizes or decreases. Both positions of switch S2 are to be used.

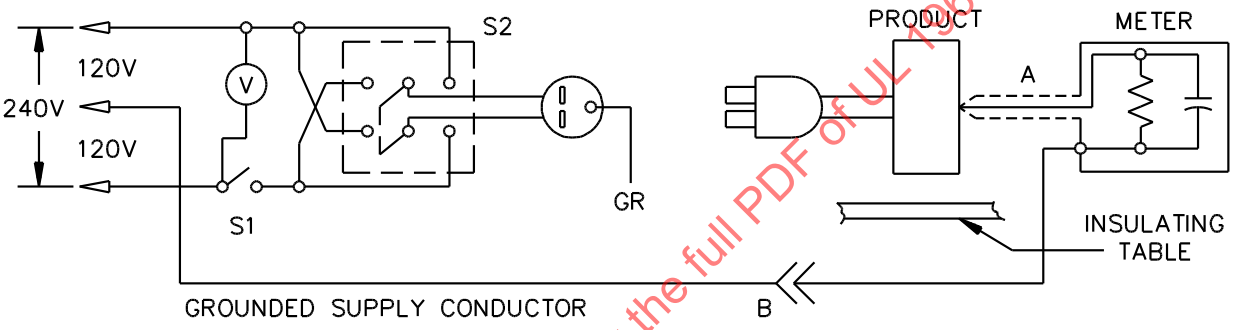
d) Switch S1 is to be opened to de-energize the unit. Measurement of leakage current is to continue, using both positions of switch S2, until values stabilize or begin to decrease.

Figure 54.1

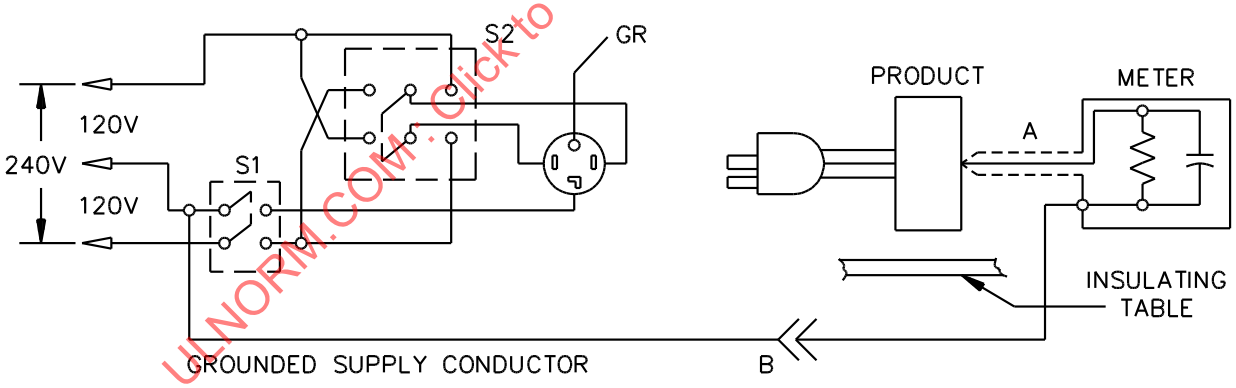
Leakage current measurement circuits



Product intended for connection to a 120–volt power supply, as illustrated above.



Product intended for connection to a 3–wire, grounded neutral power supply, as illustrated above.



Product intended for connection to a 3–wire, grounded neutral power supply, as illustrated above.

LC300J

A – Probe with shielded lead.

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

55 Input Test

55.1 The measured ampere input to cord connected equipment shall not exceed the total rating marked on the equipment nameplate by more than 10 percent when tested as described in the Temperature and Pressure Test, Section 57.

Exception: For battery-operated equipment, the input is to be measured with the equipment in the charging mode during the Temperature and Pressure Test after operating for five minutes. The battery is to be fully discharged in accordance with the battery manufacturer's instructions at the start of the test.

55.2 The measured input to permanently connected equipment shall not exceed the individual rating of each load or group of loads or the total rating as marked on the nameplate by more than 10 percent when tested as described in the Temperature and Pressure Test, Section 58.

55.3 With reference to the requirements of 55.1 and 55.2, the measured ampere input is to be the highest value obtained during refrigerant liquid and vapor recovery/recycling operations. The power input of all accessories is to be considered when establishing the minimum marked rating of the equipment.

55.4 With reference to 55.3, the measured ampere input is to be increased for accessible 15 and 20 amp convenience outlets connected to the same circuit as the equipment, as follows:

a) By 80 percent of the receptacle rating if a single receptacle is employed.

b) By 100 percent of the receptacle rating if more than one receptacle is employed.

c) By 100 percent of the load(s) marked on or adjacent to the receptacle(s) if the equipment is marked as indicated in 91.12 and is provided with overcurrent protection as specified in the Exception to 22.2.

56 Starting Test

56.1 The equipment shall start and operate as intended without rupturing a line fuse of the size required by the equipment.

56.2 The equipment, with four fuses connected in series, is to be operated under the conditions described in the Temperature and Pressure Test, Section 57.

56.3 For cord connected equipment, the fuse rating is to be determined by the rating of the attachment plug. For permanently connected equipment protected by a fuse size in accordance with 73.1.4, the fuse rating is to be as marked on the nameplate. For permanently connected equipment protected by a fuse sized in accordance with 73.1.4, no starting test is required.

56.4 When no fuse opens, the fuse size is acceptable for starting the equipment. When one fuse opens, the test is to be repeated using the three remaining fuses. If none of the three opens, the results are acceptable. when one of the three opens, the results are not acceptable, and the test is to be repeated using four time-delay fuses of the same rating as the original fuse.

56.5 When it is determined that time-delay fuses are required for starting, the equipment shall be marked in accordance with 91.16 or 93.2, whichever is appropriate.

56.6 When an automatic-reset thermal protective device interrupts the current flow one or more times during the test, the equipment shall restart and run after each interruption and shall comply with the fusing requirements of 56.4 and 56.5.

56.7 When 15 or 20 amp general purpose receptacles are provided and intended to be connected to the same circuit as the equipment, the starting test is to be conducted with an additional resistive load connected to the equipment. The resistive load is to be sized as follows:

a) The load is to be equal to 80 percent of the rating of the receptacle when a single receptacle is employed.

b) The load is to be equal to 100 percent of the rating of the largest receptacle when more than one receptacle is employed on the same circuit.

c) The load is to be equal to 100 percent of the load(s) marked on or adjacent to the receptacle(s) if the equipment is marked as indicated in 91.12 and is provided with overcurrent protection as specified in the Exception to 22.2.

57 Temperature and Pressure Test

57.1 The temperature rises measured on the electric components and surfaces of the equipment shall not exceed those specified in Table 57.1.

Table 57.1
Maximum temperature rises

Device or material	Degrees F	Degrees (C)
A. Motors		
1. Class A insulation systems on coil windings of a motor having a frame diameter of 7 in (178 mm) or less[a]		
a. In open motors –		
Thermocouple or resistance method	135	(75)
b. In totally enclosed motors –		
Thermocouple or resistance method	144	(80)
2. Class A insulation systems on coil windings of a motor having a frame diameter of more than 7 in (178 mm)[b]		
a. In open motors –		
Thermocouple method	117	(65)
Resistance method	135	(80)
b. In totally enclosed motors –		
Thermocouple method	126	(70)
Resistance method	144	(80)
3. Class B insulation systems on coil windings of a motor having a frame diameter of 7 in (178 mm) or less		
a. In open motors		
Thermocouple or resistance method	171	(95)
b. In totally enclosed motors –		
Thermocouple or resistance method	180	(100)
4. Class B insulation systems on coil windings of a motor having a frame diameter of more than 7 in (178 mm)		
a. In open motors		

Table 57.1 Continued on Next Page

Table 57.1 Continued

Device or material	Degrees	
	F	(C)
Thermocouple method	162	(90)
Resistance method	180	(100)
b. In totally enclosed motors –		
Thermocouple method	162	(90)
Resistance method	180	(100)
5. Class F insulation systems on coil windings of a motor having a frame diameter of 7 in (178 mm) or less[a]		
a. In open motors –		
Thermocouple or resistance method	216	(120)
b. In totally enclosed motors –		
Thermocouple or resistance method	225	(125)
6. Class F insulation systems on coil windings of a motor having a frame diameter of more than 7 in (178 mm)[b]		
a. In open motors –		
Thermocouple method	198	(110)
Resistance method	216	(120)
b. In totally enclosed motors –		
Thermocouple method	207	(115)
Resistance method	225	(125)
7. Class H insulation systems on coil windings of a motor having a frame diameter of 7 in (178 mm) or less[a]		
a. In open motors –		
Thermocouple or resistance method	243	(135)
b. In totally enclosed motors –		
Thermocouple or resistance method	252	(140)
8. Class H insulation systems on coil windings of a motor having a frame diameter of more than 7 in (178 mm)[b]		
a. In open motors –		
Thermocouple method	225	(125)
Resistance method	303	(168)
b. In totally enclosed motors –		
Thermocouple method	234	(130)
Resistance method	252	(140)
9. Class N insulation systems on coil windings of an open or totally enclosed motor[a]		
Thermocouple or resistance method	288	(160)
10. Class R insulation systems on coil windings of an open or totally enclosed motor[a]		
Thermocouple or resistance method	324	(180)
B. Components		
1. Capacitors		
Electrolytic type[c]	72	(40)

Table 57.1 Continued on Next Page

Table 57.1 Continued

Device or material	Degrees F	Degrees (C)
Other types [d]	117	(65)
2. Field wiring[e]	63	(35)
3. Fuses		
a. Class CC, G, J, L and T		
Tube	180	(100)
Ferrule or blade	153	(85)
b. Other classes[g]	117	(65)
4. Compressor motor enclosure[f]	302	(150)
5. Relay, solenoid, and other coils (except motor coil windings)[b]		
a. Class 105 insulation –		
Thermocouple method	117	(65)
Resistance method	153	(85)
b. Class 130 insulation –		
Thermocouple method	153	(85)
Resistance method	189	(105)
c. Class 155 (F) insulation –		
Thermocouple method	198	(110)
Resistance method	217	(121)
d. Class 180 (H) insulation –		
Thermocouple method	225	(125)
Resistance method	243	(135)
e. Class 200 (N) insulation –		
Thermocouple method	243	(135)
Resistance method	279	(155)
f. Class 220 (R) insulation –		
Thermocouple method	279	(155)
Resistance method	315	(175)
6. Solid contacts	117	(65)
7. Transformer enclosure – with		
a. Class 2 transformers	108	(60)
b. Power transformers	117	(65)
8. Wood or other flammable materials	117	(65)
C. Insulated conductors		
1. Flexible cords and wires with rubber, thermoplastic or neoprene insulation unless recognized as having special heat-resistance properties as follows:		
Temperature rating		
°F (°C)		
140 (60)	63	(35)
167 (75)	90	(50)

Table 57.1 Continued on Next Page

Table 57.1 Continued

Device or material			Degrees F	Degrees (C)
	176	(80)	99	(55)
	186	(90)	117	(65)
	221	(105)	144	(80)
D.	1. Surfaces of equipment at points of zero clearance to test enclosure		117	(65)
	2. Surfaces of equipment contacted by persons in operating it (control knobs, pushbuttons, levels, and the like)			
	Metal		81	(35)
	Nonmetallic		108	(60)
	3. Surfaces of equipment subjected to casual contact by persons (enclosure, grille, and the like)			
	Metal		81	(45)
	Nonmetallic		117	(65)
	4. Surfaces of test enclosure where clearance to flammable material is specified		117	(65)
E.	Electrical insulation – general			
	1. Fiber used as electrical insulation or cord bushings		117	(65)
	2. Phenolic composition used as electrical insulation or as parts where deterioration will result in a risk of electric shock or fire		225	(125)
	3. Thermoplastic material. Rise based on temperature limits of material		–	–

[a] Thermocouple applied directly to the integral insulation of the coil conductor.

[b] Thermocouple applied as in item a or applied to conventional coil wrap.

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

[d] A capacitor that operates at a temperature higher than 65°C (117°F) rise may be judged on the basis of its marked temperature rating.

[e] A temperature rise of no more than 90°F (50°C) is acceptable in the terminal box or wiring compartment of equipment that requires supply conductors with an ampacity of more than 100 amp if the equipment is clearly marked with the following statement or its equivalent: "For supply connections, use ____ AWG or larger wires acceptable for at least 167°F (75°C)." See 10.2.2.

[f] Maximum – not rise, see also item A in table for other than hermetic compressors.

[g] Includes both casing and ferrule or blade.

57.2 The maximum pressure developed in a refrigeration system, including equalization pressures shall be used as a basis for the Strength Test – Pressure Containing Components, Section 76.

57.3 Compressor motors shall operate continuously under the conditions of the temperature-pressure test without tripping any protective device in the circuit.

57.4 The equipment is to be fitted with pressure gauges on the high- and low-sides. Thermocouples are to be secured to electrical components, such as the compressor motor windings, starting-relay coil, capacitors, and wiring insulation, and to surfaces as indicated in item D of Table 57.1. The temperature of motor windings or of coils may be measured by the change-in-resistance method, but the primary method of temperature measurement is to be the thermocouple method. The electrical input is to be measured with a voltmeter and an ammeter.

57.5 The equipment is to be installed in accordance with the manufacturer's instructions, see 94.1 and 94.2, and operated under the conditions specified in 57.7 – 57.9, as applicable. The test potential is to be as indicated in Table 53.1.

57.6 When the wiring to a general purpose receptacle does not comply with the requirements of 12.1.11, a resistive load is to be connected to the receptacle circuit during the test and the temperature of the wiring insulation measured. The resistive load is to be sized as described in 56.7 (a), (b) or (c).

57.7 The equipment is to be placed within a room maintained at 104°F (40°C) until the assembly reaches room temperature.

57.8 Other electrical loads, that may operate concurrently with the compressor are to be energized during the test. Equipment is to be tested in the following applicable manner. The test sample is to be connected to a supply of liquid refrigerant greater in volume than the storage section of the recovery/recycling equipment. The test sample is to be started and operated recovering liquid refrigerant until temperatures and pressures have stabilized or until the equipment storage section(s) are filled in accordance with 45.1. The test is repeated with the equipment connected to recover vapor refrigerant. The potential is to be maintained as indicated in Table 53.1. The electrical input, the temperature of electrical components and surfaces, and high- and low-side pressures are to be recorded at intervals during the test. When applicable, the test shall be repeated using different refrigerant types to obtain maximum pressures and temperatures. When the equipment is provided with an integral means of throttling, manual throttling of refrigerant during this testing procedure can be conducted.

57.9 For the test of equipment of the water-cooled type, the condenser water flow is to be maintained at 80°F (26.7°C) inlet and 100°F (37.8°C) outlet temperatures. When the outlet water cannot attain a temperature of 100°F because of product design considerations, the equipment is to be tested at 80°F inlet water and 35 psig (241 kPa) nominal pressure.

57.10 Equipment intended only for automotive applications shall be evaluated in accordance with either 57.1 – 57.9 or the applicable requirements in SAE J1991, SAE J2099, or SAE J2209.

57.11 In reference to 57.10 if the equipment is subjected to the tests in SAE J1991, SAE J2099, or SAE J2209 in lieu of Table 57.1 – 57.9, then:

a) The maximum pressures developed in the refrigeration system, including equalized pressures, shall be used as the basis for the Strength Test in Section 76; and

b) A motor-compressor shall operate continuously without tripping any protective device in the circuit.

57.12 The equipment shall comply with the Dielectric Voltage-Withstand Test, Section 59, following this test.

58 Tests for Refrigerant Hoses

58.1 Reinforced rubber and reinforced thermoplastic hose, or hose assemblies for use with automotive refrigerant recovery/recycling or automotive extraction only equipment shall be subjected to the tests specified in Table 58.1 and 58.3 and 58.7 – 58.12 or evaluated in accordance with SAE J2196.

58.2 Reinforced rubber and reinforced thermoplastic hose or hose assemblies for use with non-automotive refrigerant recovery/recycling equipment, shall be subjected to the tests specified in Table 58.1 and 58.4 and 58.7 – 58.12.

58.3 REFRIGERANT EXPOSURE TEST – Three 18 in (457 mm) long samples of the hose assembly are required for this test. The inner tube is to be exposed to a refrigerant/lubricant mixture for 30 days at a temperature of 176 ±4°F (80 ±2°C). After the exposure, one of the hose assemblies is to be subjected to the pull test specified in 58.11. The remaining two samples shall withstand without failure, the pressure indicated in the Strength Tests – Pressure Containing Components, Section 76.

58.4 REFRIGERANT EXPOSURE TEST – Three 18 in (457 mm) long samples of the hose assembly are required for this test. The inner tube is to be exposed to a liquid refrigerant and refrigerant/lubricant mixture for 30 days at a temperature at least 18°F (10°C) above the maximum temperature measured during the temperature-pressure test in Section 54 but not less than 176 ±4°F (80 ±2°C). After exposure, one of the hose assemblies is to be subjected to the Pull Test specified in 58.11. The remaining two samples shall withstand without failure the pressure indicated in the Strength Tests – Pressure Containing Components, Section 76. See 58.5 for fill limits.

58.5 Each sample hose assembly subjected to the test specified in 58.3 and 58.4 shall not be filled more than 70 percent full by volume with a mixture of 95 percent refrigerant and 5 percent refrigerant lubricant at 70°F (21°C).

58.6 When exposed as specified in 58.3 and 58.9, the hose assemblies subjected to the pull test shall be subjected to a pull test using the test methods and apparatus described in Standard Test Methods for Rubber Hose, ASTM D380.

58.7 HYDROSTATIC STRENGTH TEST – The hose assembly shall withstand, without failure, the pressure indicated in the Strength Tests – Pressure Containing Components, Section 76.

58.8 THERMAL CYCLING TEST – Two sample hose assemblies are to be placed in an air circulating oven maintained at 176 ±5°F (80 ±3°C) for 23 hours. Each hose assembly is then to be removed and allowed to cool to to 77 ±5°F (25 ±3°C) for 1 hour. Each hose is then placed in a cold chamber at minus 22 ±5°F (minus 30 ±3°C) for 23 hours and allowed to return to to 77 ±5°F (25 ±3°C) for 1 hour. The cycle is to be repeated five times. Following this test, the hose assemblies shall withstand, without failure, the pressure indicated in the Strength Tests – Pressure Containing Components, Section 76.

58.9 OIL AGING TEST – Three hose assemblies shall be immersed in IRM 903 oil at 176°F (80°C) for 168 hours. Following this test, the hose shall be subjected to the pull test specified in 58.11 and withstand, without failure, the pressure indicated in the Strength Tests – Pressure Containing Components, Section 76.

58.10 VIBRATION TEST – A single sample hose assembly shall be mounted to a vibration machine and connected to an air line maintained at 50 ±5 psig (345 ±35kPa). The room ambient temperature is to be 77 ±5°F (25 ±3°C). The amplitude of vibration shall be 0.125 ±0.06 in (3.18 ±1.5 mm) and the frequency of vibration shall be 1000 ±20 vibrations per minute. The test shall be conducted for 30 hours with no leakage or failure.

58.11 PULL TEST – The hose assembly shall be mounted to a test apparatus having a crosshead speed of 1.0 in per min to determine the force necessary to separate the hose from the fitting or to pull the hose apart. Starting from zero, the force shall be gradually increased until the fitting separates and/or the hose pulls apart. The force measured shall not be less than 120 lb.

Table 58.1
Hose applications

Tests	Automotive Only[a]	Non-Automotive
30 Day Refrigerant Exposure[b]	X	–
30 Day Refrigerant Exposure[b, c, d]	–	X
Hydrostatic Strength	X	X
Thermal Cycling	X	X

Table 58.1 Continued on Next Page

Table 58.1 Continued

Tests	Automotive Only[a]	Non-Automotive
Oil Aging	X	X
Vibration	X	X
Pull	X	X
Permeation	X	X

[a] Hose assembly can be evaluated in accordance to SAE J2196 in lieu of the tests outlined in Table 58.1.

[b] Test conducted with each refrigerant and refrigerant lubricant mixture intended for use with the hose assembly.

[c] Test conducted at a temperature at least 18°F (10°C) above the maximum temperature during Temperature-Pressure Test (Sec. 54) but not less than 176°F (80°C).

[d] Exception – A 7 day refrigerant exposure test may be conducted on the hose assembly to evaluate alternate crimping methods, barb fittings or other hose connections if the hose itself has been subjected to the 30 day refrigerant exposure test.

58.12 PERMEATION TESTS – Hose and hose assemblies for use with automotive refrigerant recovery/recycling equipment shall not permit effusion of refrigerant at a rate greater than 2.0 lbs/ft^2/yr (9.8 kg/m^2/yr). Hose and hose assemblies for use in other than automotive refrigerant recovery/recycling equipment shall not permit effusion of refrigerant at a rate greater than 8 lbs/ft^2/yr (39.2 kg/m^2/yr) when tested at 120 ±4°F (49 ±2°C) as specified in 58.13 – 58.18.

58.13 The apparatus required consists of canisters with internal volumes of at least 29 to 32 in^3 (475 to 525 cm^3) and a 3000 psig (21 MPa) minimum burst pressure with appropriate fittings to connect to the hose assemblies, halogen detector, circulating air oven capable of maintaining uniform test temperature throughout the test periods, and a weighing scale capable of mass measurements to 0.1 g accuracy.

58.14 Four hose assemblies, having a free hose length of 1 meter are to be tested. Three of the hose assemblies shall be used for determining the loss of refrigerant and the fourth assembly shall be run as an empty plugged blank to be used as a means of determining the mass loss of the hose body alone.

58.15 The free length of hose in each assembly is to be measured at zero gage pressure to the nearest 0.04 in (1 mm). Each of the four hose assemblies is to be connected to a canister and obtain the total mass of each test unit including end plugs to the nearest 0.1 gram.

58.16 Three of the test units are to be loaded with 0.6 milligram of liquid refrigerant per cubic millimeter of each test unit's volume to a total variance of ±5 grams. The loaded test units are to be checked with a halogen detector at a sensitivity of 1 lb per 40 years (11 g per year) to be sure that they do not leak. Any suitable method for loading may be used.

58.17 The three loaded and one blank test units are to be placed in the air oven at the specified test temperature for a period of 30 ±5 min to drive off surface moisture. The hoses are not to be bent in a curve with a diameter smaller than 20 times the outside diameter of the hose while in the oven. The loaded test units are to be checked for leakage and all test units weighed not less than 15 min or more than 30 min after removal from the oven. The mass is to be obtained and recorded as the original mass.

58.18 The test units are to be placed back in the air oven at the specified temperature for 24 hours. At the end of the 24 hour period, the test units are to be removed, weighed in the same manner as previously specified, and returned to the oven. When a loss of 20 g or more occurs, discontinue the test, check for leaks, and repeat test procedure.

58.19 The first 24 hour period is considered the preconditioning period. The mass loss during this period is to be disregarded in final calculations. Seventy-two hours after the preconditioning weighing, the samples are to be weighed in the same manner as previously described. The 72 hours mass loss is to be calculated. The effusion rated is to be determined by subtracting the corresponding mass loss of the blank

from that of the loaded test unit. The effusion rate is to be expressed in kg/m^2/yr or pound per square foot per year. The rate of loss of refrigerant mass for the loaded test units is calculated as follows:

$$R = \left[\frac{(A - B)}{L_1} - \frac{(C - E)}{L_2} \right] \cdot \frac{K}{D}$$

In which:

A is the initial mass after preconditioning period of loaded test unit, g.

B is the final mass after 72 hour period of loaded test unit, g.

C is the initial mass after preconditioning period of blank test unit, g.

D is the nominal hose inside diameter, mm.

E is the final mass after 72 hour period of blank test unit, g.

K is 38.7

R is the rate of refrigerant mass loss, kilograms per square meter (inner tube area of free hose length) per year.

L_1 is the free hose length (between hose fittings) of loaded test unit, m.

L_2 is the free hose length of blank test unit, m.

Or in which:

D is the nominal hose inside diameter, inch.

K is 12.3

R is the Rate of refrigerant mass loss, pounds per square foot per year.

L_1 is the Free hose length of loaded test unit, inch.

L_2 is the Free hose length of blank test unit, inch.

59 Dielectric Voltage-Withstand Test

59.1 The equipment shall withstand, without breakdown, the application of a test potential of 1000 V plus twice rated voltage applied for 1 minute between high-voltage live parts and dead metal parts and between live parts of high- and extra-low-voltage circuits. The test potential shall be at any frequency between 40 and 70 hertz.

Exception No. 1: The test potential for motors rated at not more than 1/2 horsepower (373 W output) shall be 1000 V.

Exception No. 2: If the steady-state voltage developed in a motor circuit through the use of capacitors exceeds 500 V, as measured during the temperature and pressure test, the test potential for the parts affected shall be 1000 V plus twice the developed capacitor voltage.

Exception No. 3: If agreeable to all parties concerned, the test potential may be a direct-current (dc) potential as specified in , Condition A and applied for 1 minute.

59.2 Equipment employing an extra-low-voltage circuit shall withstand, without breakdown, the specified test potential applied for 1 minute between extra-low-voltage live parts and dead metal parts. The test potential shall be:

a) A dc potential of 700 V; or

b) An ac potential of 500V at any frequency between 40 and 70 Hz.

59.2.1 In reference to 59.2, if components specified in 42.3 are employed in the extra-low-voltage circuit, the dielectric voltage-withstand test, shall be:

a) Conducted on the components with the dielectric potential applied between live parts of opposite polarity; or

b) Separately conducted on the components.

59.3 In reference to 59.2.1, the test between extra-low-voltage parts of opposite polarity shall be conducted on magnet coil windings of the transformer after breaking the inner coil lead where it enters the layer.

59.4 A 500 VA or larger transformer, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with 59.1 and 59.2. The applied potential is to be increased gradually from zero until the required test value is reached and is to be held at that value for 1 minute.

Exception: The requirement of a 500 VA or larger transformer can be waived if the high potential testing equipment maintains the specified high potential voltage at the equipment during the duration of the test.

59.5 When the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is large enough so the required alternating-current test potential is unable to be maintained, the capacitors and capacitor-type filters may be tested as described in 59.6.

59.6 The capacitors and capacitor-type filters mentioned in 59.5 are to be subjected to a direct-current test potential of 1414 V for equipment rated 250 V or less or 1414 V plus 2.828 times the rated circuit voltage for equipment rated at more than 250 V. The direct-current test potential is to be maintained for 1 min without breakdown.

59.7 Components providing a d.c. path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors and voltage limiting devices (transient voltage suppressors), may be disconnected during the test.

60 Condenser Fan Motor Failure Test

60.1 Equipment shall not leak refrigerant nor develop pressures or temperatures in excess of those indicated in (a) and (b), when the condenser fan motor locks or fails to start.

a) The maximum high- and low-side pressures are to be recorded as reference values for requirements of the Strength Tests – Pressure Containing Components, Section 76. An assembly employing a pressure-limiting device complying with 48.2 is considered to comply with the high-side pressure requirement.

b) The maximum temperature of the compressor enclosure of the fan motor winding (open type) or of the fan motor enclosure (enclosed type) shall not exceed 302°F (150°C). Motors equipped with thermal protective devices as specified in Motors and Motor Overload Protection, Section 18, are considered to comply with this requirement.

60.2 A sample of the assembly is to be fitted with pressure gauges on the high- and low-pressure sides of the refrigerant system and provided with thermocouples on the compressor enclosure and condenser fan motor winding (open type) or condenser fan motor enclosure (enclosed type). The low-side pressure is to be recorded both during operation and after shutdown. When the equipment is provided with means to relieve discharge pressure into the low side of the system, the low-side pressure is to be recorded while the compressor is operating, this relief means is open and the low-side pressure is increasing, and after shutdown of the compressor.

60.3 The equipment is to be operated with the condenser fan motor locked until stabilized temperatures and pressures are reached. The compressor motor overload device the fan motor overload device, or both, may operate during this test.

60.4 The ambient air temperature is to be 77°F (25°C). The test potential is to be maintained as indicated in Table 53.1. When two or more condenser fan motors are employed, the test is to be conducted with one motor locked.

61 Condenser Water Failure Test

61.1 During failure of the cooling water supply, water-cooled equipment shall not leak refrigerant nor develop pressures or temperatures in excess of those indicated in (a) and (b), nor shall electrical parts be damaged.

a) The maximum high- and low-side pressures are to be recorded as reference values for requirements of the Strength Tests – Pressure Containing Components, Section 76.

b) The maximum temperature of the compressor enclosure shall not exceed 302°F (150°C). When the compressor is equipped with a thermal protective device(s) as specified in Motors and Motor Overload Protection, Section 18, this temperature measurement may be waived.

61.2 A sample of the assembly is to be fitted with pressure gauges on the high- and low-pressure sides of the refrigerant system and provided with thermocouples on the compressor enclosure. The low-side pressure is to be recorded as specified in 60.2. The equipment is to be operated with the condensing water shut off and also with the condensing water restricted until maximum stabilized temperatures are attained or until representative maximum temperatures are attained under cycling load. When the equipment cycles on a motor-overload protective device, the test is to continue until the maximum pressure is obtained. The room ambient is to be 77°F (25°C). The potential is to be maintained as indicated in Table 53.1.

61.3 When a pressure-limiting device is provided, the test need not be conducted to determine compliance with 61.1. The maximum cutout pressure to which the pressure-limiting device may be readily adjusted by the adjusting means provided shall be employed in determining compliance with 61.1.

62 Rain Test

62.1 Equipment exposed to weather shall be subjected to a rain exposure without creating a risk of electric shock due to current leakage or insulation breakdown.

62.2 The equipment is to be installed in accordance with the manufacturer's instructions and subjected to the rain exposure under conditions most likely to cause entrance of water into or onto the electrical components. The duration of exposure is to be 1 h with the equipment on and 1 h with the equipment off.

62.3 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 62.1. Spray heads are to be constructed in accordance with the details shown in Figure 62.2. The water pressure for all tests is to be maintained at 5 psig (34 kPa) at each spray head. The

distance between the center nozzle and the equipment is to be 5 ft (1.5 m). The equipment is to be brought into the focal area of the three spray heads in such a position and under such conditions that the greatest quantity of water will enter it. The spray is to be directed at an angle of 45 degrees to the vertical toward the louvers or other openings closest to current-carrying parts. The equipment is to be operated so that electrical components are energized.

62.4 Following the rain test exposure, the equipment shall have an insulation resistance of not less than 50,000 ohms measured between current-carrying parts and noncurrent-carrying parts, and shall withstand the Dielectric Voltage-Withstand Test, Section 59.

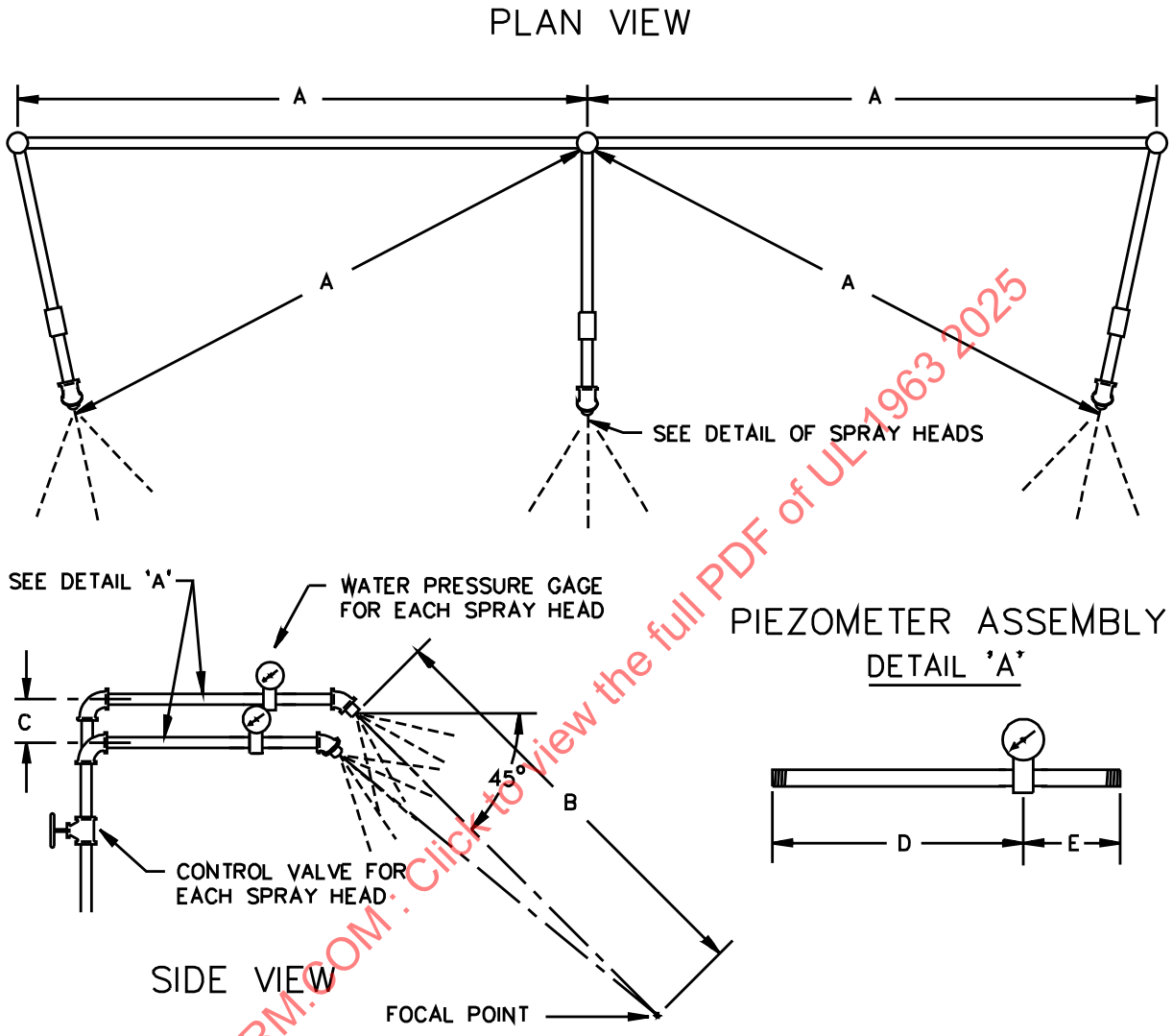
62.5 At the conclusion of the test there shall be no evidence of the entrance of water into enclosures above the lowest live part or in wetting live parts, except as follows:

a) Motor windings may be judged on the basis of the insulation resistance (see 62.4) and by the Dielectric Voltage-Withstand Test, Section 59, when the motors are within the outer enclosure and are shielded from openings in the top of the outer enclosure.

b) Water may enter an enclosure above the lowest live electrical part when the point of entrance is not in proximity to live electrical parts and live parts are not wetted during the rain exposure.

Figure 62.1

Rain-test spray-head piping

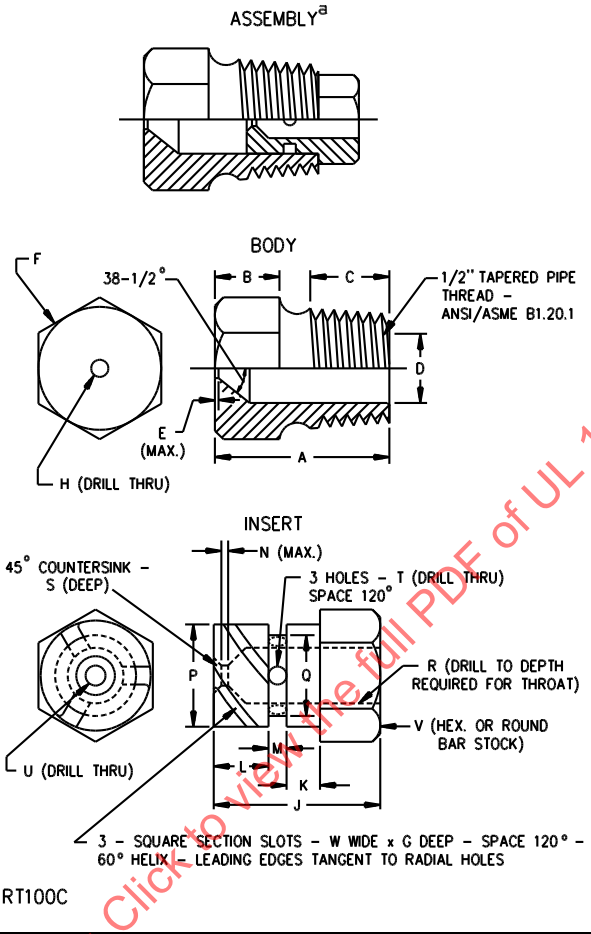


Item	inch	mm
A	28	710
B	55	1400
C	2–1/4	55
D	9	230
E	3	75

RT101E

Figure 62.2

Rain-test spray head



Item	in	(mm)	Item	in	(mm)
A	1-7/32	(31.0)	N	1/32	(0.80)
B	7/16	(11.0)	P	.575	(14.61)
C	9/16	(14.0)		.576	(14.53)
D	.578	(14.68)	Q	.453	(11.51)
	.580	(14.73)		.454	(11.53)
E	1/64	(0.40)	R	1/4	(6.35)
F	[c]	[c]	S	1/32	(0.80)
G	.06	(1.52)	T	(No. 35)[b]	(2.80)
H	(No. 9)[b]	(5.0)	U	(No. 40)[b]	(2.50)
J	23/32	(18.3)	V	5/8	(16.0)
K	5/32	(3.97)	W	0.06	(1.52)
L	1/4	(6.35)			
M	3/32	(2.38)			

[a] Nylon Rain-test spray heads are available from Underwriters Laboratories

[b] ANSI B94.11M, Drill Size

[c] Optional – To serve as wrench grip.

63 Stability Test

63.1 Equipment shall not overturn when tested in accordance with 63.2 and 63.3. Equipment having a supporting base such that both the width and depth dimensions are greater than the height is considered to comply with the requirement.

63.2 Freestanding equipment is to be supported by the legs, leveling screws, or casters provided in its base. Other means of support, such as conduit connections are not to be relied on during the test. The equipment is to be tested either empty or full, whichever results in the more severe test. Equipment shall not overturn under the conditions specified in (a) and (b):

a) Equipment:

1) With service doors, covers, and panels closed, is to be placed on a plane surface inclined at an angle of 10 degrees with the horizontal. Accessories intended for use with the equipment are to be installed. Swivel-type casters, if any, are to be oriented so that the tendency to overturn is maximum, or

2) Weighing 50 lb (22.7 kg) or more with accessories installed, is to be placed on a horizontal surface. When leveling screws are provided, they are to be adjusted equally to raise the equipment 1 in (25.4 mm) above the floor level. When swivel-type casters are provided, they are to be oriented so that the tendency to overturn is maximum. A force equal to one-fourth the weight of the equipment, but not exceeding 50 lb (223 N), is to be applied horizontally at the vertical centerline of any side of the equipment at the highest points, not to exceed 5 ft (1.5 m) above floor level, with all doors closed.

b) Equipment weighing 50 lb (22.7 kg) or more with accessories installed, is to be placed on a horizontal surface. When leveling screws are provided, they are to be adjusted equally to raise the equipment 1 in above floor level. When swivel type casters are provided, they are to be oriented so that the tendency to overturn is maximum.

1) For a drawer or horizontally-hinged door that swings downward and that provides access to the product storage compartment, a force equal to one-fourth the weight of the equipment, but not exceeding 50 lb (223 N), is to be applied vertically downward at the center of the outermost edge of the drawer or door with the drawer or door opened to its maximum.

2) For other hinged doors, a force equal to one-fourth the weight of the equipment, but not exceeding 35 lb (156 N), is to be applied vertically downward at the edge of the door farthest from the hinges with the door opened at an angle of 90 degrees to the cabinet. For equipment with three or more doors, every other door is to be opened and the force is to be applied to the one door that would result in the maximum tendency of the equipment to overturn. If it is provided with tiers of doors, only every other door in one tier is to be opened.

63.3 When the manufacturer provides hardware for securement of the unit, the unit is to be installed in accordance with the manufacturer's instructions and tested with the hardware in place.

64 Strain Relief Test

64.1 The strain relief means provided on a power supply cord, including that for an externally-mounted accessory, and wiring exposed to the equipment user, shall withstand a direct pull of 35 lb (156 N) applied to the cord or wiring without such movement of the cord or wiring as to indicate that stress would be transmitted to internal connections and wiring.

64.2 The strain relief means provided on leads intended for connection of field-installed supply conductors and power supply conductors of internally-mounted accessories shall withstand a direct pull of

20 lb (89 N) applied to the conductors without such movement of the cord or wiring as to indicate that stress would be transmitted to internal connections and wiring.

64.3 A 35 or 20 lb (15.9 or 9.1 kg) weight is to be suspended on the cord or wiring and supported by the equipment so that the strain relief will be stressed from any angle permitted by the design of the equipment. The load is to be applied for 1 min.

65 Burnout Tests – Electromagnetic Components

65.1 An electromagnet operator (solenoid) shall be subjected to a burnout test to determine when the equipment presents a risk of fire or electric shock.

Exception No. 1: This requirement does not apply to an electrically operated valve, magnetic motor controller, or a similar component incorporating an electromagnet and complying with the applicable requirements for the component.

Exception No. 2: The determination of a risk of electric shock may be waived for electromagnet operators in extra-low-voltage circuits.

65.2 A risk of fire is considered to exist if there is any emission of flame or molten metal from the equipment or a glowing or flaming of flammable material. Opening of the supply circuit fuse is acceptable if a risk of fire does not exist.

65.3 A risk of electric shock is considered to exist if the insulation resistance of the equipment is less than 50,000 ohms.

65.4 The tests are to be conducted with the component installed as intended in the equipment. The equipment is to be connected to a supply circuit maintained as indicated in 53.1. Each ungrounded conductor in the supply circuit is to be provided with a fuse of the maximum rating that may be used. For cord connected equipment, the supply circuit fuses are to correspond with the rating of the attachment plug, except that 20 amp is to be the minimum fuse size for equipment rated 150 V or less. The test is to be conducted with the component:

a) Continuously energized until the ultimate result is determined if this condition could exist due to malfunction of a single switch or controller, and

b) Blocked in the position assumed when it is de-energized and then energized continuously until the ultimate result is determined.

66 Burnout Test – High-Voltage Transformers

66.1 There shall be no emission of flame or molten metal from the equipment enclosure when a high-voltage transformer is operated under the conditions described in 66.2 and 66.3.

Exception: This test does not apply to a high-voltage transformer that is provided with thermal overload protection of other than the nonrenewable thermal cutoff type (see 25.1.2.1) or that is protected by an overcurrent device(s) in accordance with the requirements in 25.1.3.1.

66.2 Three samples of the transformer are to be operated continuously at the normal test voltage indicated in Table 53.1 and rated frequency with the enclosure grounded. The test ambient temperature is to be 77°F (25°C) and operation is to be continued until constant temperature is indicated by a thermocouple on the enclosure or until burnout occurs. The circuit on which the transformer is tested is to be protected by fuses rated not less than that required for the equipment.

66.3 Except as specified in 66.4, a resistance load that provides the highest of the current values specified in (a) – (c) shall be connected to the transformer output terminals. The load shall be readjusted to the specified value after 2 min of operation, if necessary, with no further readjustment during the test.

a) Three times the full rated transformer secondary current; or

b) The motor locked-rotor or maximum operating current plus any additional loads for any transformer supplying a motor with or without additional loads; or

c) The sum of inductive load currents (other than a motor), such as the coils of relays, solenoids, and the like, with the armature of the largest inductive load blocked open, for any transformer supplying inductive loads.

66.4 As an alternate to conducting the test in 66.3, the output terminals of the transformer shall be short-circuited. Under these conditions, the current in the output circuit shall be less than three times the rated secondary current.

67 Burnout Test – Electric Heater

67.1 Operation of an electric heater shall not result in a risk of fire or electric shock.

67.2 A risk of fire is considered to exist if there is emission of flame or molten metal from the unit or glowing or flaming of flammable material.

67.3 A risk of electric shock is considered to exist if the insulation resistance of the unit is less than 50,000 ohms.

67.4 Opening of a sheath-type heater element is acceptable if the risk of fire and electric shock does not exist. If the heater element opens, three samples are to be tested to determine that the heater is designed to function in this manner.

67.5 The ambient air temperature is to be 77°F (25°C). The heater is to be energized at the voltage specified in Table 53.1.

67.6 When an automatic-reset temperature-limiting control is employed, the control is to be allowed to cycle until representative maximum temperatures of components and materials, such as conductor insulation, electrical insulation, thermal insulation, and flammable materials near the heater element are attained. When a manual-reset temperature-limiting control is employed, the test is to terminate when the device opens the heater circuit. All other controls are to be shunted out of the circuit.

Exception: This test need not be conducted if the temperature-limiting control is calibrated to open the circuit at a temperature of 77°F (25°C) or less.

67.7 When a replaceable thermal cutoff is employed, the test is to be conducted five times using a different sample of the thermal cutoff for each test. The thermal cutoff shall open the circuit as intended without causing the short-circuiting of live parts and without causing live parts to become grounded to the enclosure. During the test, the enclosure is to be connected to ground through a 3-amp fuse, and any thermally operated control devices in the heater circuit, other than the thermal cutoff, are to be shunted out of the circuit. The 3-amp fuse shall not open during the test.

68 Burnout Tests – Extra-Low Voltage Transformers

68.1 The unit shall not emit flame or molten metal or become a risk of fire, electrical shock, or injury to persons – see 68.3 – when subjected to the tests specified in 68.2 – 68.10. Separate samples may be used for conducting these tests.

68.2 Following each test, a dielectric voltage-withstand test specified in Section 59 is to be conducted.

Exception: More than one abnormal test may be conducted on a sample, and the dielectric voltage-withstand test may be conducted after completion of all abnormal tests.

68.3 A risk of fire, electric shock, or injury to persons is considered to exist if:

a) Flame, burning oil, or molten metal is emitted from the enclosure of the unit as evidenced by ignition, glowing, or charring of the cheesecloth or tissue paper.

b) The insulation breaks down when tested in accordance with 68.2 or live parts are made accessible (see Protection of Users – Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts in the Standard for Uninterruptible Power Systems, UL 1778).

68.4 During these tests the unit is to be placed on a softwood surface covered with a white tissue paper. A single layer of cheesecloth is to be draped loosely over the entire enclosure. The cheesecloth is to be untreated cotton cloth running 14-15 yards per pound (28-30 m^2/kg), and having, for any square inch, a count of 32 threads in one direction and 28 in the other direction.

Exception No. 1: Units not having any bottom openings need not be placed on a softwood surface covered with tissue paper.

Exception No. 2: When it is impractical to drape the entire unit, cheesecloth may be placed only over all ventilating openings.

Exception No. 3: A transformer complying with the requirements in either of the following standards:

a) Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, together Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3,

b) Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type-Appliances, UL 1411.

68.5 For a portable unit having supporting feet made of rubber or neoprene material, the rubber or neoprene material is to be removed prior to the test.

68.6 The supply circuit branch circuit overcurrent protection shall equal 125 percent of the input current rating but in no case shall it be smaller than 20 amp.

Exception No. 1: When 125 percent of the input current rating does not correspond with the standard rating of a fuse or circuit breaker, the next higher standard device rating shall be used.

Exception No. 2: When a marking on the product indicates the use of branch circuit protection exceeding 125 percent of the input current, such protection shall be used.

68.7 The enclosure of the unit is to be connected directly to ground.

68.8 Each test is to be continued until further change as a result of the test condition is not likely. When an automatically reset protector functions during a test, the test is to be continued for 7 h. When a manual reset protector functions during a test, the test is to be continued until the protector operates for 10 cycles using the minimum resetting time, but not at a faster rate than 10 cycles of operation per minute. The following are considered as an acceptable termination of the test:

a) Opening or shorting of one or more components such as capacitors, diodes, resistors, solid state devices, printed wiring board traces, or the like.

b) Opening of the intended branch circuit overcurrent protection device described in 68.6 for a unit marked in accordance with 91.29.

c) Opening of an internal fuse.

Exception: When the manually reset protector is a circuit breaker that complies with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489, it is to be operated for 3 cycles using the minimum resetting time but not at a rate faster than 10 cycles of operation per minute.

68.9 An adjustable resistive load is to be connected directly to the secondary winding of each transformer and adjusted to result in the load condition described in (a) or (b) below. Opening of the intended branch circuit overcurrent protection device described in 68.6 or internal overcurrent protection device connected in the primary-winding circuit is an acceptable termination of this test.

a) For a transformer having a single isolated secondary winding, the load is to be adjusted to result in maximum volt-ampere output but not resulting in more than three times the maximum normal alternating current to flow in the primary winding.

b) For a transformer having multiple isolated secondary windings, each secondary winding is to be tested separately; that is, with the winding under test loaded with an alternating current equal to three times the rms value of the secondary current flowing through that winding during maximum normal operation of the unit and the other isolated windings, each loaded with an alternating current equal to the rms value of the secondary current flowing through their respective windings during maximum normal operation of the unit.

Exception No. 1: A transformer supplied from either an inverter circuit or other means limiting the current to the transformer to less than three times rated current is to be loaded to a condition resulting in maximum obtainable input current.

Exception No. 2: A transformer employed in a switch-mode inverter or converter circuit may be subjected to the transformer overload test described in 68.10 in lieu of the transformer burnout test.

68.10 For a unit tested in accordance with Exception No. 2 to 68.9, the power circuit supplied by the transformer is to be connected to a resistive load that will draw maximum obtainable output power without causing operation of internal overcurrent protection devices or a protection circuit or resulting in opening of a circuit component such as a diode, resistor, solid state device, or similar device.

69 Overload Test – High-Voltage Transformers

69.1 This test applies to a high-voltage transformer provided with thermal protection of other than the nonrenewable thermal cutoff type. See 25.1.2.1.

69.2 Temperatures of a thermally protected high-voltage transformer, measured on the surface of the windings, shall not exceed the insulation temperature rating when the transformer is tested as indicated in

69.3 and 69.4. Insulation temperature rating is defined as the rating for the class of insulation; such as, 105°C for Class 105 insulation, 130°C for Class 130 insulation, and the like.

69.3 A variable resistance load is to be connected to the output terminals and the transformer operated continuously at the normal test voltage indicated in Table 53.1. When the protective device controls a switching device that, in turn, interrupts primary current to the transformer, the switching device is to be in the circuit. The test ambient temperature is to be 77°F (25°C). The resistance load is to be adjusted so that the transformer winding is brought to a stabilized temperature of 18°F (10°C) below its insulation rating. The load is then to be gradually increased until operation of the protector occurs.

69.4 Three samples of the transformer-protector combination are to be tested. Average temperatures of the three samples shall not exceed the winding insulation rating and the temperature of any one sample shall not exceed the insulation rating by more than 9°F (5°C).

69.5 The transformer shall comply with the Dielectric Voltage-Withstand Test, Section 59, following the test specified in 69.3 and 69.4.

69A Overload and Endurance Test for Operating Controls

69A.1 his test applies to switches or other similar operating controls as specified in 17.18.1(b) or 17.18.2(e).

69A.2 A switching device in a product shall perform acceptably when tested as specified. There shall be no electrical or mechanical failure nor undue burning, pitting or welding of contacts, or striking of an arc to dead metal parts.

69A.3 The tests on switching devices shall be conducted by:

a) Operating the switching device mechanisms within the product in accordance with 69A.4 and 69A.6 except using the normal switching device loads of the product; or

b) Cycling the switching devices individually or collectively while controlling the loads specified in 69A.5 and 69A.6.

69A.4 If the test in 69A.3(a) is conducted, the:

a) Enclosure of the product shall be connected through a 30 ampere cartridge fuse to the electrical test circuit pole considered least likely to strike (arc) to ground;

b) Switching device shall be mounted as intended in service; and

c) Test cycling shall be as specified in 69A.6 unless a slower rate is required by the design of the product. A faster rate may be used if agreeable to all concerned.

69A.5 If the test in 69A.3(b) is conducted, the switching device shall be subjected to an overload test at the ambient temperature for which it is intended. The overload test shall consist of making and breaking the connected load for 50 cycles of operation, with 1 second ON and 9 seconds OFF. The current, power factor and voltage used for testing each type of load shall be as follows:

a) Noninductive load(s) – 150 percent of the total connected load current. The power factor shall be 1.0 and the voltage shall be as specified in 53.1;

b) One or more motors together with one or more other loads – 100 percent of the locked-rotor current, maximum operating current or maximum rated current of the largest motor plus 100

percent of the full load or maximum operating current of all other motors and/or other loads. The power factor shall be 0.4 – 0.5 and the voltage shall be as specified in 53.1;

c) One or more inductive loads, such as a transformer or ballast, with or without other noninductive or pilot duty loads – 100 percent of the total inductive and other noninductive/pilot duty loads. The power factor shall be 0.7 – 0.8 and the voltage shall be as specified in 53.1; or

d) One or more pilot duty loads, such as coils within a relay or electric valve – 100 percent of the total connected pilot duty loads. The power factor shall not exceed 0.35 and the voltage shall be 110 percent of the value specified in 53.1.

69A.6 A switching device shall be subjected to an endurance test at the ambient temperature for which it is intended. The endurance test voltage shall be as specified in 53.1. The current shall be 100 percent of the total connected load current and the power factor shall be as specified in 69A.5 for each type of load. The endurance test cycling shall consist of making and breaking the connected load for:

a) 6000 cycles of operation with 1 second ON and 9 seconds OFF for a switching device that is other than a self-resetting motor-compressor or electric heater operating control; or

b) 24,000 cycles of operation with 1 second ON and 9 seconds OFF followed by 6,000 cycles of operation with 1 second ON and 59 seconds OFF for a switching device that is a self-resetting motor-compressor or electric heater operating control.

69A.7 At the conclusion of the test in 69A.3, each switching device shall be subjected to and comply with the Dielectric Voltage-Withstand Test, Section 59.

69B Switch Mode Power Supply Units – Overload Test

69B.1 The test applies to switch mode power supply units as specified in 25.4.1.1.

69B.2 Each output winding, or section of a tapped winding, is overloaded in turn, one at a time, while the other windings are kept loaded or unloaded, whichever load conditions of normal use is the least favorable.

69B.3 Overloading is carried out by connecting a variable resistor (or an electronic load) across the power supply output. The resistor is adjusted as quickly as possible and readjusted, if necessary, after 1 minute to maintain the applicable overload. No further readjustments are then permitted.

69B.4 For this test, any protective devices such as a fuse, manual reset circuit protector, thermal protector, etc. are allowed to remain in the circuit.

69B.5 If overcurrent protection is provided by an overcurrent protection device, the overload test current is the maximum current which the overcurrent protection device is just capable of passing for 1 hr. If this value cannot be derived from the specification, it is to be established by test.

69B.6 If no overcurrent protection is provided, the maximum overload is the maximum power output obtainable from the power supply.

69B.7 In case of voltage foldback, the overload is to be slowly increased to the point which causes the output voltage to collapse. The overload is then established at the point where the output voltage recovered and held for the duration of the test.

69B.8 The duration of the test is to be for 7 hours or until ultimate results are reached. At the conclusion of the test, there shall be no charring or burning of electrical insulation, no opening of any protective device or any circuit component.

70 Overvoltage and Undervoltage Tests

70.1 An electromagnet, such as employed on a relay or solenoid in an extra-low-voltage circuit, shall withstand 10 percent above rated voltage without damage and shall operate at that voltage and also at 15 percent below rated voltage. When the component is supplied by the secondary winding of an extra-low-voltage transformer provided as part of the unit, the voltage adjustments are to be made in the primary of the transformer based on the Normal Test Voltages specified in Table 53.1.

Exception: When failure of an extra-low-voltage component to operate at 15 percent below rated voltage does not result in a risk of fire, electric shock, or injury to persons, the undervoltage test is not required to be performed.

70.2 When a relay or other control is used in combination with a motor controller to prevent automatic recycling of the motor due to the operation of a protective device, the components involved shall comply with the requirements of 70.1 under any condition that might result from operation of the protective device and de-energization of the circuit.

70.3 Relays and solenoids are to be connected to a supply source maintained at the overvoltage condition until the coils of the relays and solenoids attain constant temperature. The potential then is to be reduced to the rated voltage and each relay and solenoid shall operate as intended at this voltage. A relay or solenoid that will not be subject to continuous operation is to be energized at the overvoltage condition at the rated voltage for the maximum time permitted by its duty cycle or until constant temperature is attained, whichever occurs first.

71 Current Overload Test – Bonding Conductors and Connections

71.1 When required by 14.8 or 14.12, bonding conductors and connections shall not open, when carrying a current equal to twice the rating of the branch circuit overcurrent-protective device for the interval indicated in Table 71.1.

Table 71.1
Current overload test

Rating of overcurrent protection device, amp	Minimum duration of current flow, min
30 or less	2
31 – 60	4
61 – 100	6
101 – 200	8

72 Insulation Resistance Test

72.1 General

72.1.1 Equipment employing insulating material subject to the deteriorating conditions of moisture shall have an insulation resistance of not less than 50,000 ohms between live parts and interconnected dead metal parts after exposure for 24 hours to air having a relative humidity of 85 ±5 percent at a temperature of 90 ±4°F (32 ±2°C).

72.2 Electric heaters

72.2.1 The insulation resistance of encapsulated heaters and sheath-type heaters that are exposed to moisture in a unit shall be not less than 50,000 ohms when tested as described in 72.2.1 and 72.2.3 and the heater shall comply with the Dielectric Voltage-Withstand Test, Section 59, following exposure.

72.2.2 When an encapsulated heater or heater terminal seal is intended to be immersed in water as it is used in the unit, the test is to be conducted by cycling the heater for 30 days, submerged in water. The water is to be maintained at a temperature of 194 – 212°F (94 – 100°C). The heater is to be energized at its rated voltage and cycled at a rate of 1-1/2 min on and 13-1/2 min off.

72.2.3 When the heater terminal seal is exposed to moisture but is not subject to more than occasional contact with water in the unit, the test is to be conducted by cycling the heater assembly or terminal seal in an atmosphere of not less than 98 percent relative humidity at any convenient temperature above 32°F (0°C). The heater is to be energized at its rated voltage and operated for 1000 cycles at a rate of 1-1/2 min on and 13-1/2 min off.

73 Limited Short-Circuit Test

73.1 General

73.1.1 The components specified in (a) – (d) shall comply with the requirements of 73.2.1 – 73.4.1, as applicable, following short circuiting while protected by a branch-circuit overcurrent device of the size required by the equipment:

a) Motor overload protective devices connected in the motor circuit.

b) Motor circuit conductors and connections as required by 12.1.32.

c) Bonding conductors and connections as required by 14.8 and 14.12.

d) Conductors smaller than 18 AWG as covered by 12.1.32(b).

73.1.2 For a cord-connected unit, the branch-circuit protection specified in 73.1.1 is to be provided by a fuse having a rating not less than the rating of the attachment plug.

Exception: The minimum fuse size for cord-connected equipment is to be 20 amp rated 125 V or less.

73.1.3 For a permanently-connected unit, the branch-circuit protection specified in 73.1.1 is to be provided by either:

a) A device that is recognized for branch-circuit protection and located in the unit, or

b) A branch-circuit protective device of the type and maximum rating specified on the equipment nameplate.

73.1.4 Except as specified in 73.1.4.1, permanently-connected equipment having more than one motor wired for connection to one supply line shall withstand short-circuiting while protected by a branch-circuit overcurrent device rated at 225 percent of the rated-load or maximum rated current of the largest hermetic compressor motor of the group plus an amount equal to the sum of any additional loads supplied. If a hermetic compressor motor is not supplied, the branch-circuit overcurrent protective device is to be rated 400 percent of the full-load or maximum operating current of the largest motor of the group plus an amount equal to the sum of any additional loads supplied.

73.1.4.1 If the branch-circuit overcurrent device is sized smaller than that specified in 73.1.4, then:

a) The branch-circuit overcurrent device shall not be smaller than 15 amperes; and

b) The product shall start and operate during the Starting Test, Section 56, without opening a fuse having this smaller rating.

73.1.4.2 If a permanently-connected product incorporates a branch-circuit overcurrent device described in 73.1.3 as part of the product, the test shall be conducted with that device within the product.

73.1.5 With regard to branch-circuit overcurrent protective devices and for the purpose of these tests, fuses of the same rating are considered to be interchangeable. Fuses and circuit breakers are not considered to be interchangeable with each other. Circuit breakers are not considered interchangeable with each other.

73.1.6 The component is to be connected in a test circuit having a capacity based on the sum of the load currents and voltage rating of the equipment. See Table 73.1. When the sum of the load currents of the equipment falls between two values in the table, the larger value is to be used in determining the circuit capacity. If the equipment nameplate shows individual loads, the sum of the load current is to be the total of all individual loads that may occur simultaneously. If more than one simultaneous load condition is possible, the condition resulting in the maximum total current is to be used as a basis for determining the capacity of the test circuit. The voltage for the test circuit is to be an alternating current supply, and the circuit capacity is to be measured without the component in the circuit. The power factor of the test circuit is to be 0.9 – 1.0 unless a lower power factor is agreeable to those concerned.

73.1.7 Three samples of each component or conductor under test are to be subjected to each test condition and a new protective device is to be used for each test. Consideration is to be given to both short-circuit and ground-fault conditions.

73.2 Motor overload protective device

73.2.1 There shall be no ignition of cheesecloth surrounding the enclosure of a motor protective device when samples are subjected to this test.

73.2.2 When a thermally protected motor or a separately enclosed motor overload protective device is within an outer cabinet, and if the assembly is constructed so that flame and molten metal will be confined within the cabinet and there is no flammable material except electrical insulation within the cabinet, the short-circuit test may be waived.

Table 73.1
Short-circuit test currents

Product rating, amp				
Single phase				
110 – 120 V	200 – 208 V	230 – 240 V	254 – 277 V	Circuit capacity, amp
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
3 Phase				

Table 73.1 Continued on Next Page

Table 73.1 Continued

Product rating, amp				
200 – 208 V	**220 – 240 V**	**440 – 480 V**	**550 – 600 V**	**Circuit capacity, amp**
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000

73.3 Bonding conductors and connections

73.3.1 Bonding conductors and connections shall not open when samples are subjected to this test.

73.4 Motor circuit conductors and connections

73.4.1 Motor circuit conductors and connections shall not be damaged when samples are subjected to this test.

74 Electric Heater Control Tests

74.1 Endurance test

74.1.1 *Deleted*

74.1.2 *Deleted*

74.2 Calibration test

74.2.1 *Deleted*

75 Protective Devices – Maximum Continuous Current Test

75.1 To determine that a thermal protector or a protective system will not permit a continuous current in excess of 156 percent of the rated-load current of the motor as required by 19.3.2, the equipment is to be tested as specified in 75.2, unless the compressor motor has been separately tested as described in 75.4.

75.2 The equipment is to be connected to a circuit of rated voltage and operated under the conditions described in Table 75.1 for at least 1 hour or until stable conditions have been reached, whichever is longer. Stable operation is considered to be obtained when two consecutive readings, 15 min apart, of the temperature on top of the compressor motor shell do not change more than 3°F (1.7°C). The voltage then is to be reduced in steps of 2 percent of rated voltage (to the nearest integral volt). Operation is to be allowed to become stable after each reduction in voltage before the next reduction is made, and readings of current input to the compressor motor are to be noted after stable operation is obtained subsequent to each voltage reduction. If the equipment will operate at 90 percent of rated voltage without tripping the motor protective device, the first step in voltage reduction may be to 90 percent of rated voltage followed by alternate stabilization periods and 2 percent steps in voltage reduction as outlined above. This procedure is to be continued until the protective device opens the circuit. The compressor motor current input at the lowest voltage step during which continuous operation occurs (the lowest voltage preceding the voltage at which the protective device opens the circuit) is to be used as the basis for judging compliance with the requirements in 19.3.2.

Exception: Initial operation of the equipment may be at such a voltage that the current input is 156 percent of the rated current. The voltage then is to be reduced by 2 percent of rated voltage (to the nearest integral volt) to establish that the protective device opens.

Table 75.1
Test conditions for calibration of thermal protectors and protective systems

Location	Temperature, °F	(°C)
Air temperature surrounding unit	104	(40)
For water-cooled unit		
Water temperature entering condenser	80	(26.7)
Water temperature leaving condenser	100	(37.8) [a]
For air-cooled unit		
Air temperature entering condenser	104	(40)

[a] Where this condition cannot be attained due to the design of the unit, the unit is to be tested at 80°F inlet condenser water temperature and 35 psig (2.41 kPa) nominal pressure.

75.3 The voltage reductions mentioned in 75.2 may be applied to the compressor motor only, with the other components in the equipment operated at rated (or higher) voltage. For dual-voltage rated units, the rated voltage referred to in 75.2 is to be the higher of the two ratings.

75.4 The compressor motor and its protective system, as employed in the equipment, may be separately tested as described in 75.2 under the conditions described in Table 75.2. This separate test may be used as a basis for judging compliance with the requirements in 19.3.2.

Table 75.2
Test conditions for calibration of thermal protectors and protective systems separately

Location	Degrees F	(C)
Return gas		
Saturated vapor temperature	32	(0)
Superheat	48	(27)
Discharge gas		
Saturated vapor temperature	140	(60)
Ambient air		
Temperature	122	(50)
Velocity	400 fpm[a] (2.03 m/s)	

[a]The velocity specified in the horizontal air velocity in the test chamber without the compressor installed. The actual velocity across the compressor may be different from this value, depending on the shape of the compressor and its effect on the air- flow pattern. A higher velocity may be employed if the results of the test with the higher air velocity indicate compliance with 18.3(b) or (d).

76 Strength Tests – Pressure Containing Components Refrigerant System

76.1 High-side parts of the refrigerant system shall have an ultimate strength not less than the highest of the following:

a) Five times the marked high-side design pressure. See 91.8.

b) Five times the maximum pressure developed in the Temperature and Pressure Test, Section 57.

c) Five times the start-to-discharge pressure of a pressure relief valve or five times the set-pressure of a rupture member.

d) Three times the maximum adjustable setting of the pressure-limiting device.

e) For a unit equipped with a fusible plug, 2-1/2 times the vapor pressure of the refrigerant at the relief temperature of the fusible plug or 2-1/2 times the critical pressure of the refrigerant, whichever is smaller.

f) For an air-cooled unit, three times the maximum high-side pressure developed in the Condenser Fan Motor Failure Test, Section 60.

g) For water-cooled units and not equipped with a pressure-limiting device, five times the pressure developed in the Condenser Water Failure Test, Section 61.

h) One and one-half times the vapor pressure of the refrigerant at 140°F (60°C).

76.2 Pressure vessels bearing the ASME Code "U" symbol and having a design pressure not less than required by 76.1 or 76.4, as applicable, are acceptable without test.

76.3 A refrigerant-containing component having a marked design pressure shall have an ultimate strength equal to five times the marked design pressure.

76.4 Low-side parts of the refrigerant system shall have an ultimate strength not less than the highest of the following:

a) Three times the marked low-side design pressure. See 91.8.

b) Three times the maximum low-side pressure developed in the Temperature and Pressure Test, Section 57, including equalization pressure developed.

c) For an air-cooled unit, three times the maximum low-side pressure developed in the Condenser Fan Motor Failure Test, Section 60, including the low-side equalization pressure developed.

d) For a water-cooled unit, three times the maximum low-side pressure developed in the Condenser water Failure Test, Section 61, including the low-side equalization pressure developed.

e) One and one-half times the vapor pressure of the refrigerant at 140°F (60°C).

Exception No. 1: Low-side pressure vessels shall have an ultimate strength of not less than five times the highest of the following:

1) Low-side design pressure,

2) Maximum pressure developed during the Temperature and Pressure Test, Section 57,

3) Start-to-discharge pressure of a pressure-relief valve, or

4) The set-pressure of a rupture member.

Exception No. 2: Low-side pressure vessels protected by a fusible plug shall have an ultimate strength not less than 2-1/2 times the vapor pressure of the refrigerant at the relief temperature of the fusible plug or 2-1/2 times the critical pressure of the refrigerant, whichever is smaller.

76.5 With reference to 76.1(h) and 76.4(e), vapor pressures of R11, R12, R22, R134a, R500, and R502 at 140°F (60°C) are 31, 207, 337, 229, 248, and 362 psig (214, 1427, 2323, 1579, 1710, and 2496 kPa), respectively.

76.6 With reference to the requirements of 76.1 and 76.4, sections of the refrigerant system constructed of continuous tubing or of lengths of tubing connected by soldered, brazed, or welded joints are considered as complying with these requirements, provided the tubing employed in the assembly complies with the requirements of 46.1.1.

76.7 Except as specified in 47.3 and 47.4, the requirements in 76.1 and 76.4 shall also apply to equipment in which the high-side design pressure marked on the equipment equals or exceeds the critical pressure of the refrigerant.

76.8 Two samples of each refrigerant-containing part are to be tested. The test medium is to be any nonhazardous liquid, such as water. The test samples are to be filled with the test medium to exclude air and are to be connected in a hydraulic pump system. The pressure is to be raised gradually until the required pressure is reached. This pressure is to be maintained for 1 min during which time the samples shall not burst or leak. Leakage is to be determined visually; for example, by examination of the sample for release of the test medium or as evidenced by a decreasing hydrostatic gauge pressure.

76.8.1 In reference to 76.8, any leakage that occurs shall comply with all of the following:

a) Leakage shall occur only at gaskets or seals located within components intended for use with a refrigerant identified as having a flammability safety group classification that does not exceed Class A1 as described by ANSI/ASHRAE 34;

b) Leakage shall occur only at a pressure greater than:

1) Twice the equipment marked high-side design pressure for gaskets and seals in components located within the refrigeration system high-side; or

2) Twice the equipment marked low-side design pressure for gaskets and seals in components located within the refrigeration system low-side;

c) If leakage occurs at the component gaskets or seals, the component shall be capable of withstanding the full required test pressure.

76.9 Pressure-actuated refrigeration controllers rated for the application are exempt from strength test requirements for pressure containing components.

77 Tests on Refrigerant Storage Fill Limiting Devices

77.1 Operational test

77.1.1 A complete sample of the refrigerant storage section, along with its associated fill limiting assembly, shall be operated as intended and limit the fill of the storage section to 80 percent or less of its capacity by volume.

77.2 Endurance test

77.2.1 A complete sample of the refrigerant storage “fill” limiting assembly shall be operated as intended for 100,000 cycles. Immediately following this cycling process, the fill limiting assembly shall be subjected to the Dielectric Voltage-Withstand Test, Section 59 and the Operational Test in 77.1.1.

77.3 Vibration test

77.3.1 A complete sample of the refrigerant storage “fill” limiting assembly employed on all portable refrigerant storage containers shall be subjected to a 1/4 in (6.4 mm) displacement at a frequency of 17 hz for 48 hours. Immediately following this test, the fill limiting assembly is to be subjected to the Operational Test in 77.1.1.

77.4 Rough usage test

77.4.1 Two complete samples of the portable refrigerant storage tank, along with their fill limiting devices are subjected to this test. One sample is to be filled with water to 80 percent of its capacity by volume. The other sample is to remain empty. Each sample is to be dropped three times from a height of 3 ft (0.91 m) onto a concrete floor so that the bottom, side, and top of the storage tank is impacted with the floor. Following this test, the samples shall be subjected to the Operational Test in 77.1.1.

77.5 Float crush test

77.5.1 Two samples of the as-received floats shall be inserted into a pressure vessel. The floats shall withstand a test pressure that is a minimum of two times the maximum pressure measured during the tests outlined in Section 57 for 1 minute without leakage or deformation.

Exception: Floats intended for use in removable storage cylinders complying with Section 50 shall withstand a minimum of two times the pressure rating of the storage cylinder.

77.6 Compatibility test

77.6.1 Nonmetallic components and/or electrical insulating materials used inside refrigerant storage sections that are used to operate the fill limiting device shall be compatible with the refrigerants and oils to be used with the refrigerant recovery/recycling equipment.

77.6.2 A complete sample of the as-received fill limiting device shall be mounted inside a pressure vessel that is filled to 80 percent of its internal volume by a mixture of 5 percent oil and 95 percent refrigerant intended for use with the refrigerant recovery/recycling equipment. The pressure vessel shall be placed in an air circulating oven maintained at a minimum of 176°F (80°C) for a total of 60 days. Other values of time and temperature as noted in Table 77.1 can be employed. Immediately following this test, the fill limiting device shall be subjected to the Operational Test in 77.1.1.

Table 77.1
Alternate values of time and temperature for the compatibility test

Days	Degrees	
	°F	(°C)
60	176	(80)
45	185	(85)
30	194	(90)
22.5	203	(95)
15	212	(100)

78 Tests on Weight Scale Assemblies

78.1 Operational test

78.1.1 A complete sample of the refrigerant storage weight scale assembly shall be operated as intended to determine that the fill limit of the storage section is 80 percent or less at 70°F (21.1°C) of its capacity by volume.

78.2 Endurance test

78.2.1 A sample of the switch and mechanical assembly used to cease the refrigerant recovery operation shall be operated as intended for 100,000 cycles. The electrical rating of the switch is to be adequate for the load it controls. Following this test, the weight scale assembly shall be subjected to the Operational Test in 78.1.1.

78.3 Vibration test

78.3.1 A complete sample of the refrigerant storage weight scale assembly shall be subjected to a vibration test as noted in either 78.3.2 or 78.3.3. The test is to be conducted with the storage tank (A) full, (B) empty and (C) removed from the refrigerant storage weight scale. One of the conditions noted above may be chosen to represent the worst case. Following this test, the weight scale assembly shall be subjected to the Operational Test in 78.1.1.

78.3.2 A sample of the refrigerant storage weight scale is to be placed on a vibration table in its normal upright position but not secured in place except that it may be loosely restrained to limit the area of travel. The test apparatus is to consist of a vibration table that provides circular motion with a total displacement of 1 in (25.4 mm) in a vertical plane with the table level at all times. The speed of the apparatus is to be adjusted so that the vibration frequency generates a 1/16 in (1.6 mm) vertical displacement of the assembly from the table. During the test, the equipment is to be rotated 90 degrees from the initial position so that the sample is subjected to both longitudinal and transverse circular vibration. The sample is to be subjected to vibration in each position for 3-1/2 h (7 h total vibration time). After making the change in position of the sample (90 degree rotation), the speed of the test apparatus is to be readjusted to maintain a 1/16 in (1.6 mm) displacement.

78.3.3 A sample of the refrigerant storage weight scale shall be positively secured onto a vibration table in its normal upright position. The vibration table shall be adjusted to provide a circular motion with a total displacement of 1 in (25.4 mm), to generate a 1.25 g (12.3 m/sec^2) force of acceleration. During the test, the equipment is to be rotated 90 degrees from the initial position so that the sample is subjected to both longitudinal and transverse circular vibration. The sample is to be subjected to vibration in each position for 24 h (48 h of total vibration time).

78.4 Rough usage test

78.4.1 A sample of the refrigerant storage tank filled with refrigerant to 80 percent by volume is to be dropped three times from a height of 6 in (152 mm) onto the weight scale assembly. The test shall be repeated 3 times with an empty refrigerant storage tank. If constraints on the equipment prevent dropping the tank 6 in (152 mm), the height of the drop is to be limited by the design. Following this test, the weight scale assembly shall be subjected to the Operational Test in 78.1.1.

79 Tests of Gaskets and Seals Used in Refrigerant Systems

79.1 General

79.1.1 Gaskets and seals of neoprene, rubber, or polymeric material used to prevent refrigerant leaks between two mating surfaces shall comply with the requirements in 79.2.1 – 79.4.1.

79.2 Tensile strength and elongation test

79.2.1 Representative samples of each elastomeric material shall be subjected to this test in accordance with the Standard for Gaskets and Seals, UL 157, in the as-received condition, after the refrigerant exposure and oil immersion tests noted below. No minimum values are established for as-received samples. After exposure in each refrigerant and immersion in oil, the tensile strength and elongation shall not be less than 60 percent of original.

79.3 Refrigerant exposure test

79.3.1 Representative samples of each elastomeric material shall be exposed to the liquid phase of each refrigerant intended to be handled for 30 days at 158°F (70°C). The test apparatus shall include a pressure vessel of sufficient strength to adequately handle the test pressure developed and means of transferring the test fluid to the vessel.

79.4 Oil immersion test

79.4.1 Representative samples of each elastomeric material shall be immersed for 70 hours in IRM 903 oil. The samples and test fluid shall be at 70 ±3.6°F (21 ±2°C). The volume of the samples initially and at the conclusion of the immersion test shall be determined by the water displacement method and the percentage change and volume calculated. The material shall not show a volume change of more than 25 percent swelling or 1 percent shrinkage.

80 Shelf Strength Test

80.1 A storage shelf shall remain in position and comply with 80.3 after being subjected to three impacts as indicated in (a) and (b). In addition, the impacts shall not result in exposure of live parts, damage to electrical components or wiring, or reduction of electrical spacings.

a) The release from a height of 4 in (102 mm) of a bag containing lead shot, whose weight is equal to one-half the weight of the test load specified in 80.3, but not exceeding the weight of ten of the cylinders described in 80.3. The height of the drop is to be a measured to the bottom of the bag.

b) When the maximum loading height of the component is less than 10 in (254 mm), the bag of lead shot is to be released from a height equal to the maximum loading height minus 6 in (152 mm).

80.2 The lead shot is to be trade size No. 9 to 6, or 0.08 to 0.11 in (0.2 to 0.3 mm) diameter. The bag is to be spherical and is to impact the storage shelf at the center.

80.3 A storage shelf shall remain in position and retain a test load applied for 1 hour as specified in (a) – (c):

a) The maximum number of solid steel cylinders, each weighing 2.2 lb (1 kg) and having a diameter of 3.15 in (80.0 mm), that can be placed in a single tier, with their axes vertical, on the storage shelf without any cylinder overhanging the front edge of the component.

b) When the maximum loading height of a shelf does not exceed 5.9 in (150 mm), the solid steel cylinders are to be 3.15 in (80.0 mm) in diameter are to weigh 1.1lb (0.5 kg) each, or

c) When more than one storage shelf is supported by a bracket (for example, plaster arrangement), the bracket shall remain in position when all support components are simultaneously loaded as indicated in (a) or (b), as applicable. Adjustable storage shelves shall be equally spaced during this test.

80.4 Other loading means may be used in lieu of cylinders, provided the load is equivalent to that calculated on the basis of 80.3.

80.5 The tests in 80.1 and 80.3 are to be conducted with any arrangement or removal of storage shelf and, where the storage shelf or its structural support parts are constructed of polymeric materials, the tests in 80.1 and 80.3 are to be conducted at the temperature of 60 to 90°F (15.6 to 32.2°C).

81 Strength of Handles Test

81.1 A handle or straps used to support or carry a product shall withstand a load of three times the weight of the product without damage to the handle, its securing means, or that portion of the enclosure to which the handle is attached.

81.2 The load is to be uniformly applied over a 3 in (76 mm) width at the center of the handle, without clamping. The load is to be started at zero and gradually increased so that the test value is attained in 5 to 10 s; the test value is to be maintained for 1 min. When a product has more than one handle and is unable to be carried by one handle, the load is to be distributed between the handles. The distribution of the load is to be determined by measuring the percentage of the product weight sustained by each handle with the product in the normal carrying position. When a product is furnished with more than one handle and can be carried by only one handle, each handle is to withstand the total load.

82 Component Restraint Test

82.1 A slideout storage component (drawer, shelf, or the like) shall be restrained to prevent its being unintentionally pulled free of its supporting means.

Exception: The types of components specified in (a) – (c) need not be restrained:

a) A pan, tray, or similar container that rests freely on a shelf or on the storage compartment bottom;

b) A component that does not exceed 10 lb (4.5 kg) in weight when loaded as indicated in 73.3; and

c) A shelf or container located so that the bottom of the shelf or container is not more than 20 in (508 mm) above the floor, with levelers adjusted to raise the equipment to its maximum elevation above the floor, but not to more than 1 in (25.4 mm).

82.2 The restraint specified in 82.1 shall prevent the storage component from being pulled clear of the equipment with the application of a statically applied load equal to the weight of the component loaded in accordance with 80.3, but not more than 30 lb (13.6 kg). The component is to be loaded in accordance with 80.3 and is to be in its restrained position. The force is to be applied horizontally by hanging a weight from a cord running over a pully and attached to the center of the load edge of the component.

82A Wiring Endurance Test

82A.1 Equipment with wiring subjected to movement as specified in 12.1.10 shall be tested in accordance with 82A.2 – 82A.5. At the conclusion of the testing, the equipment shall comply with all of the following:

a) There shall be no broken conductors;

b) Individual strands shall not penetrate the insulation;

c) There shall be no damage to the wiring; and

d) The equipment shall comply with the Dielectric Voltage-Withstand Test, Section 59.

82A.2 Wiring subject to movement shall be tested by cycling the moving part(s) through the maximum travel permitted by the design. If the electrical component to which the wiring is connected is exposed to the user, the duration of the endurance test shall be 100,000 cycles, otherwise the test shall be for 6,000 cycles.

82A.3 Door restraints, such as chains, clamps, and the like, shall be removed. However, such restraints may remain in place if their removal requires the use of a tool.

82A.4 The endurance test cycle rate shall be not less than 6 cycles per minute. One cycle shall be considered a complete flexing movement from the starting position through the maximum amount permitted by the design and then returned to the starting position.

82A.5 Following the endurance cycling, the equipment shall be subjected to the Dielectric Voltage-Withstand Test, Section 59.

83 Accelerated Aging Tests on Gaskets, Sealing Compounds, and Adhesives

83.1 Gaskets and sealing compounds of neoprene or rubber, except foamed materials, required for use with electrical enclosures as determined during the Rain Test, Section 61, shall have physical properties before and after air oven aging for 70 h at 212°F ±3.6°F (100°C ±2°C) as indicated in Table 83.1.

83.2 Foamed neoprene or rubber compounds shall not harden or otherwise deteriorate to a degree that affects their sealing properties after being subjected to air oven aging for 70 h at 212°F ±3.6°F (100°C ±2°C).

83.3 A thermoplastic material, other than polyvinyl chloride materials, shall not deform, melt, or otherwise deteriorate to a degree that affects its sealing properties following exposure to air at a temperature of 190 ±3.6°F (88 ±2°C) for a period of not less than 7 days.

83.4 A polyvinyl chloride gasket material shall have an ultimate tensile strength of not less than 1200 psig (8.3 MPa) and an ultimate elongation of not less than 250 percent prior to the exposure to the elevated air temperature. The minimum tensile strength shall be not less than 90 percent and the elongation not less than 75 percent of the original values following the exposure to the elevated air temperature. The elevated air temperature shall be 190 ±3.6°F (88 ±2°C) for a period of not less than 7 days.

Table 83.1
Physical properties of gaskets and sealing compounds

	Before test	After test
Recovery – Maximum set when 1 in (25.4 mm) gage marks are stretched to 2-1/2 in (63.5 mm) and held for 2 min and measured 2 minutes after release.	1/4 in (6.4 mm)	
Elongation – Minimum increase in distance between 1 in (25.4 mm) gage marks at break.	250 percent (1 to 3-1/2 in) (25.4 to 88.9 mm)	65 percent of original
Tensile Strength– Minimum force at breaking point.	850 psig (5.9 MPa)	75 percent of original

83.4.1 Gaskets of materials other than those mentioned in 83.1 – 83.4 shall be nonabsorptive, and shall provide equivalent resistance to aging and temperatures.

83.4.2 At least three samples of neoprene, rubber or polyvinyl chloride materials shall be used for each of the following tests:

a) Recovery

b) Before elongation

c) After elongation

d) Before tensile strength and

e) After tensile strength.

83.5 Sealing compounds shall be applied to the surface they are intended to seal. A representative sample of the surface with the sealing compound applied shall be subjected to a test involving exposure to air at 190 ±3.6°F (88 ±2°C) for a period of not less than 7 days. The sealing compound shall not melt, become brittle, or otherwise deteriorate to a degree that affects its sealing properties as determined by comparing an aged sample to an unaged sample.

83.6 When gaskets are secured by adhesives, samples of the gasket adhesive and mounting surface shall be exposed to 190 ±3.6°F (88 ±2°C) air oven for not less than 7 days and immersion in distilled water maintained at 77 ±3.6°F (25 ±2°C) for not less than 3 days. The force required to peel the gasket from its mounting surface after exposure shall be not less than 50 percent of the value determined on “as-received” samples and in no case less than 2 lb per in (350 N/m) of gasket width.

84 Accelerated Aging Test – Electric Heaters

84.1 Rubber, neoprene, or thermoplastic compounds used as a heater casing or for heater terminal seals shall withstand accelerated aging without deteriorating to a degree that affects its use. Aging conditions, as specified in Table 84.1, are based on the maximum temperature rise, measured in an ambient from 77 to 104°F (25 to 40°C) on the device during the Temperature and Pressure Test, Section 52.

Table 84.1
Accelerated aging test criteria

Measured temperature rise degrees		Material	Test program
F	(C)		
63	(35)	Rubber or Neoprene	Air oven aging for 70 hours at 212°F ±3.6°F (100°C ±2°C).
63	(35)	Thermoplastic	7 days in an air circulated oven at 212°F (100°C)
90	(50)	Rubber or Neoprene	Air oven aging for 70 hours at 212°F ±3.6°F (100°C ±2°C).
90	(50)	Thermoplastic	10 days in an air circulated oven at 212°F (100°C)
99	(55)	Rubber, Neoprene, or Thermoplastic	7 days in an air circulated oven at 235.4°F (113°C)
117	(65)	Rubber or Neoprene	10 days in an air circulated oven at 249.8°F (121°C)
117	(65)	Thermoplastic	7 days at 249.8°F (121°C) or 60 days at 206.6°F (97°C) in an air circulated oven
144	(80)	Rubber, Neoprene, or Thermoplastic	7 days in an air circulated oven at 276.8°F (136°C)
180	(100)	Rubber, Neoprene, or Thermoplastic	60 days in an air circulated oven at 276.8°F (136°C)
225	(125)	Rubber, Neoprene, or Thermoplastic	60 days in an air circulated oven at 316.4°F (158°C)
315	(175)	Rubber, Neoprene, or Thermoplastic	60 days in an air circulated oven at 410°F (210°C)

85 Reliability Test – Heater Terminations

85.1 Electric heaters employing either integrally molded leads or molded terminal assemblies shall withstand, without displacement of insulation or separation of the connection between the lead and heater, a test load of 20 lb (9.1 kg) applied for 1 min. The load is to be applied to the leads or terminals in the direction at which they exit the heater case or molded connection.

85A Protective Electronic Circuit Tests

85A.1 General

85A.1.1 The tests in 85A.2 – 85A.5 are applicable to products provided with a protective electronic circuit and intended to comply with 17.15(h).

85A.1.2 User adjustable controls shall be adjusted to their most unfavorable setting.

85A.2 Fault conditions abnormal test

85A.2.1 Following the application of the operational fault conditions in accordance with 85A.2.2 – 85A.2.5, there shall be no risk of fire, electric shock or injury to persons. Electrical live parts or moving parts shall not be exposed. The product shall comply with the Dielectric Voltage Withstand Test in Section 59.

85A.2.2 In accordance with 17.18.8(b), a product provided with a protective electronic circuit intended to comply with 17.15(h) shall be operated as specified in the Temperature and Pressure Test, Section 57 except the room ambient shall be maintained at 70 – 80°F (21.1 – 26.7°C). The protective electronic circuit of the product shall then be subjected to any one of the following relevant operational fault conditions, each consecutively applied one at a time:

a) Open circuit at the terminals of any component;

b) Short circuit of capacitors, unless they comply with the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Supression and Connection to the Supply Mains, UL 60384-14;

c) Short circuit of any two terminals of an electronic component, including a metal oxide varistor (MOV). For the test applicable to an integrated circuit, see (e);

d) Failure of triacs in the diode mode;

e) Failure of microprocessors and integrated circuits except components such as thyristors and triacs. All possible output signals occurring within the component which may result in the product not complying with 85A.2.1 shall be considered;

f) Failure of an electronic power switching device, such as a field effect transistor and a bipolar transistor (including the insulated gate type) in a partial turn-on mode with loss of gate (base) control;

g) Short-circuiting of any circuit that differs in voltage from the supply source of the protective electronic circuit by connecting the different voltage circuit to the supply source.

85A.2.3 In reference to 85A.2.2, the following items shall be considered:

a) If the fault specified in 85A.2.2(c) is not applied:

1) Between two circuits of an optical isolator, then the optical isolator shall comply with UL 1577, the Standard for Optical Isolators.

2) To the short circuiting of an electronic surge protective device, such as a metal oxide varistor (MOV), then the MOV shall comply with the Type 4 requirements in the Standard for Surge Protective Devices, UL 1449.

b) For evaluating encapsulated or similar components, if the circuit and/or components cannot be evaluated by other methods, then 85A.2.2(e) shall be applied.

c) For evaluating the components in 85A.2.2(f), one method for simulating this mode is to disconnect the electronic power switching device gate (base) terminal and then connect an external adjustable power supply between the gate (base) terminal and the source (emitter) terminal of the electronic power switching device. The power supply can then be varied to obtain the current which is the most severe but which does not damage the electronic power switching device.

d) Step-function positive temperature coefficient thermistors (PTC-S) shall be short-circuited unless they comply with the DC PTC Thermistors section in the Standard for Audio, Video and Similar Electronic Apparatus – Safety Requirements, UL 60065.

e) If more than one of the operational fault conditions in 85A.2.2 (a) – (g) are applicable to the product, the product shall be allowed to cool down to room temperature after the application of each fault condition unless such cooling is determined not to adversely impact the test results.

85A.2.4 The operational fault conditions specified in 85A.2.2 (a) – (g) shall be considered completed if a manual reset (non-self-resetting) device opens the supply circuit. If the supply circuit is not opened by such a device, then the fault conditions shall be applied until thermal equilibrium is established.

85A.2.5 A product provided with a protective electronic circuit intended to comply with 17.15(h) shall additionally be operated as specified 85A.2.2 except that the product shall first be subjected to the relevant

abnormal condition(s) addressed by 6.2, 6.3, and Sections 19, 27, 57, 60, 61 and 69. The protective electronic circuit of the product shall then be subjected to any one of the relevant operational fault conditions as outlined in 85A.2.2 (a) – (g), each consecutively applied one at a time.

85A.3 Electromagnetic compatibility (EMC) tests

85A.3.1 In accordance with 17.18.8(e), a product having a protective electronic circuit intended to comply with 17.15(h) shall be subjected to the electromagnetic phenomena specified in 85A.3.3 – 85A.3.9, each applied one at a time. Each test shall be carried out:

a) After a protective electronic circuit has operated during the relevant abnormal condition(s) addressed by 6.2, 6.3, Sections 19, 27, 57, 60, 61 and 69 taking into account the most severe results (e.g., highest temperatures, pressures, etc.);

b) At conditions specified in the Temperature and Pressure Test, Section 57 except that the room ambient shall be maintained at 70 – 80°F (21.1 – 26.7°C) unless different conditions are required by the specific abnormal condition being applied; and

c) With surge protective devices disconnected unless they incorporate spark gaps.

85A.3.2 Following the application of each electromagnetic stress, a protective electronic circuit shall continue to operate as intended. In addition, there shall be no risk of fire, electric shock or injury to persons. Electrical live parts or moving parts shall not be exposed. The product shall comply with the Dielectric Voltage Withstand Test in Section 59.

85A.3.3 Electrostatic discharges shall be applied in accordance with IEC 61000-4-2, the Standard for Electromagnetic compatibility (EMC) – Part 4-2: Testing and Measurement Techniques – Electrostatic Discharge Immunity Test, test level 4 being applicable. Ten discharges having a positive polarity and ten discharges having a negative polarity shall be applied at each preselected point.

85A.3.4 Radiated fields shall be applied in accordance with IEC 61000-4-3, the Standard for Electromagnetic compatibility (EMC) – Part 4-3: Testing and Measurement Techniques – Radiated, Radio-Frequency Electromagnetic Field Immunity Test. The frequency ranges tested shall be 80 MHz to 1000 MHz, test level 3; 1.4 GHz to 2.0 GHz, test level 3; and 2.0 GHz to 2.7 GHz, test level 2. The dwell time for each frequency shall be sufficient to observe a possible malfunction of the protective electronic circuit.

85A.3.5 Fast transient bursts shall be applied in accordance with IEC 61000-4-4, the Standard for Electromagnetic compatibility (EMC) – Part 4-4: Testing and Measurement Techniques – Electrical Fast Transient/Burst Immunity Test. Test level 3 with a repetition rate of 5 kHz is applicable for signal and control lines. Test level 4 with a repetition rate of 5 kHz is applicable for the power supply lines. The bursts are applied for 2 min with a positive polarity and for 2 min with a negative polarity.

85A.3.6 Voltage surges shall be applied to the power supply terminals of the product in accordance with IEC 61000-4-5, the Standard for Electromagnetic compatibility (EMC) – Part 4-5: Testing and Measurement Techniques – Surge Immunity Test with five positive impulses and five negative impulses being applied at the selected points. An open circuit test voltage of 2 kV is applicable for the line-to-line coupling mode, a generator having a source impedance of 2 ohms being used. An open circuit test voltage of 4 kV is applicable for the line-to-ground coupling mode, a generator having a source impedance of 12 ohms being used. Sheathed heating elements in which a metal sheath is bonded in accordance with 14.2 shall be electrically disconnected during this test. For products having surge arresters incorporating spark gaps, the test shall be repeated at a level that is 95 percent of the flashover voltage. If a feedback system depends on inputs related to a disconnected heating element, an artificial network may be needed.

85A.3.7 Injected currents shall be applied in accordance with IEC 61000-4-6, the Standard for Electromagnetic compatibility (EMC) – Part 4-6: Testing and Measurement Techniques – Immunity to

Conducted Disturbances, Induced by Radio-Frequency Fields, test level 3 being applicable. During the test, all frequencies between 0.15 MHz to 80 MHz shall be covered. The dwell time for each frequency shall be sufficient to observe a possible malfunction of the protective electronic circuit.

85A.3.8 Voltage dips and interruptions specified as test level Class 3 shall be applied in accordance with:

a) IEC 61000-4-11, the Standard for Electromagnetic compatibility (EMC) – Part 4-11: Testing and Measurement Techniques – Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests, for products having a rated current not exceeding 16 A. The values specified in Table 1 and Table 2 of IEC 61000-4-11 shall be applied at zero crossing of the supply voltage; or

b) IEC 61000-4-34, the Standard for Electromagnetic compatibility (EMC) – Part 4-34: Testing and Measurement Techniques – Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests for Equipment with Mains Current More Than 16 A Per Phase for products having a rated current exceeding 16 A. The values specified in Table 1 and Table 2 of IEC 61000-4-34 shall be applied at zero crossing of the supply voltage.

85A.3.9 Supply source (mains) signals shall be tested in accordance with IEC 61000-4-13, the Standard for Electromagnetic compatibility (EMC) – Part 4-13: Testing and Measurement Techniques – Harmonics and Interharmonics Including Mains Signalling at a.c. Power Port, Low Frequency Immunity Tests. Table 11 with test level Class 2 using the frequency steps according to Table 10 of IEC 61000-4-13 shall be applied.

85A.4 Programmable component reduced supply voltage test

85A.4.1 In accordance with 17.18.8(f), the following test is applicable to a product provided with a protective electronic circuit intended to comply with 17.15(h) and having a programmable component for one or more of its safety functions.

85A.4.2 Following the voltage changes specified in 85A.4.3, a product shall continue to either operate normally from the same point in its operating cycle at which the voltage decrease occurred or a manual operation shall be required to restart the product. In addition, there shall be no risk of fire, electric shock or injury to persons. Electrical live parts or moving parts shall not be exposed. The product shall comply with the Dielectric Voltage Withstand Test in Section 59.

85A.4.3 The product shall be operated at rated voltage and at conditions specified in the Temperature and Pressure Test, Section 57 except that the room ambient shall be maintained at 70 – 80°F (21.1 – 26.7°C) until thermal equilibrium occurs. The power supply voltage shall then be changed, by approximately 10 V/s until the voltage reductions or increases specified in (a) – (d) are attained. The power supply voltage shall then be maintained at each voltage condition for not less than 60 seconds as follows:

a) Voltage shall be reduced until the product ceases to respond to user inputs or parts controlled by the programmable component cease to operate, whichever occurs first. This value of supply voltage shall be recorded.

b) Voltage shall be increased to rated voltage so that the product operates as intended.

c) Voltage shall be reduced to a value that is approximately 10 percent less than the recorded voltage.

d) Voltage shall be increased so that the product operates as intended.