UL 416

STANDARD FOR SAFETY

Refrigerated Medical Equipment

UL Standard for Safety for Refrigerated Medical Equipment, UL 416

Fourth Edition, Dated August 30, 1993

Summary of Topics

This revision to UL 416 is being issued to remove the reference to the withdrawal date of UL 873 and to address universal upkeep of UL Standards for Safety. These revisions are considered to be non-substantive and not subject to UL's STP process.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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AUGUST 30, 1993
(Title Page Reprinted: September 27, 2013)

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UL 416

Standard for Refrigerated Medical Equipment

The First and Second editions were titled Standard for Oxygen Therapy Equipment, Refrigerated.

First Edition – August, 1956
Second Edition – May, 1973
Third Edition – July, 1978

Fourth Edition

August 30, 1993

This UL Standard for Safety consists of the Fourth Edition including revisions through September 27, 2013.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover refrigerated medical equipment such as thermia and oxygen therapy devices for use in hospitals, nursing homes, medical care centers, medical and dental offices, and similar health care facilities in accordance with the National Electric Code, NFPA 70.

1.2 Equipment covered by these requirements employ hermetic refrigerant motor-compressors and air- or water-cooled condensers, designed for use on alternating current circuits rated not more than 600 volts. These requirements take into consideration the hazards resulting from the presence of oxygen and the intended use of oxygen administering equipment but do not cover the canopy (tent), or oxygen storage and distribution systems with which the equipment may be used.

1.3 These requirements do not cover equipment for use in hazardous locations, with respect to flammable anesthetics, as defined in the National Electrical Code, NFPA 70.

1.4 The requirements of this Standard do not consider the complete spectrum of physiological or therapeutic effects, beneficial or otherwise, except where generally accepted limits for potentially hazardous conditions are defined. Devices which necessitate the utilization of conditions exceeding such accepted limits for patient treatment are intended for use by or under the supervision of licensed medical persons. Such equipment shall be provided with warnings prominently displayed on the device.

1.5 A product that contains features, characteristics, components, materials, or systems new or different from those in use when the standard was developed, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the level of safety for the user of the product as originally anticipated by the intent of this standard.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.1.2 A component need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

2.2.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

2.3 Terminology

2.3.1 The term ″product″ refers to any equipment covered by the Scope of this standard.

2.4 Undated references

2.4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

3 Glossary

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

3.2 ACCESSIBLE PART – A part located so that it can be contacted by a person, either directly or by means of a probe or tool, or that is not recessed the required distance behind an opening. See Assembly.

3.3 ACCESSORY – An optional electrical device or other component, intended for installation in or connection to refrigerated medical equipment for the purpose of modifying or supplementing the functions of the equipment. It may be factory installed or intended for installation by the user or service personnel.

3.4 DOUBLE INSULATION – An insulation system comprised of both functional insulation and supplementary insulation. See 3.7, 3.19, and 3.22.

3.5 ENCLOSURE – An external portion of a product that serves to house and/or support component parts. Enclosures of patient care equipment likely to be contacted by a patient include items such as bedside monitors, bed frames, dental chairs, oxygen therapy equipment, and examination stands.

3.6 FIELD-WIRING TERMINAL – Any terminal to which power supply, control, or equipment grounding connections will be made in the field when the product is installed.

3.7 FUNCTIONAL INSULATION – The insulation necessary for the proper functioning of the product and for basic protection against electric shock.

3.8 INTERLOCK – A device used to de-energize electrical components or stop moving parts that may cause injury to persons that become exposed when an enclosure is opened or when a cover is removed.

3.9 ISOLATING TRANSFORMER – A transformer of which one or more output windings is electrically separated from the input winding and all other output windings by an insulation at least equivalent to double and/or reinforced insulation.

3.10 LEAKAGE CURRENT – Leakage current refers to any current, including capacitively-coupled currents, which may be conveyed from accessible parts of a product to ground or other accessible parts of the product and which is not intended to be applied to a patient.

3.11 LIMITED ENERGY CIRCUIT – A limited energy circuit is one in which the product and wiring is incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of cotton in an oxygen-enriched atmosphere. Abnormal conditions include unintentional damage to any part of the equipment or wiring, failure of insulation or other failure of electrical components, application of overvoltage, adjustment and maintenance operations, and other similar conditions.

3.12 OPERATING CONTROL – A control, usually a knob, pushbutton, or lever, provided to enable the user to cause the product to perform its intended function, without the use of tools.

3.13 OPERATOR (USER) SERVICING – Any form of servicing that might be performed by personnel other than qualified service personnel. Some examples are:

a) The attachment of accessories by means of attachment plugs and receptacles or by means of other separable connectors.

b) The replacement of recording paper rolls, tapes, and similar items.

c) Resetting of circuit breakers or replacement of tubes, fuses, and lamps that are accessible without the use of tools.

d) Routine operating adjustments necessary to adapt the product for its different intended functions.

e) Routine cleaning, changing of filters and pens, removal of blockages in tubing, and clearing of jams in data-recording media.

3.14 PATIENT-CONNECTED CIRCUITS – All patient connections, such as pads, contacts, probes, sensors, or cuffs applied to the patient and any associated leads, cables, components, or wiring either within or external to the product enclosure. As seen from the patient into the equipment, these circuits extend to the points where the required degree of isolation or protective impedance is reached.

3.15 PATIENT CONNECTIONS –

a) Isolated – A direct or indirect patient contact that is deliberately separated from the supply circuit and ground by virtue of spacings, insulation, protective impedance, or a combination thereof, e.g., electrocardiogram (ECG) leads, intra-aortic pressure monitor.

b) Ordinary – A direct patient contact that does not have the spacings, insulation or protective impedance associated with an isolated patient connection, e.g., blood pressure cuff, thermometers, ultrasonic transducer head.

3.16 PRINTED WIRING – A pattern of conductive material formed in a predetermined design on the surface or surfaces of an insulating base, and intended primarily to provide point-to-point electrical connections, shielding, or to form circuit elements.

3.17 PRINTED WIRING ASSEMBLY – A printed wiring board on which separate components have been added.

3.18 PRINTED WIRING BOARD – The combination of a printed wiring pattern and the insulating base, completely processed as far as the printed portion is concerned.

3.19 REINFORCED INSULATION – Improved functional insulation with such mechanical and electrical qualities that it, in itself, provides the same degree of protection against electric shock as double insulation.

3.20 SAFETY CIRCUIT – Any circuit, either in the primary or secondary, that is relied upon to reduce a risk of fire, electric shock, or unintentional contact with moving parts that may cause injury to persons, for example, an interlock circuit is considered to be a safety circuit.

3.21 SECONDARY CIRCUITS – Secondary circuits are those circuits supplied from transformer output windings which are electrically separated from the input windings.

3.22 SUPPLEMENTARY (PROTECTIVE) INSULATION – An independent insulation provided in addition to the functional insulation to assure protection against electrical shock in case of failure of the functional insulation.

3.23 SUPPLY CIRCUIT – The branch circuit supplying electrical energy to the product.

3.24 TYPES OF EQUIPMENT – Recognizing the differences in applications to the patient and in the degree of risk posed by electrical equipment in various areas of a health care facility, i.e., professional office, clinic, hospital, or laboratory, refrigerated medical equipment covered by this Standard is treated as follows:

a) Patient Care Equipment – Equipment intended to be used on or with, or likely to be contacted by, a patient in a health care facility in the course of his treatment.

b) Nonpatient Equipment – Equipment for use in a health care facility and for use where contact with a patient is unlikely.

3.25 ULTIMATE STRENGTH – The highest stress level which a refrigerant-containing component can tolerate without rupture.

4 Installation and Operating Instructions

4.1 The product shall be provided with installation and operating instructions. The instructions shall contain such directions and information as deemed by the manufacturer to be necessary for the proper installation, maintenance, and use of the product. Particular consideration shall be given to directions relating to cleaning and sterilization procedures.

4.2 A copy of the manufacturer's operating and installation instructions, or equivalent information intended to accompany each product is to be furnished with the sample submitted for investigation. These instructions are to be used as a guide in the examination and test of the product. For this purpose, a printed edition is not required initially if rough draft instructions or information as to what the instructions will include are submitted for review as part of the investigation.

CONSTRUCTION

5 General

5.1 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 the like, where corrosion of such unprotected parts would not affect compliance with the requirements of this Standard.

5.2 A product shall be constructed so that it can be cleaned or sterilized in accordance with the manufacturer's instructions, see Installation and Operating Instructions, without affecting the application, operation, and performance of the product. One sample of the product, or appropriate portion of the sample if it is intended to be only partially cleaned or sterilized, shall be subjected to the Cleaning and Sterilization Test if it is not obvious that the product complies with this requirement.

5.3 Carrying handles or grips furnished on a portable product shall withstand loading as described in 44.1. The handles shall not break loose from the product and there shall be no permanent distortion, cracking, or other evidence of failure.

5.4 Mounting brackets on a product intended to be wall or ceiling mounted shall withstand loading as described in 44.2 without evidence of damage to the brackets or mounting surface.

5.5 Unless an investigation shows the circuits to be energy limited as defined in 3.11, all electrical components shall be separated from oxygen-enriched atmospheres. An oxygen-enriched atmosphere is considered to exist if the oxygen concentration exceeds 21 percent by volume.

5.6 In applying 5.5 to products such as oxygen-therapy equipment, it will be necessary to provide barriers between the oxygen-enriched atmosphere and those areas containing electrical components. Small neoprene or asbestos gaskets and grommets are considered acceptable on a motor mounting plate and shaft and may be employed in conjunction with thermal-sensing devices extending into the oxygen-enriched atmosphere provided there is ventilation of outside air into the electrical compartment to limit the oxygen concentration. See 18.14.

5.6 revised June 24, 1997

5.7 Components requiring oiling shall not be located in areas in which oxygen is discharged.

6 Assembly

6.1 General

6.1.1 A product incorporating a condensing unit of the pull-out type shall be constructed so that the condensing unit can be pulled out without kinking or otherwise damaging the refrigerant tubing and without pinching, abrading, or stressing wires and cords.

6.2 Mechanical protection

6.2.1 Louvers and other openings in the enclosure shall be constructed and located to prevent unintentional contact with hazardous moving parts and with hot surfaces. See 6.2.5 and 6.2.6. Parts such as covers, panels, or grilles used as part of the enclosure are to be removed unless tools are required for their removal.

6.2.2 Hazardous moving parts, such as fan blades, blower wheels, or belts, shall be guarded or enclosed so that the minor dimension of any opening shall not exceed the values indicated in 6.2.3.

6.2.3 The distance from an opening to the moving part shall be in accordance with Table 6.1, but the minor dimension of the opening shall not, in any case, exceed 1 inch (25.4 mm). For an opening having a minor dimension intermediate between two of the values included in the table, the distance from the opening to the moving part shall be not less than that found by appropriate interpolation between the corresponding values in the right column of the table. The minor dimension of the opening is determined by the largest hemispherically tipped cylindrical probe that can be inserted through the opening with a force of 5 pounds (22.3 N).

Table 6.1
Dimensions of openings

Minor dimensions of opening[a]		Minimum distance from opening to moving part	
inches	(mm)	inches	(mm)
1/4	(6.4)	1/2	(12.7)
3/8	(9.5)	1-1/2	(38.1)
1/2	(12.7)	2-1/2	(63.5)
3/4	(19.1)	4-1/2	(114.0)
1	(25.4)	6-1/2	(165.0)

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

6.2.4 A moving part is not to be considered when judging compliance with 6.2.2 and 6.2.3 if:

a) The part is unlikely to be contacted through the opening because of the location of fixed components, including baffles, or

b) The part is made inoperative, when exposed, through the use of interlocking devices.

6.2.5 When tested in accordance with the Temperature and Pressure Test and the Heating Test, surfaces which exceed the temperature rise of (d) (2) or (d) (3) of Table 36.1 shall be guarded in accordance with 6.2.2 – 6.2.3.

6.2.6 The sheath of a heater element, as installed in the complete product, shall be protected against mechanical damage. In addition, if the temperature of a heater exceeds the limits permitted by (d)(2) or (d)(3) of Table 36.1, whichever is appropriate, it shall be guarded in accordance with 6.2.2 - 6.2.3 to protect persons from coming in contact with it.

6.3 Electrical protection

6.3.1 Louvers and other openings in the enclosure shall be constructed and located to prevent unintentional contact with uninsulated live parts. Parts such as covers, panels, or grilles used as part of the enclosure are to be removed unless tools are required for their removal or an interlock is provided. See 8.2.1.

6.3.2 Uninsulated live parts of the product shall be located, guarded, or enclosed as indicated in 6.3.3 - 6.3.16. These requirements apply only to parts of high-voltage circuits.

6.3.3 If an opening in the enclosure will not permit the entrance of a 3/4 inch (19.1 mm) diameter rod, the probe illustrated in Figure 6.1 shall not touch any uninsulated live parts and the probe illustrated in Figure 6.2 shall not touch any enamel insulated wire when inserted through the opening. The probe shall not pass through grilles, screens, louvers, or the like when a force of 5 pounds (22.3 N) is applied.

Figure 6.1
Probe

Figure 6.1 revised November 24, 1998

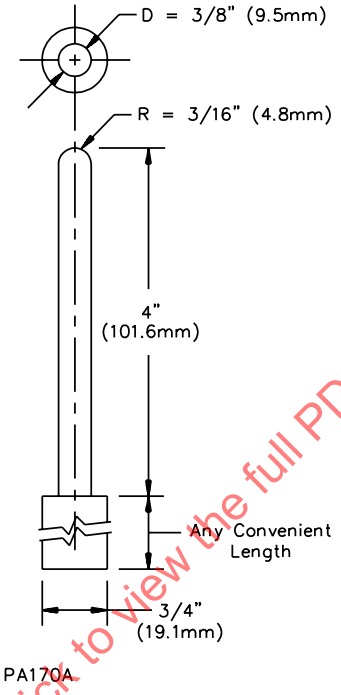
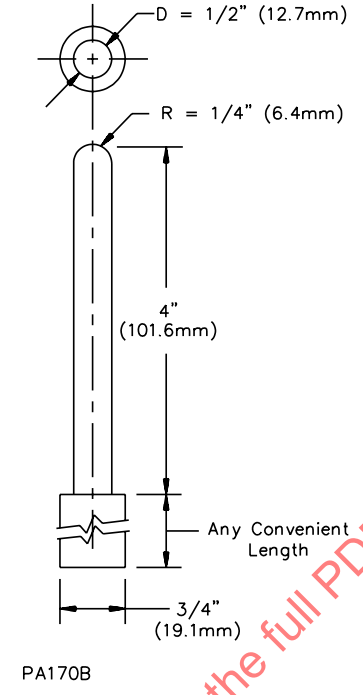


Figure 6.2
Probe

Figure 6.2 revised November 24, 1998



6.3.4 If an opening in the enclosure permits the entrance of a 3/4 inch (19.1 mm) diameter rod, the conditions described in Figure 6.3 shall be used in determining compliance with the requirements. The minor dimension of the opening shall not exceed 1 inch (25.4 mm) in any case.

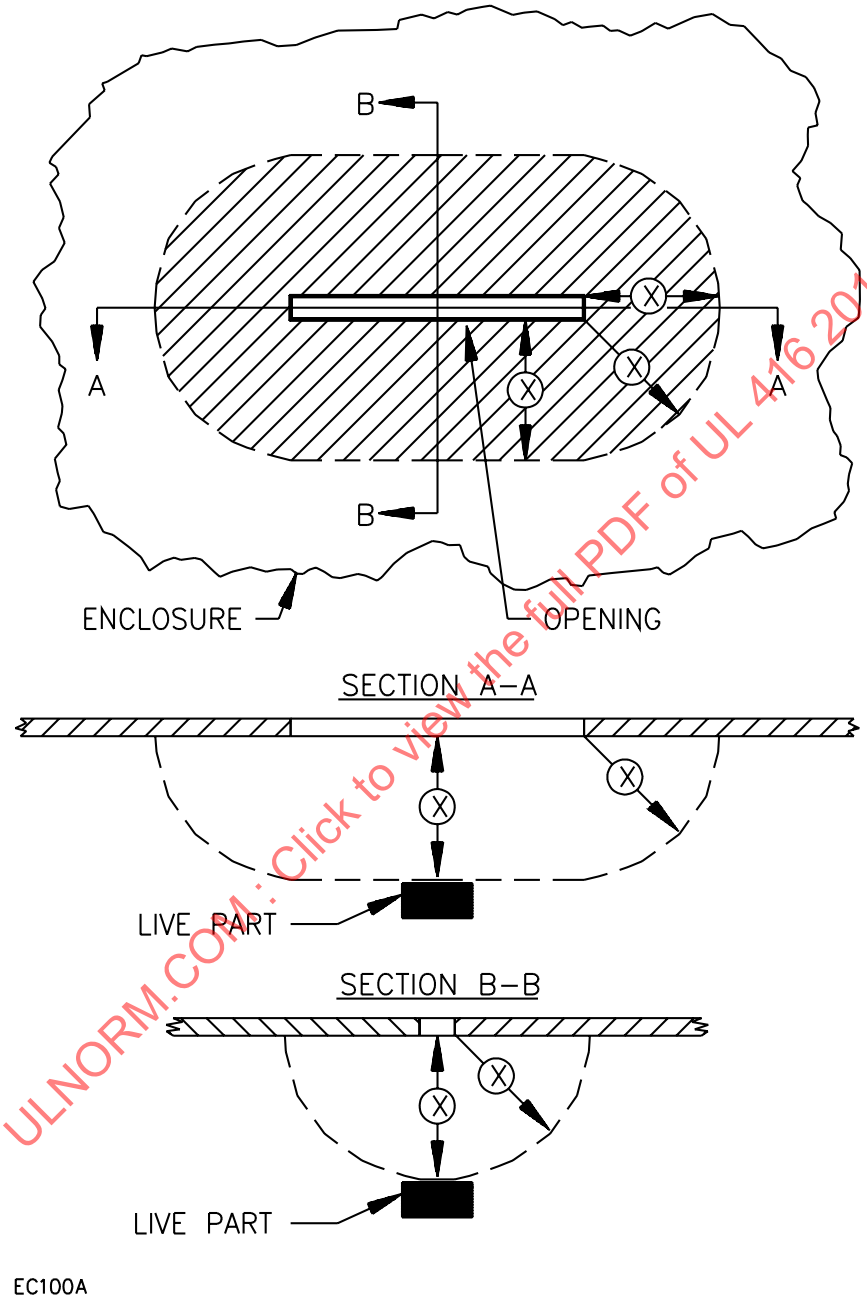
6.3.5 In addition to the requirements of 6.3.2 – 6.3.4, uninsulated live parts inside the enclosure which are likely to be contacted by persons performing operations such as refilling, relamping, replacing fuses, resetting manual-reset devices, oiling motors, or other such normal service operations shall be located, guarded, or enclosed to prevent accidental contact unless tools are required to expose the live part. See 66.2.1.

6.3.6 A fuseholder shall be constructed, installed, or protected so that adjacent uninsulated high-voltage live parts, other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. A barrier of vulcanized fiber or similar material employed as a guard for uninsulated high-voltage live parts shall be not less than 1/32 inch (0.8 mm) in thickness. A separation less than 4 inches (102 mm) is considered to be adjacent.

6.3.7 Electrical components shall be located or enclosed so that live parts will not be wetted by liquids due to accumulation, overflow, splashing, leakage, cleaning, or defrost.

Figure 6.3
Opening in enclosure

Figure 6.3 revised November 24, 1998



The opening is acceptable if, within the enclosure, there is no uninsulated live part or enamel-insulated wire:

a) Less than X inches (mm) from the perimeter of the opening, as well as

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

6.3.8 Fluid reservoirs, condensate parts or receptacles and the like shall be constructed and located so that overflow will not wet live parts or enamel insulated wire.

6.3.9 An overflow spout, drain hole, cutout, or the like in the condensate pan may be acceptable for preventing dripping of water on electrical parts. An Overflow Test, Section 41, is to be conducted if it is not evident that the product complies with 6.3.8.

6.3.10 A switch, lampholder, an attachment-plug receptacle, a motor-attachment plug, or similar component shall be secured in position and, except as noted in 6.3.11 and 6.3.12, shall be prevented from turning. See 6.3.13.

6.3.11 The requirement that a switch be prevented from turning will be waived if the following conditions are met:

a) The switch is to be of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during the operation of the switch,

b) Means of mounting the switch make it unlikely that operation of the switch will loosen it,

c) The spacings are not to be reduced below the minimum required values if the switch rotates, and

d) Operation of the switch is to be by mechanical means rather than direct contact by persons.

6.3.12 A lampholder 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, need not be prevented from turning if rotation cannot reduce spacings below the minimum acceptable values. See Spacings, Section 25.

6.3.13 The means for preventing rotation mentioned in 6.3.10 is to consist of more than friction between surfaces. A toothed lock washer that provides both spring take-up and an interference lock is acceptable as means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

6.3.14 An uninsulated current carrying part and a part that supports a live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the minimum acceptable values. See Section 25, Spacings. Friction between surfaces is not acceptable as a means to prevent shifting or turning of a live part, but a lock washer as described in 6.3.13 is acceptable.

6.3.14 revised June 24, 1997

6.3.15 Flammable or electrically conductive thermal or acoustical insulation shall not contact uninsulated live parts. See 50.2.1.

6.3.16 Materials used for acoustical or thermal insulation in oxygen-administering equipment shall be classified Type 5V in accordance with the requirements for flammability of plastic materials for use in devices and appliances, UL 94.

6.3.16 revised November 24, 1998

7 Accessories

7.1 A product having provisions for the use of electrical accessories to be attached in the field shall comply with the requirements of this section, and shall comply with the requirements of this Standard with or without the accessory installed.

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

7.3 The 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.

7.4 With reference 7.3, any installation that requires the cutting of wiring or the soldering of connections by the installer is not acceptable. Installations that require cutting, drilling, or welding are not acceptable in electrical enclosures and in other areas where such operations may damage electrical or refrigeration components and wiring within the enclosure.

7.5 Strain-relief means shall be provided for the wiring in the accessory if there is a possibility of transmitting strain to the terminal connections during installation.

7.6 All terminals and wiring intended to be field connected shall be identified on the accessory, on the product if connections are made between the accessory and the product, and on the wiring diagram(s).

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7.7 Except where it is obvious, the mounting location of the accessory shall be indicated on the product. If the mounting location is obvious due to the function of the accessory and arrangement of the product, and instructions are provided covering the installation and location for the accessory, the mounting location of the accessory need not be indicated on the product.

7.8 As part of the investigation, accessories are to be trial installed to determine that their installation is feasible, and that the instructions provided are detailed and correct.

8 Enclosures

8.1 General

8.1.1 Enclosures shall be formed and assembled so that they will have the strength and rigidity necessary to resist the abuses to which they may be subjected without increasing the risk of fire or unintentional contact with hazardous moving parts due to total or partial collapse with the resulting reduction of spacings, loosening or displacement of parts, or other serious defects. Enclosures for individual electrical components, outer enclosures, and combinations of the two are considered in determining compliance with this requirement.

8.1.2 A risk of fire is considered to exist at a component part or assembly if an investigation shows that the supply for such part or assembly is capable of delivering a power of more than 15 watts into an external resistor connected between the point in question and any return to the power supply.

8.1.3 An electrical shock is considered to exist at any accessible conductive part of a product if the available current through an appropriate impedance connected between the part and other accessible conductive parts or between the part and ground, is more than the values specified in 33.4.1 and 33.7.1.1, as determined by the type of equipment involved. See 3.24.

8.1.4 For unreinforced flat surfaces, cast metal shall be not less than 1/8 inch (3.2 mm) in thickness, except malleable iron shall be not less than 3/32 inch (2.4 mm) in thickness and die-cast metal shall be not less than 5/64 inch (2.0 mm) in thickness. Corresponding thicknesses of not less than 3/32, 1/16, and 3/64 inch (2.4, 1.6, and 1.2 mm) may be used if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape and/or size of the surface is such that adequate physical strength is provided.

8.1.5 Unless investigated and found acceptable for the application, the thickness of a sheet-metal enclosure shall be not less than the value indicated in Table 8.1. See 8.2.3 with reference to the minimum thickness at a point where conduit or metal-clad cable is to be connected.

8.1.6 Among the factors which are taken into consideration when evaluating an enclosure are:

a) Mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Flammability,

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 are considered with respect to aging.

Table 8.1
Thickness of sheet metal

Table 8.1 revised June 24, 1997

Maximum dimensions of enclosure				Minimum thickness of sheet metal in inches											
				Steel[a]								Copper, brass, or aluminum[a]			
				Without supporting member				With reinforcing support[c]							
Length or width,		Area in,		Zinc coated,		Uncoated,		Zinc coated,		Uncoated,		Without supporting member,		With reinforcing support[c],	
inch	mm	inch^2	cm^2	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
3	76.4	6[b]	38.7	0.023 (24)	0.584	0.020 (24)	0.508	0.023 (24)	0.584	0.020 (24)	0.508	0.023 (22)	0.584	0.023 (22)	0.584
8	203.2	36	232.3	0.029 (22)	0.740	0.026 (22)	0.660	0.023 (24)	0.584	0.020 (24)	0.508	0.036 (18)	0.910	0.029 (20)	0.740
12	304.8	90	580.7	0.034 (20)	0.864	0.032 (20)	0.813	0.023 (24)	0.584	0.020 (24)	0.508	0.045 (16)	1.143	0.029 (20)	0.740
18	457.2	135	871.0	0.045 (18)	1.143	0.042 (18)	1.067	0.034 (20)	0.864	0.032 (20)	0.813	0.058 (14)	1.473	0.045 (16)	1.143
24	609.6	360	2322.1	0.056 (16)	1.422	0.053 (16)	1.346	0.045 (18)	1.143	0.042 (18)	1.067	0.075 (12)	1.905	0.058 (14)	1.473
48	1219.2	1200	7742.0	0.070 (14)	1.778	0.067 (14)	1.702	0.056 (16)	1.422	0.053 (16)	1.346	0.095 (10)	2.413	0.075 (12)	1.905
60	1524.0	1500	9678.0	0.097 (12)	2.464	0.093 (12)	2.362	0.056 (16)	1.422	0.053 (16)	1.346	0.122 (8)	3.099	0.075 (12)	1.905
Over 60	1524.0	Over 1500	9678.0	0.126 (10)	3.200	0.123 (10)	3.124	0.056 (16)	1.422	0.053 (16)	1.346	0.153 (6)	3.886	0.075 (12)	1.905

[a] The figures in parentheses are the Manufacturer's Standard Gage numbers (for uncoated steel), the Galvanized Sheet Gage numbers (for zinc-coated steel) and the American Wire Gage (B&S) numbers (for copper, brass, or aluminum) which provide the specified minimum thickness of metal.

[b] Volume of enclosure not more than 12 cubic inches (196.7 cm^3).

[c] Any subdivided area not provided with a reinforcing support is considered to be without support in determining minimum thicknesses.

8.1.7 The enclosure(s) of a product shall prevent mechanical damage to wiring, electrical components, and refrigerant tubing.

8.1.8 The enclosure shall prevent the emission of molten metal, burning insulation, flaming particles, or the like through openings onto flammable material, including the surface upon which the product is mounted.

8.1.9 Unless it can be determined that failure of an electrical component will not result in a risk of fire, components, such as controls, solenoids, starting relays, and switches, shall be individually enclosed except at terminals. See Burnout Tests – Components.

8.1.10 The requirement in 8.1.8 necessitates the use of a metal barrier or a barrier of material classified as Type 5V when tested in accordance with the requirements for flammability of plastic material for parts in devices and appliances, UL 94:

a) Under a motor unless:

1) The structural parts of the motor or of the product provide the equivalent of such a barrier.

2) The overload (overcurrent) protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the product when the motor is energized under each of the following fault conditions:

i) Open main winding,

ii) Open start winding,

iii) Starting switch short-circuited, and

iv) Capacitor of a permanent-split-capacitor motor short-circuited, or

3) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) so that the temperature of the motor windings will not exceed 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle and will not exceed 150°C (302°F) with the rotor of the motor locked.

b) Under wire unless it is of the flame-retardant type, e.g., polyvinyl chloride- or neoprene-insulated.

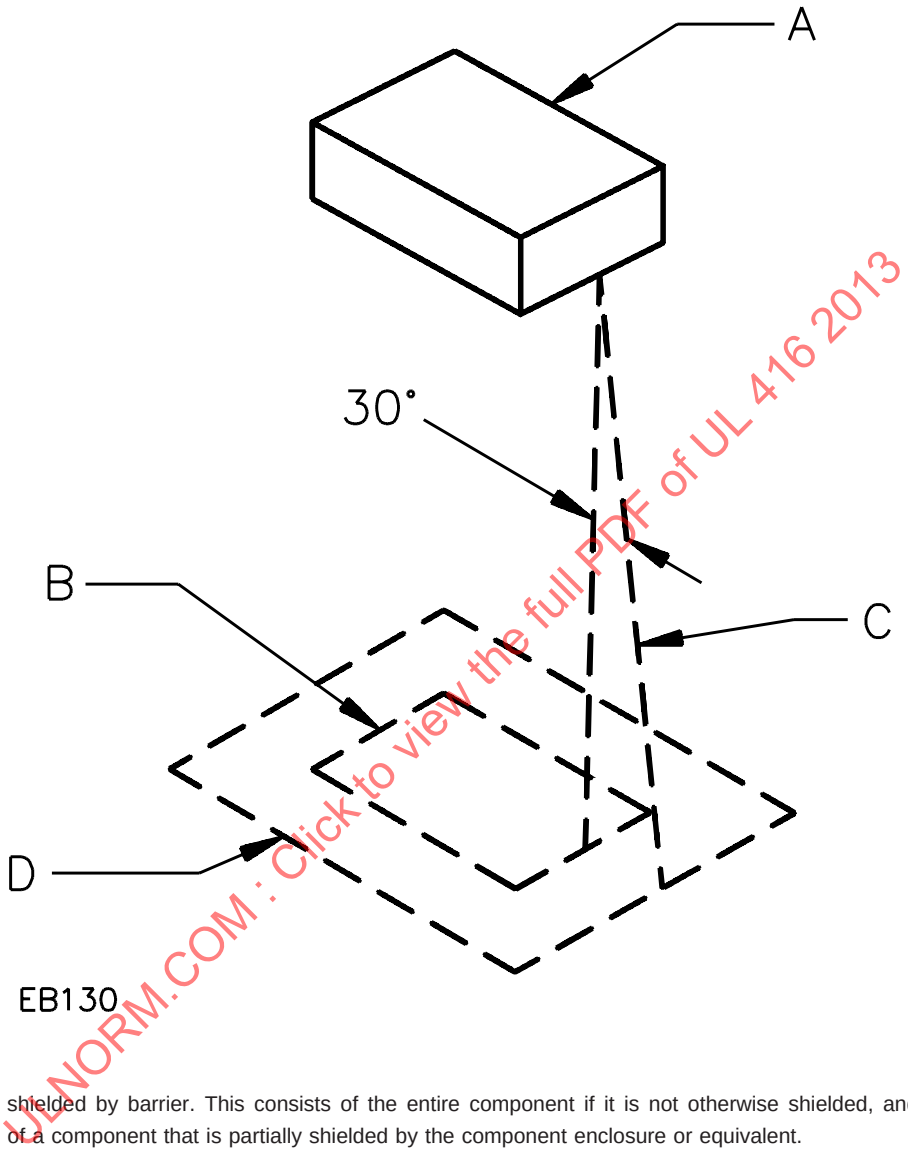
8.1.10 revised November 24, 1998

8.1.11 The barrier mentioned in 8.1.10 shall be horizontal or constructed to provide equivalent protection, shall be located as indicated in Figure 9.1, and shall not be smaller in area than indicated in Figure 9.1. Openings for drainage, ventilation, or the like, may be employed in the barrier if the openings are protected by a baffle, screen, or the like so that molten metal, burning insulation, and the like cannot fall outside the enclosure.

8.1.12 Sheet metal to which wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.81 mm), if uncoated steel; not less than 0.034 inch (0.86 mm) if galvanized steel; and not less than 0.045 inch (1.14 mm) if nonferrous metal.

Figure 8.1
Location and extent of barrier

Figure 8.1 revised November 24, 1998



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

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. When moving, the line is always:

1) Tangent to the component;

2) Thirty degrees from the vertical, and

3) So oriented that the area traced out on a horizontal plane is maximum.

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

8.1.13 If threads for the connection of conduit are tapped through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than three nor more than five threads in the metal, and the construction of the device shall be such that a conduit bushing can be properly attached. If threads for the connection of conduit are not tapped through a hole in an enclosure wall, conduit hub, or the like, there shall be not less than 3-1/2 threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductor equivalent to that provided by a standard conduit bushing and which shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

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8.1.14 A knockout in a sheet metal enclosure shall be secured in place, but shall be capable of being removed without undue deformation of the enclosure which would result in damage to electrical components and/or reduction in electrical spacings. See 8.1.16.

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

8.1.16 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 result in spacings between uninsulated live parts and the bushing of less than those required by this Standard.

8.1.17 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 8.2 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

8.1.17 revised June 24, 1997

8.1.18 Steel enclosures shall be protected against corrosion by metallic or nonmetallic coatings such as plating or painting.

Table 8.2
Knockout or hole sizes and dimensions of bushings

Trade size of conduit		Knockout or hole diameter		Bushing dimensions			
				Overall diameter		Height	
inches	(mm O.D.)	inches	(mm)	inches	(mm)	inches	(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)

8.2 Doors and covers

8.2.1 Service covers or panels in the outer enclosure shall require the use of tools for removal or shall be provided with an interlocking mechanism if they give access to unenclosed uninsulated live parts or hazardous moving parts.

8.2.2 An interlocking mechanism which:

a) Must be engaged in the closed position of the cover before parts are energized and

b) Will secure the cover in the closed position when engaged is considered to comply with 8.2.1.

8.2.3 A hinged or pivoted panel or cover shall be positioned or arranged so that it is not subject to falling or winging from an open position due to gravity or vibration in such a manner as to cause injury to persons from the panel or cover, from other moving parts, or from uninsulated live parts.

8.2.4 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 without removing parts other than a service cover(s) or panel(s), and the cover or door enclosing the device.

8.2.5 A required protective device shall be wholly inaccessible 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.

8.2.6 An opening in an outer enclosure around a handle, reset button, or other control member is acceptable if the clearance between the control member and the edge of the opening is not more than 1/8 inch (3.2 mm) for any setting or position of the control member.

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

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

a) Supplementary type control circuit fuses, provided 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 amperes or less for small auxiliary resistance heaters, such as crankcase heaters, with a maximum rating of 100 watts (W), or

c) An extractor-type fuse with its own enclosure, or

d) Fuses in low-voltage circuits.

8.2.8 Hinged covers, if required, shall not depend solely upon screws or other similar means to hold them closed, but shall be provided with a latch or the equivalent.

8.2.9 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door in place and will require some effort on the user's part to open it is considered to be a means for holding the door in place as required in 8.2.8. When provided as the sole means for securing the cover or panel, a cover interlocking mechanism as described in 8.2.2, is considered to comply with 8.2.8.

8.2.10 A door or cover giving direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4 inch (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 proper and shall overlap the edges of the box not less than 1/2 inch (12.7 mm). A special construction, such as a fuse enclosure, located within an outer enclosure, or a flange and rabbet combination which affords the equivalent protection is acceptable.

8.2.11 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 inches (38.1 mm) from each end of each strip and at points between these end fastenings, not more than 6 inches (152 mm) apart.

9 Field Supply Connections

9.1 General

9.1.1 If a product is intended to be connected to the grounded conductor of a power supply circuit, a lampholder with a screw shell base shall be wired so that the screw shell will be connected to that conductor.

9.1.2 A single-pole switching device shall not be connected to the grounded conductor.

9.1.3 An automatic control which does not have a marked OFF position is not required to comply with 9.1.2.

9.2 Permanently connected products

9.2.1 Products of the following types shall have provision for permanent connection to the power supply:

a) Products rated in excess of 250 volts.

b) Polyphase products.

c) Products having a total marked rating exceeding 16 ampere full-load current.

d) Products intended for permanent attachment to the building structure, ducts, water, steam, gas supply, drains, or the like.

e) Products requiring 120/208 volt or 120/240 volt, three-wire supply circuit.

9.2.2 With reference to 9.2.1(c), the largest sum of concurrent loads shown on the nameplate is used to determine the total marked rating.

9.2.3 A product shall have provision for connection of one of the wiring methods in accordance with the National Electrical Code, ANSI/NFPA 70-1990.

9.2.4 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 9.1.

Table 9.1
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)

NOTES

1 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 in the conduit. If more than six conductors will be involved or if all of them are not 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.

2 Trade size per Specifications for Zinc-Coated Rigid Steel Conduit, ANSI C80.1.

Table 9.2
Attachment plug designations

Table 9.2 deleted February 22, 1994

9.2.5 Space shall be provided in the field-wiring compartment or outlet box for installation of conductors of the number and size required by 9.2.8 using Type TW or THW wire when at least a 6 inch (152 mm) length of each conductor is brought into the wiring compartment. If necessary, a trial installation is to be made.

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

9.2.6 The location of a terminal box or compartment in which power supply connections are to be made shall be such that these connections may be inspected after the product 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.

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

9.2.8 The product shall be provided with field-wiring terminals or leads for the connection of conductors having an ampacity of not less than that indicated in 64.11. It is assumed that branch circuit conductors rated 60°C (140°F) will be used.

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

9.2.9 revised June 24, 1997

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

9.2.10 revised March 16, 2010

9.2.11 A wire binding screw at a field-wiring terminal shall be not smaller than a No. 8 (4.2 mm diameter), except that a No. 6 (3.5 mm diameter) screw may be used for the connection of one 14, 16, or 18 AWG (2.1, 1.3, or 0.82 mm^2) conductor.

9.2.11 revised March 16, 2010

9.2.12 It should be noted that according to the National Electrical Code, ANSI/NFPA 70-1990, 14 AWG (2.1 mm^2) is the smallest conductor which 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.

9.2.12 revised March 16, 2010

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

9.2.13 revised March 16, 2010

9.2.14 A terminal plate formed from stock having the minimum required thickness may have the metal extruded at the tapped hole for the binding screw to provide two full threads, except that two full threads are not required if a lesser number of threads results in a connection in which the threads will not strip with intended tightening torque in accordance with the values indicated in:

a) The Standard for Wire Connectors, UL 486A-486B or

b) The requirements for wire connectors for use with aluminum conductors, UL 486A-486B, as applicable.

9.2.14 revised March 16, 2010

9.2.15 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size mentioned in 9.2.8 and 64.11, but no smaller than 14 AWG (2.1 mm^2), under the head of the screw or the washer.

9.2.15 revised March 16, 2010

9.2.16 A wire binding screw shall thread into metal.

9.2.17 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 proper identification of that terminal shall be shown in some other manner, such as on an attached wiring diagram. A lead intended for the connection of a grounded conductor shall be finished to show a white or gray color, shall be readily distinguishable from other leads, and no other lead shall be so identified.

9.2.17 revised September 27, 2013

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

Exception: The lead may be less than 6 inches (152 mm) in length if it is evident that the use of a longer lead may result in damage to the lead insulation.

9.2.19 Leads intended for connection to an external circuit shall be provided with strain relief if a strain on the lead may be transmitted to terminals, splices, or internal wiring.

9.2.20 Leads provided for spliced connections to an external high-voltage circuit shall not be connected to wire binding screws or pressure wire connectors located in the same compartment as the splice unless the screws or connectors are rendered unusable for field-wiring connections or the leads are insulated at the unconnected ends.

9.3 Cord connected products

9.3.1 A product intended for cord connection to the power supply shall be provided with a flexible cord of proper type, length, and ampacity and with an attachment-plug or proper type and rating.

9.3.2 Cord-connected products shall employ grounding-type attachment plugs.

Exception: Patient care equipment may employ either the locking type attachment plug designated "Hospital Only," or a conventional two-blade with grounding pin attachment plug designated "Hospital Grade," and shall be marked in accordance with 65.3.

9.3.2 revised February 22, 1994

9.3.3 The marked rating of a cord connected product, see 65.1, shall not exceed 80 percent of the rating of the attachment plug.

9.3.4 A cord-connected product may employ Type SO, ST, STO, SJO, SJT, or SJTO power-supply cord rated for use at a voltage not less than the rated voltage of the product. The ampacity of the cord as given in the National Electrical Code, ANSI/NFPA 70-1990, shall not be less than that required by the ampere input measured in the Temperature and Pressure Test, Section 36, the Heating Test, Section 37, or both. The ampere input value shall include the loads for convenience outlets and the current drawn by accessories intended for use with the product. See 63.9.

9.3.5 The supply cord shall be permanently attached to the product.

Exception: A separate cord set with means for connection to the product may be employed if it can be shown that unintentional disconnection is unlikely or that unintentional disconnection or the additional impedance of the ground circuit contacts will not constitute a potential risk to the patient or operator.

9.3.6 The power supply cord for a product shall be no less than 6 feet (1.8 m) nor more than 15 feet (4.6 m) in length. The length is measured between the attachment plug and:

a) Any point at which the cord exits the product cabinet or

b) The last strain relief, whichever is shorter.

9.3.7 The power supply cord shall be provided with strain relief means so that strain on the cord will not be transmitted to terminals, splices, or internal wiring. If a metallic strain relief means is provided, it shall not contact uninsulated live parts or reduce spacings within the enclosure if the cord is moved inward. The cord shall not be subject to damage by moving parts if it can be moved inward.

9.3.8 To determine the adequacy of the strain relief means, a 35 pound (15.9 kg) weight is to be suspended on the cord and supported by the product so that the strain relief means will be stressed from any angle which the design of the product permits. The load is to be applied for 1 minute. The strain relief is not acceptable if there is such movement of the cord as to indicate that stress would have resulted on the cord connections.

9.3.9 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 which might damage the cord insulation. The power supply cord shall be routed to reduce the risk of damage to the cord insulation.

9.4 Grounding

9.4.1 A product shall have provision for grounding as follows:

a) In a permanently connected product, an equipment grounding terminal or lead.

b) In a cord connected product, an equipment grounding conductor in the cord terminating in an identified grounding terminal as specified in 9.3.7.

9.4.2 On a permanently connected product, a terminal solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size acceptable in accordance with the National Electrical Code, ANSI/NFPA 70-1990.

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

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9.4.4 On permanently connected products, 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 9.4.5, 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 product. The wire binding screw or pressure wire connector shall be secured to the frame or enclosure of the product 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.

9.4.5 If 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, with a green color identification, or both.

9.4.6 On a permanently connected product, 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.

9.4.7 On cord connected products, the grounding conductor of the flexible cord shall be 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. The grounding conductor shall be secured to the frame or enclosure of the product by a positive means, see 12.5, that is not likely to be removed during any servicing operation not involving the power supply cord. The grounding conductor shall be connected to the grounding blade of the attachment plug.

10 Internal Wiring and Wiring Methods

10.1 General

10.1.1 All wires and cords used in a product shall be routed and supported to prevent damage due to:

a) Sharp edges,

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

c) Moving parts, and

d) Parts which can be expected to vibrate such as motors, motor-compressors, refrigerant lines, and the like. Clamping means are to have smooth, rounded surfaces.

10.1.2 With reference to 10.1.1, wires and cords may contact a vibrating part provided:

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 which might abrade the insulation, and

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

10.1.3 Wiring shall have insulation rated for the potential involved and the temperatures to which it may be subjected. Compliance is to be judged on the basis of the temperatures measured during the applicable temperature tests specified in Sections 36 and 37.

Exception: If it can be determined that the wiring shall not be exposed to heat from radiating sources or heated components, and if the ampacity of the conductors is in accordance with Table 10.2 and 10.1.5, the temperature tests on the wiring may be waived.

10.1.3 revised February 22, 1994

10.1.4 Wiring which is color coded green or green with one or more yellow stripes shall be used only for grounding conductors. Wiring used for other purposes shall not be identified with the above color codes.

10.1.5 With reference to the Exception to 10.1.3 high voltage circuit conductors supplying one motor shall have an ampacity not less than 125 percent of the full-load current rating of the motor. Conductors supplying more than one motor shall have an ampacity not less than 125 percent of the full-load current rating of the largest motor plus the full-load current rating of any other motors supplied. Conductors supplying a motor load and other loads shall have an ampacity not less than 125 percent of the full-load current rating of the motor plus the marked current ratings or measured inputs of the additional loads supplied.

10.1.5 revised February 22, 1994

10.1.6 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. The wiring arrangement shall be such as to prevent water from entering wiring enclosures and electrical enclosures.

Exception: Water may enter an enclosure providing:

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

b) the live parts are not wetted.

10.1.7 Parallel conductor appliance wiring material of the integral type is not to be ripped more than 3 inches (76.2 mm) unless the minimum wall thickness of the conductor insulation after ripping is at least 0.058 inch (1.47 mm) in thickness. If the material has conductor insulation not less than 0.028 inch (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.

10.1.8 If wiring extends from the cabinet to a hinged door or other parts which are moved in use, stranded conductors shall be employed, and the arrangement shall prevent twisting or stressing of conductors as a result of the movement. The wiring shall be routed or protected to prevent damage to the insulation. The conductors shall be of a jacketed type such as Type SJO or SJT and shall be provided with strain relief so that stress will not be transmitted to terminals or splices.

10.1.9 With reference to 10.1.8, wiring which is subjected to movement is to be tested by cycling the moving part through the maximum travel permitted by the design. The duration of the test is to be 100,000 cycles. Following this, the unit is to be subjected to the Dielectric Voltage Withstand Test, and the wiring is to be examined for damage to determine if any conductors are broken or if individual strands have penetrated the insulation.

10.1.10 14 AWG (2.1 mm^2) conductors supplying 15 ampere, general purpose receptacles and 12 AWG (3.3 mm^2) conductors supplying 20 ampere, general purpose receptacles are considered as complying with the temperature requirement of 10.1.5. See 36.6.

10.1.10 revised March 16, 2010

10.1.11 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.

10.1.12 If any failure of low-voltage wiring may cause malfunctioning of a pressure-limiting device, motor overload protective device, or other protective device which may result in unsafe operation of the product, such wiring shall be enclosed wire as indicated in 10.2.1 or shall be Type SPT-2 cord or one of the types indicated in Group B of Table 10.1. Wires of types indicated in Group A of Table 10.1, or low-energy safety control wire may be used if such wiring is located in a cavity or compartment of the product and is shielded from damage.

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

10.1.14 Splices shall be located within the product 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, or the like. Strain relief shall be provided on the conductors if the wiring is liable to be moved during service operations, such as replacing fuses, resetting manual-reset devices, or oiling motors.

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

Table 10.1
Typical wiring materials

Table 10.1 revised March 16, 2010

Group	Type of wire, cord, or cable[a]	Wire size		Insulation thickness	
		AWG	(mm^2)	inch	(mm)
A	TF, TFF, TFN, TFFN, THW, XHHW, MTW, THW-MTW, THWN, PF, PGF, PFF, PGFF, TW, or thermoplastic appliance wiring material	10 and smaller	(5.3)	2/64	(0.8)
		8	(8.4)	3/64	(1.2)
B	SO, ST, SPT-3, SJO, SJT, or appliance wiring material[a] with thermoplastic or neoprene insulation	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)

[a] Appliance wiring recognized for refrigeration use.

Table 10.2
Wiring materials ampacities

Table 10.2 added February 22, 1994

Wire size		Ampacity
mm^2	(AWG)	
0.41	22	4
0.66	20	7
0.82	18	10
1.3	16	13
2.1	14	18
3.3	12	25
5.3	10	30
8.4	8	40
13.3	6	55
21.2	4	70
33.6	2	95
42.4	1	110

NOTE – The ampacities shown apply to appliance wiring materials with insulation rated not less than 90°C (194°F). For types of wires other than appliance wiring materials, the ampacity shall be determined from Tables 310-16 and 310-17 in the National Electrical Code, ANSI/NFPA No. 70-1993 for the type of wire employed. The correction factors of the referenced tables need not be applied.

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10.1.16 Splicing devices, such as fixture-type splicing connectors and pressure wire connectors, may be employed if they provide mechanical security and employ insulation rated for the voltage to which they are subjected. In determining if splice insulation consisting of coated fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its electrical, mechanical, and flammability properties. Thermoplastic tape wrapped over a sharp edge is not acceptable.

10.1.17 Quick-connecting assemblies are to form a secure electrical connection, such as by detents in the mating parts, and are to be capable of carrying the current involved.

10.1.18 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. Open-slot type connectors shall not be used unless they are constructed to prevent disconnection resulting from loosening of the clamping means. The shanks of terminal connectors shall be protected by electrical insulation if the spacings may be reduced below the minimum acceptable values by slight loosening of the clamping means. The insulating material shall be secured in position. The thickness of the insulation on the shanks shall be not less than 0.028 inch (0.71 mm) except as permitted by 25.1.9.

10.1.19 Holes in walls, panels, or barriers through which insulated wires or cords pass and on which they may bear shall be provided with smoothly rounded bushings or shall have smooth, rounded surfaces upon which the wires or cords may bear to prevent abrasion of the insulation. Bushings shall be fabricated from materials such as ceramic, phenolic, cold-molded composition, or fiber.

10.2 Permanently connected products

10.2.1 Wiring shall be of the type indicated in Table 10.1, Group A, and enclosed by means such as conduit, electrical metallic tubing, metal raceways, or control boxes. Fittings shall be constructed for use with the type of wiring enclosure employed.

Exception: Cords or appliance wiring material of a type indicated in Table 10.1, Group B, may be employed in lieu of the enclosed wiring provided the wiring is enclosed by the cabinet to prevent damage to wiring, ignition of flammable material, or emission of flame or molten metal through openings in the cabinet.

10.2.2 With reference to 10.2.1, the wiring is considered to be enclosed when the cabinet or compartment enclosing the wiring complies with the following:

a) There are no openings in the top of the compartment unless barriers or baffles are placed between the wiring and the openings.

b) There are no openings in the bottom unless a U-shaped channel or trough is located under the wiring, and the wires do not project through the plane of the top of the trough or channel.

c) Louvers or openings, other than in the bottom, will not permit entrance of a rod having a diameter of 1/2-inch (12.7-mm).

d) Openings are not closer than 6 inches (152 mm) to the wiring unless barriers or baffles are placed between the wiring and the openings. A nonmetallic material employed as a barrier or baffle shall be investigated for use as an enclosure. See 8.1.6.

e) Where flammable material, other than electrical insulation, is located within the compartment, the wiring is to be separated from such material or the material shall not introduce a risk of fire.

Exception: Wiring need not be isolated as indicated above if it complies with the VW-1 flame test or the vertical flame test described in the reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581.

10.2.3 Conductors of motor circuits having two or more thermal- or overcurrent-protected motors wired for connection to one supply line shall withstand the conditions of the Limited Short-Circuit Test, Section 51.

Exception: A conductor that complies with one or more of the following is acceptable without test:

a) A conductor that has an ampacity of not less than one-third of ampacity of the branch circuit conductors as determined in 9.2.8, or

b) A conductor that is 18 AWG (0.82 mm^2) or larger and not more than 4 feet (1.2 m) in length, provided that the circuit will be protected by a fuse or "HACR Type" circuit breaker rated not more than 60 amperes, or

c) A conductor that serves as a jumper lead between controls, provided that either the length of the lead does not exceed 3 inches (76.2 mm), or the conductor is located in an electrical control enclosure.

10.2.3 revised March 16, 2010

10.3 Cord-connected products

10.3.1 A cord-connected product shall be wired by either of the following means or combinations of the two:

a) Cords or appliance wiring material as referenced in Table 10.1, Group B.

b) Wiring material as referenced in Table 10.1, Group A, enclosed in conduit, electrical metallic tubing, metal raceways, control boxes, or cabinet walls.

Exception: Neoprene or thermoplastic insulated wiring material in Group A of Table 10.1 need not be enclosed as indicated above, if all of the following conditions are met:

1) Internal wiring shall be cabled, routed, located or secured to reduce the likelihood of damage to the wiring during routine servicing such as replacing fuses, adjusting the settings of controls, or the like; and

2) Internal wiring shall be separated from flammable material in accordance with 10.3.2.

10.3.1 revised February 22, 1994

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10.3.2 With reference to 10.3.1(a), the wiring shall be arranged so that burning insulation or molten material will not fall onto flammable material within or under the enclosure. There shall be no openings in the top of the compartment unless damage to the wiring is prevented by means such as barriers, baffles or the like. Such protective means is considered acceptable if it will not permit entrance of a 1/2 inch (12.7 mm) diameter rod inserted vertically.

Exception: Wiring need not be isolated as indicated above if it complies with the VW–1 flame test or the vertical flame test described in the reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581.

10.3.2 revised June 24, 1997

11 Separation of Circuits

11.1 Patient care equipment

11.1.1 If the shorting together of two adjacent conductive parts (wires, terminals, structural metal, and the like) of an appliance will result in available leakage current in patient-connected circuits in excess of the limits outlined in 33.4.1, the construction shall comply with at least one of the following:

a) For insulated conductive parts, each insulation employed shall be rated for the maximum voltage possible (for example, the highest voltage on a part with respect to ground or with respect to any exposed conductive part, either with or without the introduction of any random failure of one insulation involved). A spacing between parts that is not less than that required in Table 25.1 may be used in place of a single insulation.

b) For two uninsulated conductive parts, a spacing between parts that is not less than 1-1/2 times that required in Table 25.1 may be used.

c) If not insulated or spaced apart as in (a) or (b) the parts shall be separated by means of a solid (unpierced) barrier, permanently secured in place, of one of the types noted below:

1) An electrical barrier located so that the barrier is acceptable as a supplement to conductor insulation, or in the case of a barrier between two uninsulated parts, will satisfy the requirements for reinforced insulation thereby reducing the risk of electric shock equivalently to that accomplished by double insulation.

2) A conductive barrier located and electrically connected so that any likely breakdown will not result in any increase in available leakage current above the specified limits.

11.1.2 In evaluating the required separation of the patient-connected circuits from adjacent circuits derived from different sources in accordance with 11.1.1, consideration shall be given to the effects, including deterioration of insulation, of abnormal operation involving overload, short-circuit, or component failure conditions.

11.1.2 revised June 24, 1997

11.1.3 For nonpatient-connected accessible parts (enclosures, chassis, remote low-voltage circuitry, or the like,) of patient care equipment, the construction of the product shall comply with the requirements for nonpatient equipment in 11.2.1.

11.1.3 revised June 24, 1997

11.2 Nonpatient equipment

11.2.1 The construction of a product shall comply with 11.2.2 if the shorting together of two adjacent conductive parts (wires, terminals, structural metal, and the like) of the product will result in either of the following:

a) A difference of potential greater that 212 volts peak (150 volts RMS if the waveform is sinusoidal) between any accessible parts of a product or between any accessible parts of a product and ground which would cause more than 7.07 milliamperes peak (5.0 milliamperes RMS if the waveform is sinusoidal) to flow through a 500 ohm resistor connected between the parts in question.

b) A difference of potential greater than 42.4 volts peak (30 volts RMS if the waveform is sinusoidal) between any accessible parts associated with circuitry routed to remote locations not within the confines of the appliance enclosure, between the terminals intended for the connection of such circuits, or between such parts or terminals and ground which would cause more than 7.07 milliamperes peak (5.0 milliamperes if the waveform is sinusoidal) to flow through a 500 ohm resistor connected between the parts in question.

11.2.2 A product mentioned in 11.1.3 shall comply with at least one of the following:

a) For insulated conductive parts, each insulation employed shall be rated for the maximum voltage possible (for example, the highest voltage on a part with respect to ground or with respect to any exposed conductive part, either with or without the introduction of any random failure of one insulation involved). A spacing between parts that is not less than that required in Table 25.1 may be used in place of a single insulation.

b) For two uninsulated conductive parts, a spacing between parts that is not less than 1-1/2 times the required in Table 25.1 may be used.

c) If not insulated or spaced apart as in (a) or (b) the parts shall be separated by means of a solid (unpierced) barrier, permanently secured in place, of one of the types noted below:

1) An electrical insulating barrier located so that the barrier is acceptable as a supplement to conductor insulation, or, in the case of a barrier between two uninsulated parts, will satisfy the requirements for reinforced insulation thereby affording a degree of protection against electrical shock equivalent to that afforded by double insulation.

2) A conductive barrier so located and electrically connected that any likely electrical breakdown will not cause voltages in excess of the limits in 11.2.1(a) and (b), to appear on exposed conductive parts or on circuitry to remote locations.

12 Bonding for Grounding

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

12.2 Uninsulated metal parts, 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 plumbing accessories, and refrigerant-containing parts are to be bonded for grounding if they may be contacted by the user or serviceman.

Exception: Metal parts described as follows need not be grounded:

a) Adhesive-attached metal-foil markings, screws, handles, and the like, which are located on the outside of enclosures or cabinets 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, which are positively separated from wiring and uninsulated live parts.

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

d) Panels and covers which are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar materials not less than 1/32 inch (0.8 mm) in thickness, 0.028 inch (0.71 mm) minimum, and secured in place. If material having a lesser thickness is used, consideration is to be given to such factors as its electrical, mechanical, and flammability properties when compared with materials in thicknesses specified above.

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

12.4 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 the 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:

a) Be protected from mechanical damage or be located within the confines of the outer enclosure or frame, and

b) 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.

12.5 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 455°C (851°F). 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 12.8.

12.6 With reference to 12.5, 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.

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

Terminal dimensions		Rating of protective device
inches	(mm)	amperes
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

12.8 A connection that depends upon the clamping action exerted by rubber or other nonmetallic material may be acceptable if it complies with 12.12 under any normal degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation which may occur in service. Also, the effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with particular emphasis on the likelihood of the clamping device being reassembled in its intended fashion.

12.9 On a cord connected product, a bonding conductor or strap shall have a cross-sectional area not less than that of the grounding conductor of the supply cord except as permitted by 12.12 and 12.13.

12.10 On a permanently connected product, 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 12.12, the size of the conductor or strap shall be in accordance with Table 12.1.

Table 12.1
Bonding wire conductor size

Rating of overcurrent device	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
amperes	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)

[a] Or equivalent cross-sectional area.

12.11 A conductor, such as a clamp or strap, used in place of a separate wire conductor as indicated in 12.10, is considered acceptable provided the minimum cross-sectional conducting area is equivalent to the wire sizes indicated in Table 12.1.

12.12 A smaller conductor may be used if the bonding conductor and connection comply with the provisions of the Current Overload Test and the Limited Short-Circuit Test.

12.13 A bonding conductor to a motor or other electrical component need not be larger than the size of the motor-circuit conductors or the size of the conductors supplying the component. See 10.2.3.

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

12.15 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 sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

ELECTRICAL COMPONENTS

13 Capacitors

13.1 A motor starting or running capacitor, and a capacitor connected across the line, such as a capacitor for radio-interference elimination or power-factor correction, shall be housed within an enclosure or container which shall protect the plate against mechanical damage and which shall prevent the emission of flame or molten material resulting from malfunctioning of the capacitor. The container shall be of metal providing strength and protection not less than that of uncoated sheet steel having a minimum thickness of 0.020 inch (0.51 mm).

Exception: The individual container of a capacitor may be of sheet metal having a thickness less than 0.020 inch (0.51 mm) or may be of material other than metal if the capacitor is mounted within the enclosure of the product or within an enclosure which houses other parts of the product.

13.2 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 inch (0.8 mm) thick except as indicated in 25.1.9.

13.3 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this Standard, including faulted overcurrent conditions based on the circuit in which it is used. See Short-Circuit Test, Section 51.

Exception: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 51.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component(s).

14 Current-Carrying Parts

14.1 All current-carrying parts of a product shall be of silver, copper, a copper alloy, or other material acceptable for use as an electrical conductor.

Exception: Multimetallic thermal elements and heater elements of a thermal protector need not comply with this requirement.

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

14.3 Iron or steel, if provided with a corrosion resistant coating, or stainless steel may be used for a current-carrying part:

a) If permitted in accordance with 2.1.1 or

b) Within a motor, but the use of ordinary iron or steel for current-carrying parts elsewhere in the product is not acceptable.

15 Electric Heaters

15.1 Heater elements

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

15.1.2 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 15.1.3.

15.1.3 Uncoated copper tubing may be employed for temperatures of 200°C (392°F) and lower; metallic coated copper tubing is acceptable for temperatures below the melting temperature of the coating. Uncoated or oxide-coated steel tubing is not considered acceptable as a heater sheath. Plated steel tubing may be employed if the coating is determined to be corrosion resistant and will withstand the temperatures to which it may be subjected. Aluminum tubing may be employed if the alloy withstands a burnout test without melting or other failure. Stainless steel tubing of the austenitic grades such as ASTM Type 304 is generally acceptable for defrost heater sheaths.

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

15.1.5 Insulating material employed in a heating element shall be acceptable 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 it is necessary to investigate a material, consideration is to be given to its mechanical strength, dielectric strength, insulation resistance (see 50.1.1– 50.1.5), heat resistant qualities, the degree to which it is enclosed or protected, and any other features having a bearing on the risk of fire or unintentional contact involved in conjunction with conditions of actual service. All of these factors are considered with respect to thermal aging.

15.1.6 To comply with 15.1.1, a heater case or a terminal seal of neoprene or thermoplastic materials shall have suitable aging properties for temperatures measured during heating tests. See Accelerated Aging Test – Electric Heaters, Section 53.

15.1.7 An electric heater assembly shall be sealed to prevent entrance of moisture. See Insulation Resistance Test, Section 50. Molded seal caps, vulcanized to the heater leads and heater sheath, shall have a wall thickness equivalent to that required for the heater leads.

15.2 Heater control

15.2.1 If failure could result in an electrical shock or risk of fire, electric heaters shall be provided with a thermal protective device or a replaceable thermal cutoff. See Burnout Test, Section 47. Thermal cutoffs are to comply with the requirements specified in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

15.2.1 revised March 3, 2006

15.2.2 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. See 15.2.3.

15.2.3 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 the cutoff itself or to a heating element assembly on which the cutoff is mounted.

16 Insulating Material

16.1 Material for the mounting of uninsulated live parts shall be porcelain, phenolic composition, or other material with consideration given to its electrical and mechanical properties.

16.2 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a risk of fire or electrical shock. Plastic materials may be acceptable for the sole support of uninsulated live parts if found to have adequate mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric voltage withstand, and other factors involved with the conditions of actual service. All of these factors are to be considered with respect to thermal aging.

17 Lampholders and Lamps

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

Exception: The requirement does not apply if, in order to remove or replace a lamp, it is necessary to dismantle the product by means of tools. However, common Edison-base or fluorescent lamps used for illumination, or pilot lamps are to be user serviceable without such dismantling of the product. Also see 3.1.3 (c).

17.2 A lampholder shall not employ a paper liner.

17.3 If necessary to reduce the risk of injury or electrical shock during the operation of the product, a guard or shield shall be provided to contain lamp fragments and reduce the risk of contact with live parts in the event of lamp breakage.

17.4 A guard, such as a lens or shield, shall not be supported by the lamp unless the guard, when subjected to an impact as described in 17.5, is capable of retaining any broken glass.

17.5 A lamp guard shall sustain without cracking or breaking, an impact of 1.6 foot-pound (2.1 J) from a 2 inch (50.8 mm) diameter, 1.18 pound-mass (0.53 kg) steel ball when tested as follows: The impact energy is to be imposed on the sample by the steel ball, either falling vertically or by swinging as a pendulum. The sample component is to be struck within 1 inch (25.4 mm) of its center. Three samples of each component shall be tested, and a separate sample is to be used for each test.

18 Motors and Motor Overload Protection

18.1 Except as indicated in 18.9, all motors shall be protected by thermal or overcurrent protective devices.

18.2 For a motor other than a hermetic refrigerant motor-compressor, overcurrent protection as mentioned in 18.1 is obtained if the protection is provided by a separate overcurrent device that is responsive to motor current, and is rated or set to trip at not more than the percentage of the motor nameplate full-load current rating shown in column A of the following table. For an overload relay, where the percentage protection indicated in column A does not correspond to the percentage value resulting from selection of a standard size of relay, the next higher size of overload relay may be used, but not higher than will provide the percentage protection indicated in column B.

	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 40°C (72°F)	125	140
Any other motor	115	130

18.3 A hermetic refrigerant motor-compressor is considered to comply with the requirement in 18.1 if the protection complies with (a),(b),(c) or (d).

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 current of the motor-compressor marked on the product nameplate.

b) A thermal protector integral with the motor-compressor that:

1) Complies with Standard for Hermetic Refrigerant Motor-Compressors, UL 984, and

2) Will not permit a continuous current in excess of 156 percent of the rated load current of the motor-compressor (or 156 percent of the branch-circuit-selection current if the latter value is marked). However, this 156 percent limitation does not apply to the units described in 18.3. The values of rated load current and branch-circuit-selection current referred to are the values marked on the product nameplate. See 52.1.

c) A fuse or circuit breaker responsive to motor current, and rated at not more than 125 percent of the rated load current of the motor-compressor marked on the product nameplate. The product shall start and operate normally with the fuse or circuit breaker provided.

d) A protective system that:

1) Complies with the Standard for Hermetic Refrigerant Motor-Compressors, UL 984, and

2) Will not permit a continuous current in excess of 156 percent of the rated load current of the motor-compressor (or 156 percent of the branch-circuit-selection current if the latter value is marked). However, this 156 percent limitation does not apply to the units described in 18.3. The values of rated load current and branch-circuit-selection current referred to are the values marked on the product nameplate. See 52.1.

18.4 For a cord-connected product or a permanently connected product marked with a single-ampere rating, the rated-load current of the motor-compressor is the current drawn by the motor-compressor during the Temperature and Pressure Test, Section 36.

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18.5 Hermetic refrigerant motor-compressors with thermal protective devices employed in equipment intended for connection to a 15 or 20 ampere, 120 volt or a 15 ampere, 208 or 240 volt, single-phase branch circuit are not required to meet the 156 percent limitation specified in (b)(2) and (d)(2) of 18.3.

18.6 All components of the ″protective system″ mentioned in 18.3(d), shall be provided as part of the product.

18.7 Hermetic compressors with thermal protective devices which conform to the Standard for Hermetic Refrigerant Motor-Compressors, UL 984, are considered to comply with this requirement provided that under running conditions the motor-compressor enclosure does not exceed the temperature limit specified in Table 36.1.

18.8 Thermal protective devices used with nonhermetic motors are to comply with the Standard for Overheating Protection for Motors, UL 2111.

Exception: Motors, such as direct-drive fan motors, which are not ordinarily subjected to overloads and which are determined to be protected against overheating due to locked-rotor current by a thermal or overcurrent protective device may be accepted under this requirement provided it is determined that the motor will not overheat under actual conditions of use.

18.8 revised November 24, 1998

18.9 Direct-drive motors employing impedance protection and which comply with the locked-motor requirements specified in Overheating Protection for Motors, UL 2111, may be used provided it is determined that the motor will not overheat under actual conditions of use.

18.9 revised November 24, 1998

18.10 Three-phase motors shall be provided with overcurrent protection as follows:

a) Three overcurrent units, rated as specified in 18.2 and 18.3, shall be employed, or

b) Thermal protectors, combinations of thermal protectors and overcurrent units, or other methods of protection may be employed where the specific protective arrangement has been investigated and found to provide protection under primary single-phase failure conditions when supplied from transformers connected wye-delta or delta-wye. Assemblies so investigated shall be marked as described in 64.19.

18.11 Fuses shall not be used as motor overload protective devices unless the motor is protected by the largest size fuse which can be inserted in the fuseholder.

18.12 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 51.

18.13 Refrigerant motor-compressors are to be constructed in accordance with the Standard for Hermetic Refrigerant Motor-Compressors, UL 984. Other motors are to be constructed in accordance with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

18.13 revised September 27, 2013

18.14 Motors used in oxygen-administering equipment shall be totally enclosed. Motors that require oiling shall be constructed and installed so that excessive oil cannot enter the area in which oxygen is present. A clearance of 1/2 inch (12.7 mm) between the motor bearing and the wall through which the shaft projects or a shaft seal at the wall opening is considered to provide the necessary protection. See 5.6.

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19 Overcurrent Protection

19.1 Overcurrent protection shall be provided by a circuit breaker(s) or fuse(s) that is intended for branch circuit use, as a part of a product, for each receptacle or lighting circuit included in the product. Such overcurrent protection may be omitted if, in accordance with the National Electrical Code, ANSI/NFPA 70-1990, the product can be connected to a branch circuit rated at not more than 20 amperes.

19.2 If not exempted by 19.1, a 15 ampere protective device shall be provided when a single 15 ampere receptacle outlet is furnished. Two or more 15 ampere receptacles (two separate receptacles or a duplex receptacle) shall be protected by either a 15 or 20 ampere protective device. A 20 ampere receptacle or a combination 15 and 20 ampere receptacle shall be protected by a 20 ampere protective device.

19.3 A fuseholder provided in accordance with 19.1 shall be of Type S construction or shall be of a Edison-base type with a factory-installed nonremovable adapter of Type S construction or other noninterchangeable type.

19.4 A fuse mounted in a fuseholder marked in accordance with 66.3.1 and a fuse that is accessible without the use of a tool, shall be mounted or guarded so that no live parts will be exposed to unintentional contact. The arrangement shall be such that the fuse will not be positively gripped or held by any part of the fuseholder while live parts are exposed at any time during replacement.

19.5 The screwshell of a plug fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

20 Printed Wiring

20.1 If a risk of fire or electric shock could occur due to failure of the bond between the conductor and the base material, printed wiring boards used in primary circuits and secondary circuits that may involve a risk of fire or electric shock shall be evaluated in accordance with Printed Wiring Assembly Tests, Section 56. See 8.1.2 and 8.1.3.

20.2 Printed wiring boards used in circuits where failure of the bond between the conductor and the base material does not result in a risk of fire or electric shock are considered to be acceptable without further investigation.

20.3 The securing of components, such as resistors, capacitors, inductors, transformers, and the like, to a printed wiring board to form a printed wiring assembly, and the mounting of the printed wiring assembly itself shall be such that any forces that might be exerted on the components or board during assembly, shipping, or handling of the equipment, or during use or servicing will not displace the components or deflect the board so as to result in a risk of fire or electric shock.

21 Receptacles

21.1 A receptacle intended for general use shall be rated 15 or 20 amperes, 125 or 250 volts and shall be of the grounding type.

21.2 Receptacles intended to accommodate single-prong, shielded-type plugs for signal applications shall not involve hazardous energy. See 8.1.3.

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

22 Switches and Controllers

22.1 Except as indicated in 22.3 and 22.4, a motor controller(s) for controlling the loads involved shall be provided for all products incorporating:

a) Two or more motors or

b) A motor(s) and other load(s) intended for connection to the same power supply.

22.2 A motor "controller" is defined as any switch or device normally used to start and stop a motor.

22.3 The attachment plug and receptacle may serve as the controller on a cord-connected product if the marked ampere rating does not exceed the values shown in Table 22.1 for the voltage indicated.

Table 22.1
Ampere rating

Amperes	Voltage
7.2	115
4.0	208
3.6	230

22.4 A controller is not required for any supply circuit of a permanently connected product which supplies:

a) Two or more motors or

b) A motor(s) and other load(s) if the marked maximum size of the supply circuit overcurrent protection device for that circuit does not exceed 20 amperes at 125 volts or less or 15 amperes at 600 volts or less, and if the rating of any motor in the circuit does not exceed 1 horsepower (hp) (746 W) and 6 full load amperes.

22.5 Except as specified by 22.3, a manually operable switch which has a marked OFF position shall be installed on a cord connected product for shutting off the assembly.

22.6 On a cord-connected product, 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 motor-compressor's rated load current and

b) The rated current for other controlled loads. See 18.4.

22.7 A switch or other control device shall be rated for the load which it controls as determined by the Temperature and Pressure Test, Section 36, and the Heating Test, Section 37.

22.8 If a branch-circuit selection current value is marked on a permanently connected product, a controller for a hermetic refrigerant motor-compressor shall have a full-load current rating not less than this marked value plus any additional loads controlled.

22.9 On a permanently connected product, 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 motor-compressor's rated load current or branch-circuit selection current, whichever is greater, and

b) The rated current for other controlled loads, as shown on the product nameplate. See 18.4.

22.10 A switch provided for the control of an inductive load, such as a transformer or an electric-discharge lamp ballast, shall have a current rating of not less than twice the total marked current ratings of the transformer, ballast, or other equipment which it controls.

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

22.12 A switch is acceptable for use with tungsten filament lamp loads if it has a T or L rating equal to the tungsten filament lamp load. A general-use alternating current snap switch, a circuit breaker, or a nonautomatic circuit interrupter are considered acceptable for controlling tungsten filament lamps at their full ampacity. A switch having an alternating current ampacity of six times or more of the tungsten filament lamp load is also acceptable for use with the tungsten filament lamp load without additional test.

22.13 A switching device which may be called upon to break a motor load under locked-rotor conditions shall have a current interrupting capacity not less than the locked-rotor current of the motor.

22.14 If a switching device controls a compressor motor and fan motor and/or other load, it shall have a current interrupting capacity not less than the locked-rotor load of the compressor motor plus the full load of the fan motor and/or other load.

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

22.16 Coil windings of switching devices shall be impregnated, dipped, varnished, or otherwise treated to resist absorption of moisture.

22.17 Switching devices shall be housed within an enclosure which 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 product enclosure, by inherent construction of the component, or by means of a separate enclosure.

23 Transformers

23.1 Construction

23.1.1 The coils of a transformer shall be impregnated or otherwise treated to resist absorption of water.

23.1.2 Transformers having separate windings shall be constructed to prevent any electrical connections, under normal and overload conditions, between primary and secondary windings or between separate adjacent secondary windings if such connection would result in an electric shock or risk of fire.

23.2 Patient care equipment

23.2.1 In determining compliance with 23.1.2, one or more of the following methods shall be used, and the product shall also comply with the tests outlined in 55.2.1 – 55.2.8.

a) Windings wound on separate bobbins of functional insulating material on separate legs of the core of the transformer.

b) Primary and secondary windings, or adjacent secondary windings, wound on one length of functionally insulated core (both coils on the core, not concentric) if the two windings are separated end to end by electrical insulating material (reinforced or double insulation is required if one winding is connected to a patient circuit).

c) Concentrically wound primary and secondary windings, or adjacent secondary windings thermally protected and separated by a grounded copper shield at least 0.005 inch (0.127 mm) thick, or equivalent, which completely isolates the adjacent windings, adjacent splices, or both and crossover leads if present.

d) Concentrically wound primary and secondary windings or adjacent secondary windings separated by either two layers of mica or other insulating material of equivalent resistance to ignition, 0.007 inch (0.178 mm) thick (total) or three layers of sheet insulating material, any two of which shall withstand the Dielectric Voltage Withstand Test, Section 38, for reinforced insulation and protected by means of a thermally sensitive device. The sheet insulating material should also provide protection for the splices and crossover leads if present.

e) Other constructions that examination and tests show are equivalent to those specified in (a) - (d).

23.2.2 Thermal protection, where required in 23.2.1(c) or (d), is to be such that the temperature of the insulating material used to separate the primary and secondary or adjacent secondary windings from grounded metal or each other cannot exceed the values specified in 55.1.1 during performance of the overload and short circuit tests described in 55.2.1 – 55.2.8.

23.3 Nonpatient equipment

23.3.1 In determining compliance with 23.1.2, any of the methods described in 23.2.1 shall be used, and the product shall also comply with the tests outlined in 55.2.1 - 55.2.8 except that thermal protectors or double or reinforced insulation is not required.

24 Valves and Solenoids

24.1 The coil of an electrically operated valve or solenoid shall not overheat when the product is subjected to the Temperature and Pressure Test, Section 36, and the Heating Test, Section 37.

24.2 An electrically operated valve or solenoid shall comply with the requirements of the Burnout Tests – Components, Section 47.

24.3 If a valve must be cleaned periodically, the arrangement shall permit this operation to be performed without damage to the electrical parts of the valve or wiring.

24.4 Coil windings of electrically operated valves or solenoids shall be impregnated, dipped, varnished, or otherwise treated to resist absorption of moisture.

25 Spacings

25.1 High-voltage circuits

25.1.1 A high-voltage circuit is one involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit as defined in 25.4.1.

25.1.1 revised May 15, 1996

25.1.2 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 25.1.

25.1.2 revised May 15, 1996

25.1.3 The spacings indicated in Table 25.2 are applicable to electrical components mounted in totally enclosed compartments that are nonrefrigerated, nonair-handling, or both, and that are free of moisture, including that caused by condensation. At wiring terminals and for circuits over 250 volts or over 2000 volt-amperes spacings in Table 25.1 apply.

25.1.3 revised May 15, 1996

Table 25.1
Electrical spacings in refrigerated and/or air-handling compartments

Table 25.1 revised May 15, 1996

Ratings		Minimum spacing					
		Through air[a]		Over surface[a]		To enclosure[c]	
Volt-amperes	Volts	inches	(mm)	inches	(mm)	inches	(mm)
2000 or less	300 or less	1/8[b]	(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[b]	(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] 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 inch (1.6 mm) Through air and Over surface for heaters rated 0 – 300 volts.

1/4 inch (6.4 mm) Though air and Over surface for heaters rated 301 – 600 volts.

[b] The spacings between wiring terminals of opposite polarity or between a wiring terminal and ground shall be not less than 1/4 inch (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.

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

25.1.4 The ″Through Air″ and ″Over Surface″ spacings given in Tables 25.1 and 25.2 at an individual component part are based on the total volt-ampere (VA) consumption of the load or loads which the component controls. For example, spacings at a component which controls only the compressor motor are based on the VA of the compressor motor. The spacings at a component which controls loads in addition to the compressor motor are based on the sum of the volt-amperes of the loads so controlled, except that spacings at a component which independently controls separate loads are based on the volt-amperes of the larger load. The volt-ampere values for the loads referred to above are to be determined by the marked rating of the loads, except that for loads which are not required to have a marked rating, the measured inputs is to be used in determining the volt-ampere values.

25.1.4 revised May 15, 1996

Table 25.2
Spacings in nonrefrigerated and/or nonair handling compartments

Table 25.2 revised May 15, 1996

Ratings		Minimum spacing					
		Through air		Over surface		To enclosure[a]	
Volt-amperes	Volts	inches	(mm)	inches	(mm)	inches	(mm)
0 – 2000	0 – 125	1/16	(1.6)	1/16	(1.6)	1/4	(6.4)
	126 – 250	3/32	(2.4)	3/32	(2.4)	1/4	(6.4)

NOTE – See 25.1.3.
[a] Includes fittings for conduit or metal-clad cable.

25.1.5 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 above and shall be based on the highest voltage involved.

25.1.5 revised May 15, 1996

25.1.6 With reference to 25.1.2 and 25.1.4, the To Enclosure spacings are not to be applied to an individual enclosure of a component part within an outer enclosure or cabinet.

25.1.6 revised May 15, 1996

25.1.7 The spacings requirements specified in 25.1.1 – 25.1.6 do not apply to the inherent spacings of a component part of the product, such as a hermetic motor-compressor, motor, snap switch, controller, attachment plug, or the like, for which spacing requirements are given in a standard for the component. See 2.1.1. 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.

25.1.7 revised May 15, 1996

25.1.8 If higher than rated potential is developed in a motor circuit through the use of capacitors, the rated voltage of the system shall be employed in applying the spacings indicated in this section.

Exception: If the developed steady-state potential as determined in the Temperature and Pressure Test, Section 36, and Heating Test, Section 37, exceeds 500 volts, the developed potential is to be used in determining the spacings for the parts affected.

25.1.8 revised May 15, 1996

25.1.9 An insulating lining or barrier of fiber or similar material, employed where spacings would otherwise be less than the required values, shall be no less than 0.028 inch (0.7 mm) in thickness and shall be so located or of such material that it will not be adversely affected by arcing.

Exception No. 1: Fiber no less than 0.013 inch (0.3 mm) thick may be used in conjunction with an air spacing of no less than 50 percent of the spacing required for air alone.

Exception No. 2: Material having a lesser thickness may be used if it has equivalent insulating, mechanical, and flammability properties when compared with material in thicknesses specified above.

25.1.9 revised May 15, 1996

25.1.10 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 inch (12.7 mm) if the potential is 600 volts or less and not less than 3/4 inch (19.1 mm) if the potential is 601 – 1000 volts.

25.1.10 added May 15, 1996

25.2.1 Deleted May 15, 1996

25.3 Patient-connected circuits

25.3.1 The spacings between uninsulated parts of patient-connected circuits and adjacent circuits derived from different sources shall be 1-1/2 times the spacings specified in 25.1.2 and Table 25.1. See 11.1.2.

25.4 Low-voltage circuits

25.4.1 A low-voltage circuit is one involving a potential of not more than 30 volts alternating current, 42.4 volts peak or direct current, and supplied by a standard Class 2 transformer or by a suitable combination of transformer and fixed impedance having output characteristics in compliance with those required for a Class 2 transformer.

25.4.1 added May 15, 1996

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

25.4.2 added May 15, 1996

25.4.3 The spacings for low-voltage electrical components which are installed in a circuit which includes a pressure-limiting device, motor overload protective device, or other protective device, where a short or grounded circuit may result in unsafe operation of the equipment shall comply with the following:

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 inch (3.2 mm).

b) The spacing between wiring terminals, regardless of polarity, and between the wiring terminal and a deal metal part, including the enclosure and fittings for the connection of conduit, which may be grounded when the device is installed, shall be not less than 1/4 inch (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, which may be grounded when the device in installed, shall be not less than 1/32 inch (0.8 mm) provided that the construction of the parts is such that spacings will be maintained.

25.4.3 added May 15, 1996

25.4.4 The spacings in low-voltage circuits which do not contain devices such as indicated in the previous paragraph are not specified.

25.4.4 added May 15, 1996

REFRIGERATION SYSTEM

26 Refrigerant

26.1 The kind of refrigerant employed in the system shall comply with the Standard for Refrigerants, UL 2182.

26.1 revised November 3, 1997

26.2 Deleted February 22, 1994

27 Refrigerant Tubing and Fittings

27.1 Copper or steel tubing used to connect refrigerant-containing components shall have a wall thickness not less than indicated in Table 27.1.

Exception: Capillary tubing which is protected against mechanical damage by the cabinet or assembly shall have a wall thickness not less than 0.020 inch (0.51 mm).

27.2 Tubing shall be constructed of corrosion resistant material, such as copper, or shall be plated, dipped, coated, or otherwise treated to resist external corrosion. Aluminum may be used where the material is not subject to galvanic corrosion.

27.3 Tubing forming part of components, such as evaporators or condensers, where protection is afforded by inherent construction shall be judged by the Strength Tests – Pressure Containing Components, Section 57.

27.3 revised February 22, 1994

27.4 Special alloys or constructions used in refrigerant-containing components, including tubing with a wall thickness less than indicated in 27.1, may be acceptable. Among the factors taken into consideration when judging the acceptability are its:

a) Resistance to mechanical abuse,

b) Strength against internal pressure,

c) Resistance to corrosion,

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d) Protection against refrigerant contamination, and

e) Conformity with requirements of safety codes, such as the Safety Code for Mechanical Refrigeration, ANSI/ASHRAE 15-89, as compared to tubing of the minimum wall thickness indicated in Table 27.1.

Table 27.1
Minimum wall thickness for copper and steel tubing

Outside diameter		Copper				Steel	
		Protected within product		Unprotected			
inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
1/4	(6.4)	0.0245	(0.622)	0.0265	(0.673)	0.025	(0.64)
5/16	(7.9)	0.0245	(0.622)	0.0285	(0.724)	0.025	(0.64)
3/8	(9.5)	0.0245	(0.622)	0.0285	(0.724)	0.025	(0.64)
1/2	(12.7)	0.0245	(0.800)	0.0285	(0.724)	0.025	(0.64)
5/8	(15.9)	0.0315	(0.800)	0.0315	(0.800)	0.032	(0.81)
3/4	(19.1)	0.0315	(0.799)	0.0385	(0.978)	0.032	(0.81)
7/8	(22.2)	0.0410	(1.041)	0.0410	(1.041)	0.046	(1.17)
1	(25.4)	0.0460	(1.168)	0.0460	(1.168)	–	–

NOTE – Nominal wall thickness of tubing will have to be greater than the thickness indicated to maintain the minimum wall thickness.

27.5 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 conform to the Standard for Refrigeration Tube Fittings, ANSI/SAE J513F-JUN90.

28 Refrigerant-Containing Parts

28.1 The parts of a product subjected to refrigerant pressure shall withstand, without failure, the pressure indicated in the Strength Tests - Pressure Containing Components.

28.2 The parts of a product subjected to refrigerant pressure shall be constructed of corrosion resistant material, such as copper or stainless steel, or shall be plated, dipped, coated, to otherwise treated to resist external corrosion.

28.3 Pressure vessels, as referred to in this Standard, are any refrigerant-containing parts other than compressor; controls; evaporators, each separate section of which does not exceed 1/2 cubic foot (0.01 m^3) of refrigerant containing volume evaporator and condenser coils; headers; pipe; and pipe fittings.

28.4 Pressure vessels over 6 inches (152 mm) inside diameter shall be designed, tested, and stamped in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, for a working pressure in compliance with the performance requirements of this Standard.

28.5 Pressure vessels bearing the ASME Code ″U″ symbol complying with 28.4 are considered acceptable without tests.

28.6 Pressure vessels bearing the ASME Code ″UM″ symbol are to be tested to determine compliance with the Strength Tests - Pressure Containing Components requirements. The manufacturer is to submit evidence of compliance of these vessels with the ASME Boiler and Pressure Vessel Code, Section VIII.

29 Pressure Limiting Device

29.1 A pressure limiting device designed to automatically stop the operation of the compressor shall be installed on all products with a system containing more than 22 pounds-mass (10 kg) of refrigerant.

29.1 revised June 24, 1997

29.2 The adjustable cutout pressure setting of a pressure-limiting device shall not exceed one-third of the ultimate strength of high-side refrigerant-containing parts, provided this setting does not exceed 90 percent of the setting of the pressure-relief device.

29.2 revised June 24, 1997

29.3 Deleted June 24, 1997

29.4 There shall be no stop valves between the pressure-limiting device and the compressor.

29.4 revised June 24, 1997

30 Pressure Relief

30.1 General

30.1.1 A product shall be constructed so that pressure due to fire, or other abnormal conditions, will be relieved. Pressure relief devices, fusible plugs, soldered joints, or special terminals may be employed for this purpose. See 30.4.1.

30.1.1 revised June 24, 1997

30.1.2 A pressure relief device is a pressure-actuated valve or rupture member designed to relieve excessive pressures automatically.

30.1.3 A product with a pressure vessel over 3 inches (76.2 mm) inside diameter, but not exceeding 3 cubic feet (0.08 m^3) internal gross volume, shall be protected by a pressure relief device or fusible plug.

30.1.4 A product with a pressure vessel exceeding 3 cubic feet (0.08 m^3), but less than 10 cubic feet (0.28 m^3) internal gross volume, shall be protected by a pressure relief device.

30.1.5 There shall be no stop valve between the pressure relief means and the parts or section of the system protected.

30.1.5 revised June 24, 1997

30.1.6 All pressure relief devices shall be connected as close as practicable or directly to the pressure vessel or parts of the system protected. They shall be connected above the liquid refrigerant level, installed so that they are readily accessible for inspection and repair, and arranged so that they cannot readily be rendered inoperative.

30.1.6 revised June 24, 1997

30.1.7 Fusible plugs may be located above or below the liquid refrigerant level.

30.2 Required discharge capacity

30.2.1 Deleted June 24, 1997

30.3 Relief valves

30.3.1 Pressure relief valves shall comply with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII. Valves of 1/2 inch [0.840 inches (21.3 mm) outside diameter] iron pipe size (ips) and larger shall bear the authorized Code ″UV″ symbol together with the set pressure and capacity. Valves of less than 1/2 inch ips 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 which do not bear the code symbol shall provide evidence of certification of the valve and its pressure and capacity rating by proper code authorities.

30.3.2 Pressure relief valves shall be sealed at a start-to-discharge pressure not exceeding the marked working pressure of the pressure vessel protected or not exceeding one-fifth of the ultimate strength of pressure vessels which do not have a marked working pressure.

30.3.3 The marked discharge capacity shall be not less than the minimum required discharge capacity as specified in 30.4.1.

30.3.3 revised June 24, 1997

30.4 Fusible plugs or rupture members

30.4.1 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 Code for Mechanical Refrigeration, ANSI/ASHRAE 15-1994.

Revised 30.4.1 effective June 24, 1998

30.4.2 Fusible plugs shall be stamped with the relief temperature.

30.4.3 Rupture members shall be stamped with the minimum and maximum bursting pressures.

30.4.4 Fusible plugs and rupture members, shall comply with performance requirements for such devices as contained in the Standard for Refrigerant-Containing Components and Accessories, Nonelectrical, UL 207.

30.4.4 revised March 16, 2010

PERFORMANCE

31 Instrumentation

31.1 Temperature measurements

31.1.1 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 36.4. The thermocouples are to consist of 24 – 30 AWG (0.21 – 0.05 mm^2) wires. The thermocouple wire is to conform to the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

31.1.1 revised March 16, 2010

31.1.2 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.

31.1.3 Thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer type of indicating instrument shall be used whenever referee temperature measurements by means of thermocouples are necessary.

31.1.3 revised March 16, 2010

31.2 Pressure measurements

31.2.1 Pressure gauges are to be attached in such a manner as to prevent leakage. Special fittings for direct connection to the system or minimum lengths of 1/8 inch (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.

31.2.2 Opening of the gauge line valves shall not cause a significant change in the electrical input of the system. High-side gauges and lines may be heated above the saturation temperature corresponding to the expected pressure or may be precharged with a liquid refrigerant of the same type as used in the system to minimize the effect of opening the gauge line valves.

32 Test Voltage

32.1 Unless otherwise specified, products are to be tested at the following 60 hertz (Hz)[a] potentials maintained at the product supply connections:

Nameplate voltage rating	Test voltage[b]
110 to 120	120
208	208
220 to 240	240
254 to 277	277
440 to 480	480
550 to 600	600

[a] Products rated at frequencies other then 60 Hz are to be tested at their rated voltages and frequencies.

[b] These voltages are nominal for the condenser fan motor failure test, and condenser water failure test.

33 Leakage Current Test

33.1 General

32.1.1 All products shall be investigated for leakage current. Each product shall comply, depending upon its intended use, with 33.4.1 (patient care equipment) or 33.6.1 (nonpatient equipment).

33.2 Permanently connected equipment

33.2.1 Leakage current measurements in accordance with 33.7.1.1 – 33.7.3.2 normally are not made between the equipment frame and ground on equipment intended for permanent connection to the supply, provided all accessible metal parts that are likely to become energized (except electrodes, probes, and the like) are reliably connected to the equipment grounding means. However, measurements are to be made between accessible ungrounded parts (such as patient-connected electrodes, probes, and the like) and between such parts and ground in the manner described in 33.7.1.1 – 33.7.3.2.

Exception: The total impedance of capacitors and other electronic components connected from one or more sides of the line to the frame or enclosure of a permanently connected appliance shall be large enough to prevent the flow of more than 0.5 milliampere of leakage current measured through a 1000 ohm resistance in the grounding conductor for frequencies up to and including 1 kilohertz (kHz) and equivalent values at higher frequencies with a restriction of 10 milliamperes. Also see 33.5.1.

33.3 Cord-connected equipment

33.3.1 All accessible parts of a cord-connected product are to be tested for leakage current between the parts and between the parts and ground. The measurements are to be made in the manner described in 33.7.1.1 – 33.7.3.2.

33.4 Patient care equipment

33.4.1 When a patient care product is tested in the manner described in 33.7.1.1 – 33.7.3.2 the available leakage currents shall not exceed the values in Table 33.1.

Table 33.1
Patient care equipment maximum leakage current (microamperes)

Patient connection[a]				Enclosure or chassis[b,c,f]	
Isolated[d]		Ordinary[e]			
AC RMS	DC	AC RMS	DC	AC RMS	DC
10	14	50	70	100	140

[a] Measured between patient leads (applied part) or between patient leads and ground. Value indicated is acceptable for each particular body function or parameter measured or monitored.
[b] Metal enclosure or metal foil over insulating material, per 33.7.1.3.
[c] See 3.5.
[d,e] See 3.15.
[f] Measured with loss of ground per 33.7.1.2 (see 9.3.3 for appropriate plug cap).

33.4.2 The alternating current values in Table 33.1 are based on data obtained with 60 Hz sinusoidal voltages and apply for frequencies up to 1 kHz. For frequencies above 1 kHz the acceptable levels of leakage current are equal to the values indicated in Table 33.1 times the frequency in kHz up to a maximum multiplier of 100. See Figure 33.1.

33.5 Isolated patient connections

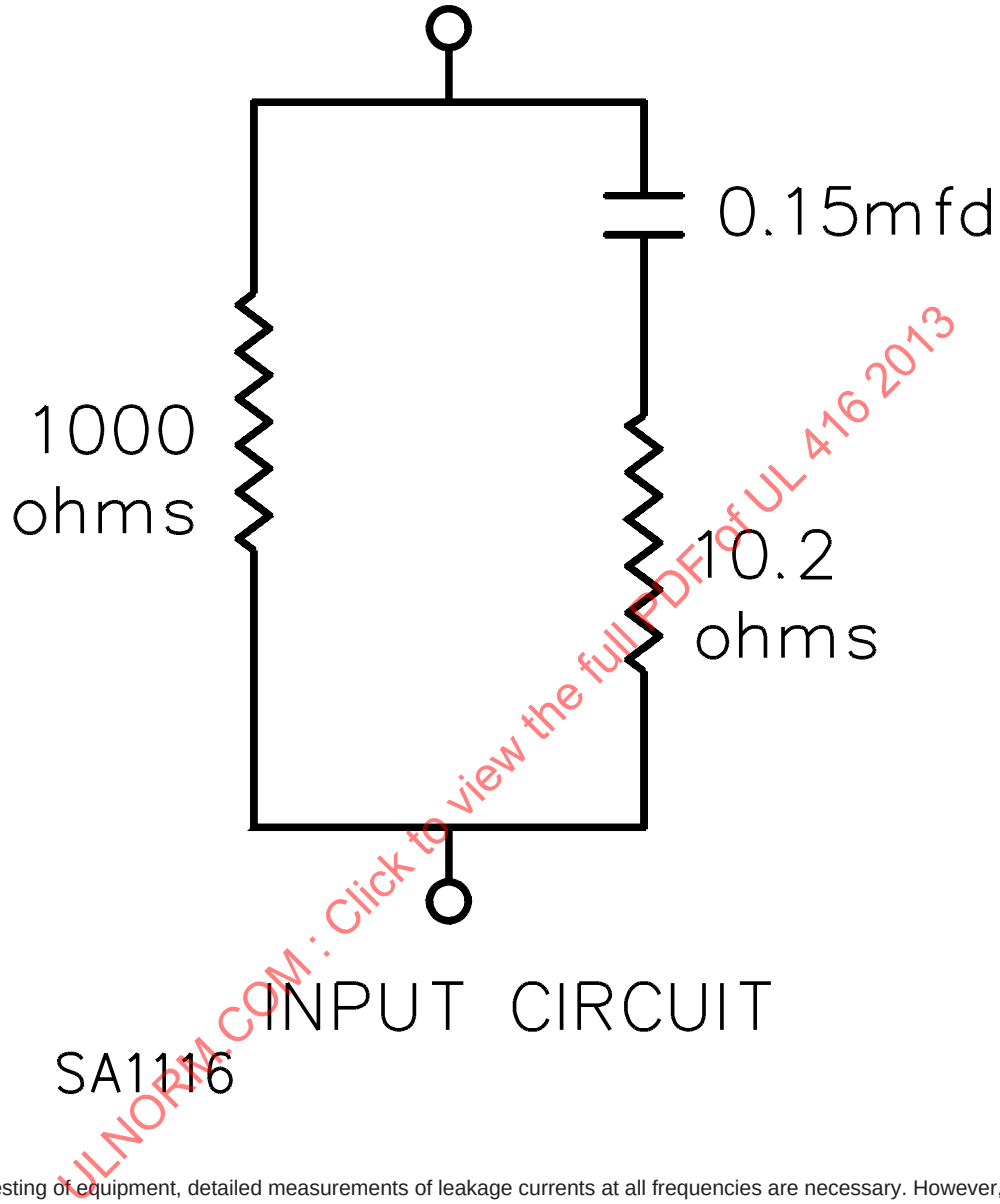
33.5.1 When equipment having an isolated patient connection is subjected to the outlined in 33.6.1, the available current shall not exceed 20 microamperes when measure at the patient end of the connecting cables.

Exception: When equipment having isolated patient connection terminals but no cables is subjected to the test outlined in 33.6.1, the available current shall not exceed 10 microamperes RMS when measured at the terminals.

33.5.2 A 120 volt, 60 Hz potential shall be applied between each isolated patient connection and ground in series with the measurement circuit (100 ohm resistor and meter) described in 33.7.2.1. This test shall be conducted with the appliance on and operating and also with the appliance off but connected to the supply circuit. The test shall be completed with the polarity of the supply connections reversed.

Figure 33.1
Input circuit

Figure 33.1 revised November 24, 1998



In the type testing of equipment, detailed measurements of leakage currents at all frequencies are necessary. However, to evaluated currents at frequencies over 1 kilohertz it is sometimes desirable to use an approximation during routine equipment testing.

The measurement circuit described in 33.7.2.1 would be employed in recording the actual leakage current determinations in 33.7.1.1 – 33.7.3.2. However, for a rapid approximate evaluation, an appropriate meter input circuit may be employed having an impedance-frequency characteristic that approximates the inverse of the allowable leakage current versus frequency relationships described in 33.4.2 and automatically provides the appropriate multiplying factor for frequencies greater than 1 kilohertz.

A sample input circuit is shown which would be applicable to measurements usually made. The 1000 ohm resistor shown is the same test load as noted in 33.7.2.1. A series resistor-capacitor combination is placed in parallel with the 1000 ohm resistor across the meter input terminals.

33.6 Nonpatient equipment

33.6.1 When a nonpatient product is tested in the manner described in 33.7.1.1 – 33.7.1.5, 33.7.3.1 and 33.7.3.2, and if the open circuit voltage between the parts in question exceeds 42.4 volts peak (30 volts RMS if the waveform is sinusoidal) the available leakage currents shall not exceed the values in Table 33.2.

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Table 33.2
Nonpatient equipment maximum leakage current (microamperes)

Enclosure or chassis	
AC RMS	DC
500	700
NOTES –	
1 Metal enclosure or metal foil over insulating material as per 33.7.1.3.	
2 Measured with loss of ground per 33.7.1.2.	

33.7 Test methods

33.7.1 General

33.7.1.1 Prior to making the measurements outlined in 33.7.1.2 – 33.7.3.2, the appliance circuits are to be analyzed and a preliminary review made by oscilloscope to determine the nature of the available currents. The measurements circuits described in 33.7.2.1 and 33.7.3.1 are to be employed for essentially sinusoidal currents. An appropriate direct-current meter is to be employed for the recording of direct-currents. Complex wave shapes, pulses, etc., are to be the subject of further oscilloscope evaluation with respect to the intent of these requirements. For test purposes only, the grounded supply conductor (neutral), is used as the ground reference point. See Figure 33.2.

33.7.1.2 In making the measurements outlined in 33.1.1 and 33.7.1.4, the following single fault conditions likely to increase the leakage current are to be introduced:

a) The loss of ground in a cord-connected appliance.

b) The loss of either functional insulation or of supplementary insulation in a double-insulated appliance.

33.7.1.3 If an insulating material is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area not exceeding 10 by 20 centimeters in contact with accessible surfaces of the insulating material. Where the accessible surface of insulating material is less than 10 by 20 centimeters the metal foil shall be the same size as the surface. The accessible parts shall be tested individually, collectively, and from one part to another. Parts are considered accessible unless guarded by an enclosure as defined in 6.3.1 – 6.3.4.

33.7.1.4 A sample of the product is to be prepared and conditioned for leakage current measurement as follows:

a) The sample is to be representative of the wiring methods, routing, components, component location, installation, etc., of the production equipment.

b) The grounding conductor is to be open at the attachment-plug cap and the test product isolated from ground.

c) The sample is to be conditioned in an ambient temperature of 32 ±2°C (89.6 ±3.6°F) and approximately 88 ±5 percent relative humidity for not less than 48 hours.

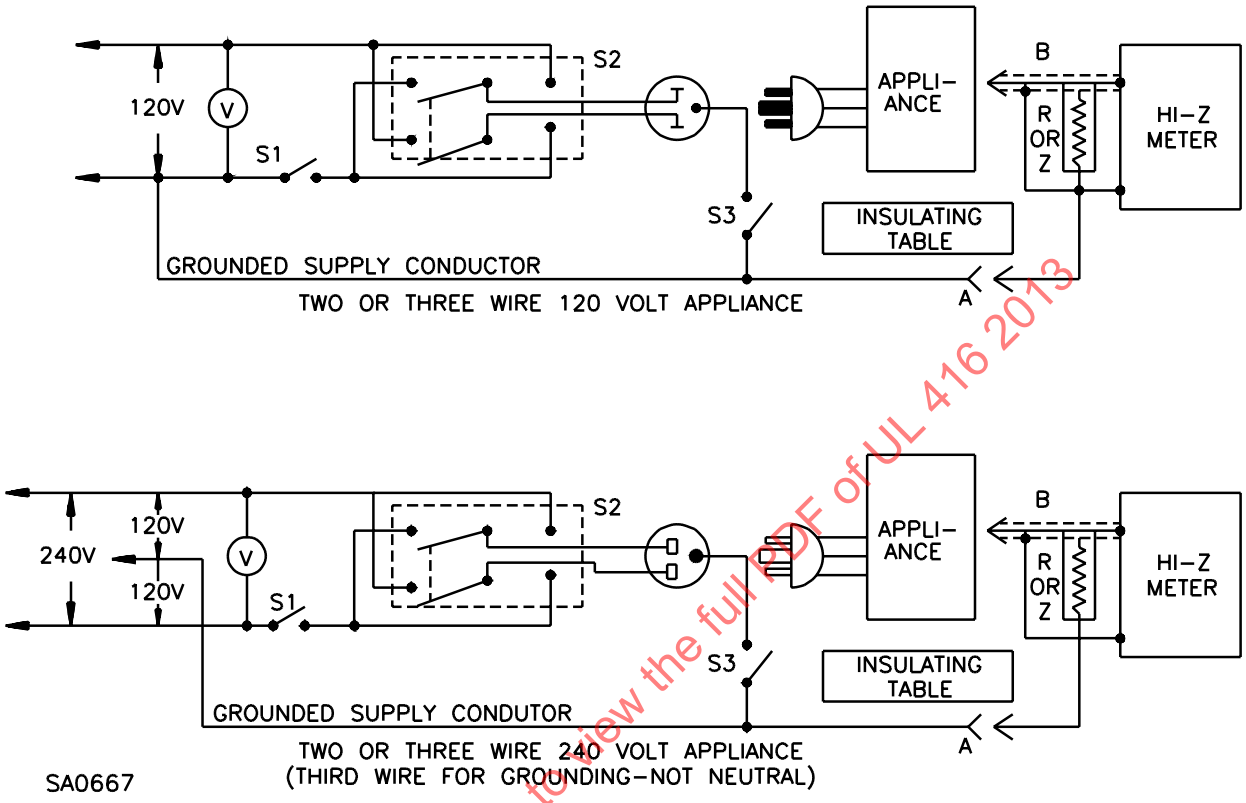
d) The test is to be conducted at the ambient conditions specified by (c).

e) The supply voltage is to be adjusted to that specified in 32.1.

f) A product, such as a hypo- or hyper-thermia machine, is to be filled with a liquid if needed to operate normally.

Figure 33.2
Leakage-current measurement circuit

Figure 33.2 revised November 24, 1998



Notes:

A – Separated and used as clip when measuring voltages (currents) from one part of appliance (including patient leads, probes, etc.) to another.

B – Probe with shielded lead.

33.7.1.5 During any of the tests, if the compressor stalls during positioning of switch S2, the test is to be conducted in its entirety in one polarity. The polarity is then to be reversed and the test repeated.

33.7.1.6 The test sequence with reference to the measurement circuit in Figure 33.2 shall be as follows:

a) Nonpatient equipment is tested in accordance with (1), (2), and (3) below,

b) Patient care equipment is tested in accordance with (2) and (3).

1) With switch S1 open, the appliance shall be connected to the measurement circuit. Leakage current shall be determined using both positions of switch S2, with the appliance switching devices and variable controls in all their normal operating positions, and with switch S3 in both the open and closed positions.

2) With switch S1 closed to energize the appliance, leakage current shall be determined using both positions of switch S2, with the appliance switching devices and variable controls in all their normal operating positions, and with switch S3 in both the open and closed positions.

3) Leakage current shall be monitored at sufficient intervals to determine the maximum leakage current from the time of the previous measurement to the conditions under which the normal temperature test would be terminated. Both positions of switch S2 shall be used in determining this measurement.

33.7.2 Patient care equipment

33.7.2.1 The measurement circuit for leakage current on patient care equipment is to be as follows:

a) Normally the measuring circuit is to have a resistive input impedance (R) of 1000 ohms. If, in the preliminary analysis and review mentioned in 33.7.1.1, product circuit is found to have a low source impedance, it will be evaluated using a 500 ohm resistance.

b) The meter is to be average-responding and indicate RMS value of a pure sine wave within an overall measuring circuit error of not more than 5 percent at indications of 10, 50, 100, and 500 microamperes (10, 50, 100 and 500 millivolts, respectively, when using a 1000 ohm resistor) at frequencies from 10 Hz to 100 kHz.

c) Unless the measuring circuit is being used to measure leakage current from one part of the appliance to another, the resistor and meter are to be connected between the accessible parts and the grounded supply conductor.

d) The supply voltage is to be adjusted to the test voltage as specified in 32.1.

33.7.3 Nonpatient equipment

33.7.3.1 The measurement circuit for leakage current from nonpatient equipment is to be as follows. The measurement instrument is defined in (a) – (c). The meter which is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all of the attributes of the defined instrument.

a) The measuring circuit is to have an input impedance (Z) 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 wave-form 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 0.5 milliampere the measurement is to have an error of not more than 5 percent at any frequency within the range of 0 – 100 kHz.

d) Unless the measuring circuit is being used to measure leakage current from one part of the appliance to another, the impedance and meter are to be connected between the accessible parts and the grounded supply conductor.

e) The supply voltage is to be adjusted to the test voltage as specified in 32.1.

33.7.3.2 Generally, a peak reading voltmeter having an input impedance of 1 megohm or greater is to be employed in measuring the open circuit voltage between the parts in question. However, where the voltage is sinusoidal, the peak voltage can be computed from the RMS or average value.

34 Input Test

34.1 The measured ampere input to a cord connected product shall not exceed the total rating marked on the product nameplate by more than 10 percent when tested as described in the Temperature and Pressure Test and the Heating Test.

34.2 The measured ampere input to a permanently connected product during a normal cycle 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 and the Heating Test.

34.3 With reference to 34.1 and 34.2, the power input of all accessories is to be considered in judging the marking of the product. The measured ampere input is to be increased for accessible 15 and 20 ampere convenience outlets as follows:

a) By 80 percent of the receptacle rating if the product incorporates only one 15 or 20 ampere receptacle.

b) By 100 percent of the receptacle rating if the product incorporates more than one 15 or 20 ampere receptacle.

35 Starting Test

35.1 A product shall start and operate as intended without rupturing a line fuse of the size required by the product.

35.2 A product is to be operated under the conditions described in the Temperature and Pressure Test and the Heating Test with four fuses connected in series.

35.3 For cord connected products, the fuse rating is determined by the rating of the attachment plug. For permanently connected products protected by a fuse sized according to 51.2.1, the fuse rating is to be as marked on the nameplate. For permanently connected products protected by a fuse sized according to 51.1.6, no starting test is required.

35.4 If no fuse opens, the fuse used is proper for starting the product. If one fuse opens, the test is repeated using the three remaining fuses. If none of the three fuses open, the results are acceptable. If one of the three fuses open, the results are not acceptable and the test is repeated using four time-delay fuses of the same rating as the original fuse.

35.5 If it is determined that time-delay fuses are required for starting, the product is to be marked in accordance with 64.14 or 65.2, whichever is applicable.

35.6 If an automatic-reset thermal-protective device interrupts the current flow one or more times during the test, the product shall restart and run after each interruption and shall meet the fuse requirements of 35.4 and 35.6.

35.7 If 15 or 20 ampere, general-purpose receptacles are provided and are intended to be connected to the same circuit as the product, the starting test is to be conducted with an additional noninductive load connected to the unit, sized as follows:

a) 80 percent of the receptacle rating if the product incorporates only one 15 or 20 ampere receptacle, or

b) 100 percent of the receptacle rating if the product incorporates more than one 15 or 20 ampere receptacle.

36 Temperature and Pressure Test

36.1 The temperature rises measured on the electric components and surfaces of a product shall not exceed those specified in Table 36.1.

36.2 The maximum pressure developed in a product tested as described in 36.3 – 36.9 shall be used as a basis for the Strength Tests – Pressure Containing Components requirements.

36.3 The assembly is to ″pulldown″ under the following test conditions. Pulldown will be affected when the assembly runs continuously at approximately constant electrical input and low-side pressure. An automatic-reset protective device may cycle provided pulldown is obtained within 8 hours. A manual-reset protective device shall not trip during the starting or operating period.

36.4 For this test, a representative product is fitted with pressure gauges on the high- and low-sides. Thermocouples are secured to various electrical components, including compressor motor enclosure, fan-motor windings, starting-relay coil, capacitors, wiring insulation, and to surfaces as indicated in (d) of Table 36.1. The temperature of motor windings or coils may be measured by the resistance method, but the primary method of temperature measurement is to be the thermocouple method. The electrical input is measured with a voltmeter and an ammeter. The temperature controller is short-circuited during this test.

36.5 The product is to be installed in accordance with the manufacturer's instructions, see 4.1 and 4.2, and operated under the conditions specified in 36.7 – 36.9, as applicable.

36.6 If the wiring to a general purpose receptacle does not comply with 10.10, 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 shall be as follows:

a) Where a single receptacle is employed, the load shall be equal to 80 percent of the rating of the receptacle,

b) Where more than one receptacle is employed on the same circuit, the load shall be equal to 100 percent of the largest receptacle.

36.7 A built-in type product is to be placed in an enclosure simulating actual conditions of use. The enclosure is to consist of 3/8 inch (9.5 mm) thick plywood with the inside surfaces painted flat black and with all joints sealed. The enclosure is to be brought into close contact with the product except where, for proper operation, one or more of the panels must be spaced, in which case, the enclosure is to be as recommended in the manufacturer's instructions.

Table 36.1
Maximum temperature rises

Device or material	°C	(°F)
A. MOTORS		
1. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including hermetic motor-compressors)[a]		
a) In open motors – Thermocouple or resistance method	75	(135)
b) In totally enclosed motors – Thermocouple or resistance method	80	(144)
2. Class A insulation systems on coil windings of alternating – current motors having a frame diameter of more than 7 inches (178 mm) (not including hermetic motor-compressors)[b]		
a) In open motors –		
Thermocouple method	65	(117)
Resistance method	75	(135)
b) In totally enclosed motors –		
Thermocouple method	70	(126)
Resistance method	80	(144)
3. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including hermetic motor-compressors)		
a) In open motors – Thermocouple or resistance method	95	(171)
b) In totally enclosed motors – Thermocouple or resistance method	100	(180)
4. Class B insulation system on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) (not including hermetic motor-compressors)		
a) In open motors –		
Thermocouple method	85	(153)
Resistance method	95	(171)
b) In totally enclosed motors –		
Thermocouple method	90	(162)
Resistance method	100	(180)
B. COMPONENTS		
1. Capacitors:		
Electrolytic type[c]	40	(72)
Other types[d]	65	(117)
2. Field wiring	35	(63)
3. Hermetic motor-compressor enclosure[e]	150	(302)

Table 36.1 Continued on Next Page

Table 36.1 Continued

Device or material	°C	(°F)
4. Relay, solenoid, and other coils (except motor coil windings) with:[b]		
a) Class 105 insulated winding –		
Thermocouple method	65	(117)
Resistance method	85	(153)
b) Class 130 insulation –		
Thermocouple method	85	(153)
Resistance method	105	(189)
5. Solid contacts	65	(117)
6. Transformer enclosures – with		
a) Class 2 transformers	60	(108)
b) Power transformers	65	(117)
7. Wood or other flammable material	65	(117)
C. INSULATED CONDUCTORS		
1. Flexible cords and wires with rubber, thermoplastic, or neoprene insulation unless recognized as having special heat-resistant properties as follows:		
Temperature Rating –		
Degrees C / Degrees F		
60 / 140	35	(63)
75 / 167	50	(90)
80 / 176	55	(99)
90 / 194	65	(117)
105 / 221	80	(144)
D. SURFACES		
1. Surfaces of products at points of zero clearance to test enclosure	65	(117)
2. Surfaces of products contacted by persons in operating it (control knobs, pushbuttons, levers, etc.)		
Metal	35	(63)
Nonmetallic	60	(108)
3. Surfaces of products subjected to casual contact by persons (enclosure, grille, etc.)		
Metal	45	(81)
Nonmetallic	65	(117)
4. Surfaces of test enclosure where clearance to flammable material is specified	65	(117)

Table 36.1 Continued on Next Page

Table 36.1 Continued

Device or material	°C	(°F)
E. ELECTRICAL INSULATION – GENERAL		
1. Fiber used as electrical insulation or cord bushings	65	(117)
2. Phenolic composition used as electrical insulation or as parts where failure will result in a hazardous condition	125	(225)
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 (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 65°C (117°F).

[d] A capacitor which operates at a temperature higher than a 65°C (117°F) rise may be judged on the basis of its marked temperature rating.

[e] Maximum – not rise.

36.8 The product is placed within a room maintained at 40°C (104°F) and 26.7°C (80°F) wet bulb until the assembly reaches room temperature. Lights and/or other electrical loads which may operate concurrently with the condensing unit are to be energized during the test. The assembly is then started and operated until temperatures and pressures have stabilized. The potential is maintained as indicated in 32.1. The electrical input, the temperature of electrical components and surfaces, and high- and low-side pressures are recorded at intervals during the test.

36.9 For the test of a product 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. If 100°F (37.8°C) outlet water cannot be attained due to design, the product is to be tested at 80°F (26.7°C) inlet water and 35 psig (241 kPa) nominal pressure.

36.10 The product is to comply with the Dielectric Voltage Withstand Test following the Temperature and Pressure Test.

37 Heating Test

37.1 A hot gas, reverse cycle, bypass cycles, or electric heating cycle shall not result in overheating of flammable material, wiring insulation, motor windings, insulation of electric valves, or other electrical components, shall not cause excessive pressures in the refrigeration system, and shall not result in water draining on uninsulated live parts or collecting within enclosures for electrical parts or wiring.

37.2 Overheating of these materials is considered to occur if the temperature rises measured in this test exceed the permissible temperature rises for the insulating material as tabulated in Table 36.1.

37.3 Excessive pressures in the system occur if they exceed one-fifth of the ultimate strength of high- or low-side parts as determined by the Strength Tests.

37.4 Thermocouples are attached to flammable material, electrical components, and electrical insulation which may be affected by operation of the system.

37.5 The product is to be placed in a room ambient of 25°C (77°F) and the controls adjusted to cause maximum heating.

37.6 Temperatures and electrical input are to be measured at intervals during the heating cycle. When required by 37.1, the maximum high- and low-side pressures are to be recorded as reference values for the Strength Tests - Pressure Containing Components.

37.7 Upon completion of the heating cycle, the assembly is to be examined to determine if water contacts uninsulated live parts or collects within the enclosure of electrical parts or wiring.

37.8 The heating system is to comply with the Dielectric Voltage Withstand Test following the Heating Test.

38 Dielectric Voltage Withstand Test

38.1.1 Revised and combined with 38.1.2 and relocated as 38.1 May 15, 1996

38.1.2 Revised and combined with 38.1.1 and relocated as 38.1 May 15, 1996

38.1.3 Deleted May 15, 1996

38.1.4 Deleted May 15, 1996

38.1.5 Revised and relocated as 38.4 May 15, 1996

38.2.1 Deleted May 15, 1996

38.2.2 Revised and relocated as 38.3 May 15, 1996

38.2.3 Deleted May 15, 1996

38.2.4 Deleted May 15, 1996

38.2.5 Deleted May 15, 1996

38.3.1 Deleted May 15, 1996

38.4.1 Deleted May 15, 1996

38.4.2 Deleted May 15, 1996

38.4.3 Deleted May 15, 1996

38.1 A product shall withstand, without breakdown, a test potential applied for 1 minute between high-voltage live parts and dead metal parts and between live parts of high-voltage and low voltage circuits. The test potential shall be 1000 V plus twice rated voltage at any frequency between 40 and 70 hertz.

Exception No. 1: The test potential for units rated at not more than 1/2 horsepower (373 watts 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.

38.1.1 and 38.1.2 revised, combined and relocated May 15, 1996

38.2 Equipment employing a low-voltage circuit shall withstand, without breakdown, a test potential of 500 volts applied for 1 minute between low-voltage live parts and dead metal parts. The test potential shall be at any frequency between 40 and 70 hertz. If components specified in paragraph 25.4.3 are employed in the low-voltage circuit, the dielectric voltage withstand test shall also be conducted between live parts of opposite polarity.

38.2 added May 15, 1996

38.3 With reference to the previous paragraph, the test between low-voltage parts of opposite polarity is to be conducted on magnet coil windings of the transformer after breaking the inner coil lead where it enters the layer. This opposite polarity test may be waived on the complete assembly provided that the components have been separately subjected to this test.

38.2.2 revised and relocated as 38.3 May 15, 1996

38.4 A 500 volt-ampere or larger transformer, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with the previous paragraphs. 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 volt-ampere 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.

38.1.5 revised and relocated as 38.4 May 15, 1996

38.5 If the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is large enough to make it impossible to maintain the required alternating-current test potential, the capacitors and capacitor-type filters may be tested as described in 38.6.

38.5 added May 15, 1996

38.6 The capacitors and capacitor-type filters mentioned in 38.5 are to be subjected to a direct-current test potential of 1414 volts for equipment rated 250 volts or less or 1414 volts plus 2.828 times the rated circuit voltage for equipment rated at more than 250 volts. The direct-current test potential is to be maintained for 1 minute without breakdown.

38.6 added May 15, 1996

38.7 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.

38.7 added May 15, 1996

38.8 If the circuit is a patient connected circuit, then in addition to any applicable tests in 38.1 - 38.7, a 60 Hz, essentially sinusoidal potential of 2500 volts is to be applied between primary circuits and the patient connected circuits. See 3.14.

38.8 added May 15, 1996

39 Condenser Fan Motor Failure Test

39.1 A product shall not be exposed to hazardous pressure or temperature or leak refrigerant if the condenser fan motor locks or fails to start.

39.2 The requirement in 39.1 will be complied with if:

a) The refrigeration system does not rupture or develop leaks during the test. The maximum high- and low-side pressures are to be recorded as reference values for the Strength Test requirement. An assembly employing a pressure-limiting device conforming with 29.1 or 29.2, as applicable, 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) does not exceed 150°C. Compressors and condenser fan motors equipped with thermal protective devices as specified in 18.7 and 18.8 are considered to comply with this requirement.

39.3 A sample of the assembly is to be fitted with a pressure gauge on the high-pressure side of the refrigeration system and provided with thermocouples on the compressor enclosure and condenser fan motor winding (open type) or condenser fan motor enclosure (enclosed type). When evaluating low-side components for compliance with the strength requirement of 57.10, a pressure-gauge is to be fitted on the low-side of the system. The low-side pressure is to be recorded while the compressor is operating and after shutdown. The controls are to be set for maximum cooling and the product is operated with the condenser fan motor locked until stabilized temperatures and pressures are reached. The compressor motor overload device and/or the fan motor overload device may operate during this test. The test ambient temperature is approximately 25°C (77°F). The potential is maintained as indicated in 32.1. If two or more condenser fan motors are employed, the test is to be conducted with one motor locked.

40 Condenser Water Failure Test

40.1 A water-cooled product shall not be exposed to hazardous pressure or leak refrigerant during water failure.

40.2 The requirement of 40.1 will be complied with if:

a) The refrigeration system does not rupture or develop leaks during the test. The maximum high- and low-side pressures are to be recorded as reference values for the Strength Tests - Pressure Containing Components requirements.

b) The maximum temperature of the compressor enclosure does not exceed 150°C. If the compressor is equipped with a thermal protective device(s) as specified in 18.7, this temperature test may be waived.

40.3 A sample of the assembly is to be fitted with a pressure gauge on the high-pressure side of the refrigeration system and provided with thermocouples on the compressor enclosure. When evaluating low-side components for compliance with the strength requirement of 57.10, a pressure gauge is to be fitted on the low side of the system. The low-side pressure is to be recorded as specified in 39.3. The product is to be operated with the condensing water shut off and also with the condensing water restricted until maximum stabilized temperatures are reached or until representative maximum temperatures are attained under cycling

load. If the product cycles on a motor-overload protective device, the test is to continue until the maximum pressure during the protective device operation is obtained. The room ambient is to be approximately 25°C. The potential is maintained as indicated in 32.1.

40.4 The test is not to result in damage to electrical parts.

40.5 The test need not be conducted to determine compliance with 40.1 if a pressure-limiting device is provided. 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 40.1. See 57.1, 57.4, and 57.8.

Revised 40.5 effective August 25, 1995

41 Overflow Test

41.1 With reference the 6.3.9, a product in which liquids may accumulate or overflow shall not allow the liquid to wet live parts or the windings of motors or coils.

41.2 The product is to be positioned as intended in operation and the liquid reservoir, receptacle, or condensate drain pan is to be filled until overflowing occurs.

41.3 Compliance with 41.1 can be determined by means such as visual examination, dielectric voltage withstand, or insulation resistance, except that motor windings are to have an insulation resistance of not less than 50,000 ohms and are to comply with the Dielectric Voltage Withstand Test.

42 Cleaning and Sterilization Test

42.1 The leakage current resulting from cleaning or sterilizing a product shall not exceed the values specified in Table 33.1 for patient care equipment and Table 33.2 for nonpatient equipment.

42.2 Each product or portion of a product which is intended to be cleaned by wiping or sterilizing shall be conditioned as outlined in 42.3 and 42.4 after which the leakage current test described in 33.7.1.3 – 33.7.3.1 shall be repeated. The conditioning specified in 33.7.1.6(b)(3) is not to be applied.

42.3 For products intended to be wiped clean, the outer surface of one sample is to be wiped thoroughly with a folded cheesecloth applicator saturated in the cleaning agent specified by the manufacturer. The complete wiping procedure is to be repeated until a total of five operations has been completed.

42.4 For products intended to be sterilized by autoclaving or other methods, one sample is to be subjected to the sterilizing procedure outlined in the manufacturer's instructions until a total of five sterilization cycles has been completed. Between each successive cycle, the product is to be removed from the sterilizing equipment and allowed to adjust to room temperature before the cycle is repeated.

42.5 Each product or portion of a product which is intended to be cleaned by washing shall comply with 42.6 – 42.10.

42.6 The product is to be isolated from ground with the normal grounding means disconnected. The product is to be connected so that the switch or control to be tested is in the ungrounded side of the supply. The complete sample is to be at room temperature considered to be approximately 25°C (77°F).

42.7 The product is to be energized with a source of electrical supply consistent with its rating and with the refrigeration system not operating. The meter used for the measurement of the leakage current is described in 33.7.2.1 for patient care equipment and 33.7.3.1 for nonpatient equipment. The meter is to be connected between a metal backing on a cellulose sponge and the grounded conductor of the power supply.

42.8 The sponge is to be approximately 1-5/8- by 3- by 5-inches (41- by 76- by 127-mm), is to retain from 75 to 100 grams of solution, and is to have a metal backing on one of the 3- by 5-inch (76- by 172-mm) faces.

42.9 The sponge is to be saturated in a solution consisting of 2 tablespoons (30 milliliters) of sodium bicarbonate and 4.5 grams of chip soap conforming to the specifications for chip soap, ASTM D496-74(1990), in 1 quart (0.95 liters) of water at approximately 25°C (77°F). The saturated sponge is to be wiped six times with a pressure of 2 to 3 pounds (8.9 to 13.4 N) applied to the metal-backed side, over the exposed mounting surfaces, including any operating devices of the electrical components. The sponge may be resaturated in the test cleaning solution after the third wipe. The test is to be conducted with attached knobs or handles in place and also removed if they can be removed without the use of tools.

42.10 The test is to be conducted with switch contacts opened and closed. In the case of a control with intermediate positions, the test is to be conducted at a minimum, maximum, and intermediate setting of the control.

43 Stability Test

43.1 A product shall be stable when tested in accordance with 32.1 – 43.3. A product having a supporting base such that both the width and depth dimensions are greater than the height is considered to comply with the requirement.

43.2 A freestanding product is to be supported by the legs, leveling screws, or casters provided in its base. Other means of support, such as wall brackets, plumbing connections, or conduit connections, shall not be relied on for the purpose of the test.

a) The product shall not overturn under the following conditions:

1) An empty product 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 which are intended for use with the refrigerator are to be installed. Swivel-type casters, if any, are to be oriented so that the tendency to overturn is maximum, or

2) An empty product with accessories installed, weighing 50 pounds (22.7 kg) or more, is to be placed on a horizontal surface. If leveling screws are provided, they are to be adjusted equally to raise the machine 1 inch (25.4 mm) above floor level. If 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 product, but not exceeding 50 pounds (223 N), is to be applied horizontally at the vertical center line of any side of the product at the highest point, not to exceed 5 feet (42.5 m) above floor level, with all doors closed.

b) The product shall not overturn under the following conditions – an empty product with accessories installed, weighing 50 pounds (22.7 kg) or more, is to be placed on a horizontal surface. If leveling screws are provided, they are to be adjusted equally to raise the machine 1 inch (25.4 mm) above floor level. If swivel type casters are provided, they are to be oriented so that the tendency to overturn is maximum.

1) For a drawer of horizontally-hinged door which swings downward and which provides access to a storage compartment, a force equal to one-fourth the weight of the product, but not exceeding 50 pounds (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 product, but not exceeding 35 pounds (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.

43.3 Unique mounting or support systems for products which would require securing to a wall or other support surface would need to be separately evaluated to determine their reliability, ease of operation, and likelihood of continued use.

44 Mechanical Abuse

44.1 To determine compliance with 5.3, the handle and its means of securing to the product is to be subjected to a force of four times the weight of the product. The load is to be uniformly applied over a 3 inch (76.2 mm) width at the center of the handle, without clamping, started at zero and gradually increased so that the test value will be attained in 5 to 10 seconds and maintained for a period of 1 minute. If more than one handle is furnished on a product, the force is to be distributed between the handles. The distribution of forces is to be determined by measuring the percentage of the product weight sustained by each handle with the product in the normal carrying position. If a product is furnished with more than one handle but is designed such that it may readily be carried by only one handle, each handle is to be capable of sustaining the total force.

44.2 To determine compliance with 5.4 after the product is installed, the product is to be mounted in accordance with the manufacturer's installation instructions using fasteners and constructions as described. If no wall constructions are specified, 3/8-inch (9.5-mm) thick plasterboard, drywall, on nominal 2- by 4-inch, [1-1/2- by 3-1/2-inch (38.1- by 88.9-mm)], studs at 16-inch (406-mm) centers is to be used as the support surface. Fasteners are to be applied as specified in the instructions and, if not noted, are to be positioned in the plasterboard between studs. An adjustable product is to be adjusted to the position that will give the maximum projection from the wall. A gradually increasing force is to be applied to act vertically through the center of gravity of the product in the extended position. The force is to be increased in a 5- to 10-second interval until a load of four times the weight of the product is applied to the mounting system (weight of product plus force of three times the weight of the product) and is to be sustained for a period of 1 minute.

45 Grounding Impedance Test

45.1 The impedance at 60 Hz between the point of connection of the equipment grounding means and any other metal part that is required to be grounded shall be not more than 0.1 ohm. Compliance is determined by measuring the voltage when a current of 25 amperes derived from a 60 Hz source with a no-load voltage not exceeding 6 volts is passed between the grounding connection and the metal part in question.

46 Endurance Test – Heater Control

46.1 A control for an electric heater shall be capable of withstanding an endurance test under the load which it controls for the number of cycles indicated in 46.2. There shall be no electrical or mechanical failure of the control nor undue burning, pitting, or welding of the contacts.

46.2 The number of cycles for the test is to be as follows:

a) An automatic-reset control which operates in each heating cycle is to withstand 6000 cycles of operation under load, but is to withstand 100,000 cycles of operation under load if its short-circuiting results in an electric shock or risk of fire. See 47.1.4.

b) An automatic-reset limit device which opens only in response to abnormal temperature is to withstand 6000 cycles of operation under load if its short-circuiting results in an electric shock or risk of fire. The test may be omitted if its short-circuiting does not result in an electric shock or risk of fire.

c) A manual-reset limit device which opens only in response to abnormal temperature is to withstand 1000 cycles of operation under load plus an additional 5000 cycles without load. The test may be omitted if its short-circuiting does not result in an electric shock or risk of fire.

46.3 The test is to be conducted with the device connected either to the heater element load or to an equivalent noninductive load. The frame of the device is to be connected through a 15 ampere fuse to ground or to the grounded conductor of the supply circuit.

46.4 If the device ″fails safe″ in the open position before the end of the test, it is not to be considered a failure provided the ″fail safe″ feature is inherent in the design.

47 Burnout Tests

47.1 Electric heaters

47.1.1 Operation of an electric heater shall not result in an electrical shock or risk of fire in the product.

47.1.2 A risk of fire is considered to exist if there is any emission of flame or molten metal from the product, or flaming or glowing of flammable material. Blowing the supply circuit fuse is not considered a failure if a risk of fire does not exist.

47.1.3 An electrical shock is considered to exist if the insulation resistance of the product is less than 50,000 ohms.

47.1.4 The test ambient temperature is to be approximately 25°C (77°F). The heater is connected to a supply circuit maintained as indicated in 32.1 and energized until the ultimate results are determined. Each ungrounded conductor in the supply circuit is to be provided with a fuse of the maximum rating which may be used. For cord connected products, the supply circuit fuses are to correspond in the size to the rating of the attachment-plug cap, except that 20 amperes is the minimum size for products rated 150 volts or less.

47.1.5 If an automatic-reset type of protective device is employed and which has not met the Endurance Test - Heater Control requirement of 100,000 cycles, see 46.2, it is to be shorted out of the circuit. If the automatic-reset type of protective device has met the Endurance Test - Heater Control requirement of 100,000 cycles, the test is to terminate when the temperatures of components and materials such as conductor insulation, electrical insulation, thermal insulation, and flammable materials near the heater element have stabilized. If a manual-reset type of thermal protective device is employed, the test is to terminate when the device opens the heater circuit.

47.1.6 If a replaceable thermal cutoff is employed, the test is to be conducted five times using different samples of the thermal cutoff in each test. The thermal cutoff is to open the circuit in the intended manner 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 through a 3 ampere fuse to ground, and any thermally-operated control devices in the heater circuit other than the thermal cutoff are to be short-circuited.

47.2 Other components

47.2.1 To determine if a risk of electric shock or fire exists, a burnout test is to be conducted on components such as an intermittent-duty relay, solenoid, electrically-operated valve, or others, which the design of the product indicates may present a risk of electric shock or fire. The tests should be made with the component installed as intended in the product. The product is to be connected to a supply circuit maintained as indicated in 32.1. Each ungrounded conductor in the supply circuit is to be provided with a fuse of the maximum rating which may be used. For cord connected products, the supply circuit fuses are to correspond in size to the rating of the attachment plug, except that 20 amperes is the minimum size for products rated 150 volts or less.

47.2.2 A risk of fire is considered to exist if there is any emission of flame or molten metal from the refrigerator, or glowing or flaming of flammable material. Opening of the supply-circuit fuse is acceptable if a risk of fire does not exist.

47.2.3 A risk of electrical shock is considered to exist if the insulation resistance of the product is less than 50,000 ohms.

47.2.4 If a single component malfunction may result in an intermittent-duty relay or solenoid being continuously energized, a risk of electric shock or fire shall not result from such malfunction. The test is to be conducted with the relay or solenoid continuously energized until the ultimate result is determined.

47.2.5 If a relay, solenoid, or electrically operated valve becomes blocked in the de-energized position, a risk of electric shock or fire shall not result. The component is to be blocked in the position assumed when it is de-energized and then energized continuously until the ultimate result is determined.

48 Overvoltage and Undervoltage Tests

48.1 An electromagnet, as employed on a relay or solenoid, shall be able to withstand 10 percent above normal voltage without damage and shall operate at that voltage and also at 15 percent below normal voltage. The test voltages are to be as indicated in Table 48.1.

48.2 A relay or solenoid that has been separately investigated for the voltage and operating conditions involved, including ambient temperature conditions, is not required to be tested in the product to determine if it complies with the requirement in 48.1.

Table 48.1
Test voltages

Rated voltage	Overvoltage	Undervoltage
110 – 120	132	102
208	229	177
220 – 240	264	204
254 – 277	305	235
440 – 480	528	408
550 – 600	660	510

48.3 If a relay or other control is used in combination with the compressor controller to prevent automatic recycling of the compressor due to the operation of a protective device, the components involved shall comply with 46.1 under any condition which might result from operation of the protective device and de-energizing the circuit.

48.4 Relays and solenoids are to be connected to a supply source maintained at the overvoltage condition until the coils of the relays and solenoids reach constant temperature. The potential is then reduced to the test voltage specified in 32.1, and each relay and solenoid is to operate at this voltage. The potential is maintained at this test voltage until the coils reach constant temperatures. The potential is then reduced to the undervoltage condition, and each relay and solenoid is to operate at this voltage. If relays and solenoids are energized through a transformer, the voltage adjustments described are to be made at the transformer primary. A relay or solenoid which will not be subject to continuous operation is to be energized at the overvoltage condition and at the normal test voltage for the maximum time permitted by its duty cycle or until constant temperature is reached, whichever occurs first.

49 Current Overload Test – Bonding Conductors and Connections

49.1 When required by 12.9 or 12.13, bonding conductors and connections shall carry, without opening, twice the current equal to the rating of the branch circuit overcurrent-protection device for the interval indicated in Table 49.1.

Table 49.1
Current overload test

Rating of overcurrent protection device amperes	Minimum duration of current flow minutes
30 or less	2
31 – 60	4
61 – 100	6
101 – 200	8

50 Insulation Resistance Test

50.1 Heaters

50.1.1 An electric heater of the metallic sheath or encased type which is exposed to moisture, as used in a product, shall maintain an insulation resistance of not less than 50,000 ohms when cycled in the presence of water and shall comply with the requirements specified in the Dielectric Voltage Withstand Test, Section 38.

50.1.2 If an encased heater or heater terminal seal is in contact with water as it is used in the product, a test is to be conducted by cycling the heater for 30 days, submerged in water.

50.1.3 In the test the water is to be maintained at a temperature not less than that measured on the heater terminal seal or case material during heater operation, nor more than 90°C (194°F). The heater is to be cycled four times per hour with an ON time of approximately 1-1/2 minutes and an OFF time of approximately 13-1/2 minutes.

50.1.4 If the electric heater is not wetted but is exposed to moisture in the product, a test is to be conducted by cycling the heater assembly or terminal seal in an atmosphere of not less than 98 percent relative humidity.

50.1.5 For the test indicated in 50.1.4, the heater is cycled in a humidity controlled test chamber. The cycle is to be initiated by a time switch and terminated by a control set to disconnect the heater when a temperature rise on the sheath or case is equivalent to the rise measured during the heater operation. The rate of cycling is to be maintained from 3 to 10 cycles per hour for 1000 cycles.

50.2 Thermal and/or acoustical insulating material

50.2.1 A product employing insulating material that can be impaired by moisture under conditions of use 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).

51 Limited Short-Circuit Test

51.1 General

51.1.1 The following components shall withstand short circuiting when protected by a branch-circuit overcurrent device of the size required by the product:

a) Motor overload protective devices which are connected in the motor circuit.

b) Motor circuit conductors and connections as required by 10.3.2.

c) Bonding conductors and connections and required by 12.8 and 12.12.

51.1.2 For a cord-connected unit, the protection specified in 51.1.1 is to be provided by a fuse having a rating not less than the rating of the unit's attachment plug. The minimum fuse size for cord-connected appliances is 20 amperes for units rated 125 volts or less and 15 amperes for units rated 126 - 250 volts.

51.1.3 For a permanently-connected unit, the protection specified in 51.1.1 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 product nameplate.

51.1.4 A permanently-connected appliance having more than one motor wired for connection to one supply line shall withstand short-circuiting when protected by a branch-circuit overcurrent device rated at 225 percent of the full-load current of the largest hermetic motor of the group plus an amount equal to the sum of any additional loads supplied. If a hermetic motor is not supplied, the branch-circuit overcurrent protective device is to be rated 400 percent of the full-load current of the largest motor of the group plus an amount equal to the sum of any additional loads supplied.

Exception No. 1: The test may be conducted with a branch-circuit overcurrent device having a lower rating than calculated above, but not less than 15 amperes, provided the appliance will start and operate without opening a fuse having this lower rating. See Starting Test, Section 35.

Exception No. 2: If the unit incorporates a branch-circuit overcurrent device as described in 51.1.3(a), the test is to be conducted with that device.

51.1.5 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 and ″HACR Type″ circuit breakers of the same rating are considered to be interchangeable. Fuses and circuit breakers are not considered to be interchangeable. Circuit breakers of other than ″HACR Type″ are not considered interchangeable with each other nor are they interchangeable with ″HACR Type″ circuit breakers.

51.1.6 The component is to be connected in a test circuit having a capacity based on the full-load current and voltage rating of the appliance. See Table 51.1. When the full-load current is between two values in the table, the larger value is to be used in determining the circuit capacity. If the appliance nameplate shows individual loads, the full-load current is the total of all individual loads which 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 – 42.0 unless a lower factor is agreeable to those concerned.

Table 51.1
Short-circuit test currents

Product full-load amperes				
Single phase				Circuit capacity amperes
115 V	208 V	230 – 240 V	277 V	
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
Three phase				Circuit capacity amperes
208 V	220 – 240 V	440 – 480 V	550 – 600 V	
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	42.8 or less	42.4 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 42.8	Over 42.4	5000

51.1.7 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.

51.2 Motor overload protective devices

51.2.1 There shall be no ignition of cheesecloth surrounding the enclosure of a motor protective device when samples are subjected to the test.

51.2.2 If 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 with the cabinet, the short-circuit test may be waived.

51.3 Bonding conductors and connections

51.3.1 Bonding conductors and connections shall not open when samples are subjected to the conditions of this test.

51.4 Motor circuit conductors and connections

51.4.1 Motor circuit conductors and connections shall not be damaged when samples are subjected to the conditions of this test.

52 Protective Devices – Maximum Continuous Current Test

52.1 To determine if a thermal protector complies with the requirement in 18.3(b)(2) or if a protective system complies with the requirement in 18.3(d)(2), the product is to be tested in accordance with 52.2, unless the motor-compressor has been separately tested as described in 52.4.

52.2 Except as indicated in 52.3, the product is to be connected to a circuit of rated voltage and operated under the conditions described in Table 52.1 for at least 1 hour or until stable conditions have been reached, whichever is longer. The voltage is then 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 motor-compressor are to be noted after stable operation is obtained subsequent to each voltage reduction. If the product will operate at 90 percent of rated voltage without tripping the motor protective device, the first step in voltage reduction can 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 motor-compressor 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 a basis for judging compliance with the requirements in 18.1 and 18.3(b)(2), or (d)(2).

Table 52.1
Test conditions for calibration of thermal protectors and protective systems in products

Location	Temperature °F	Temperature (°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, it is to be tested at 80°F inlet condenser water temperature and 35 pounds per square inch gauge (241 kPa) nominal pressure.

52.3 With reference to 52.2, initial operation may be at such voltage that the current input is 156 percent of the rated current. The voltage is then reduced by 2 percent of rated voltage (to the nearest integral volt) to establish that the protective device opens. The voltage may be reduced to the motor-compressor only, with the other components in the product maintained at rated voltage or higher if the results of the test under these conditions indicate compliance with 18.3(b)(2) or (d)(2). The rated voltage referred to is the highest of the rated voltages for dual-voltage-rated units. Stable operation is considered to be obtained when two consecutive readings, 15 minutes apart, of the temperature on top of the motor-compressor shell do not change more than 1°F (0.6°C).

52.4 The motor-compressor, with its protective system as employed in the product may be separately tested as described in 52.2 and 52.3 under the conditions described in Table 52.2. This separate test may be used as a basis for judging compliance with the requirements in 18.1 and 18.3(b)(2) or (d)(2).

Table 52.2
Test conditions for calibration of thermal protectors and protective systems separately from the product

Table 52.2 revised June 24, 1997

Location	Temperature °F	Temperature (°C)
Return gas		
Saturated vapor temperature	53.5	(142.9)
Superheat	26.5	(14.7)
Discharge gas		
Saturated vapor temperature	154	(67.8)
Ambient air		
Temperature	115	(46.1)
Velocity	400 fpm[a]	(2.0 m/s)

[a] The velocity specified is 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)(2) or (d)(2).

53 Accelerated Aging Test – Electric Heaters

53.1 The requirement in 53.2 applies to the case of heater assemblies and terminal seals of metallic sheath heaters.

53.2 Neoprene or thermoplastic compounds used as a heater casing or for the seal of terminals shall withstand accelerated aging as indicated in Table 53.1 for the maximum temperature rise measured on the device during a Temperature and Pressure Test, Section 36, Heating Test, Section 37, or both conducted in an ambient from 25 to 40°C (77 to 104°F) without deteriorating to a degree which will affect its use.

Table 53.1
Accelerated aging test criteria

Table 53.1 revised May 15, 1996

Measured temperature rise		Material	Test program
°C	(°F)		
35	(63)	Neoprene	Air oven aging for 70 hours at 100 ±2°C (212 ±3.6°F)
35	(63)	Thermoplastic	7 days in an air circulating oven at 100°C (212°F)
50	(90)	Neoprene	Air oven aging for 168 hours at 100 ±2°C (212 ±3.6°F)
50	(90)	Thermoplastic	10 days in an air circulating oven at 100°C (212°F)
55	(99)	Neoprene or thermoplastic	7 days in an air circulating oven at 113°C (235.4°F)
65	(117)	Neoprene	10 days in an air circulating oven at 121°C (249.8°F)
65	(117)	Thermoplastic	7 days at 121°C (249.8°F) or 60 days at 97°C (206.6°F) in an air-circulating oven
80	(144)	Neoprene or thermoplastic	7 days in an air circulating oven at 136°C (276.8°F)
100	(180)	Neoprene or thermoplastic	60 days in an air circulating oven at 136°C (276.8°F)
125	(225)	Neoprene or thermoplastic	60 days in an air circulating oven at 158°C (316.4°F)
175	(315)	Neoprene or thermoplastic	60 days in an air circulating oven at 210°C (410°F)

54 Reliability Test – Heater Termination

54.1 Electric heaters employing integrally molded leads or molded terminal assemblies shall withstand a test load of 20 pounds-mass (9.1 kg) applied for a 1 minute. The load is to be applied in the same direction at which the lead exits the heater case or molded connection and shall not result in displacement of insulation or separation of the connection between the lead and the heater.

55 Abnormal Operation Test

55.1 General

55.1.1 If the conditions of normal operation are not representative of abnormal conditions that can occur in actual service, a product shall not result in a risk of electrical shock or fire when operated under abnormal conditions and a transformer shall not experience temperature rises greater than indicated in Table 55.1.

Table 55.1
Acceptable temperature rises

Type of protection	Degrees C maximum		Degrees C average	
	Class 105 or A insulation	Class 130 or B insulation	Class 105 or A insulation	Class 130 or B insulation
Impedance	135	160	–	–
Thermal cut-out				
Automatic reset				
1. During first hour of operation	175	200	–	–
2. After first hour of operation	150	175	125	150
Manual reset				
1. During first hour of operation, or during the first 10 cycles of operation mentioned in 55.2.8, whichever is the shorter interval.	175	200	–	–
2. After first hour of operation, if the first 10 cycles of operation mentioned in 55.2.8 require more than 1 hour for completion	150	175	–	–
Fusible and nonresettable devices				
1. Before opening during first hour of operation	175	200	–	–
2. Opening after first hour of operation	150	175	–	–

55.1.2 To determine if an electrical shock or risk of fire actually exists, separate tests are to be conducted with the product or specific portion thereof operating until the ultimate results have been observed. Unless otherwise indicated, each test is to be conducted in accordance with the Temperature and Pressure Test and the Heating Test. The product is to be connected in series with a nontime-delay fuse of the maximum current rating that can be accommodated by the fuseholder of the branch circuit to which the product can be connected. For each test of cord connected products, the grounding means shall be interrupted, and a separate connection which includes a 1 ampere fuse shall be made between the enclosure and ground. For permanently connected products, the normal grounding means shall be employed. In most cases, continuous operation for 7 hours will be necessary to assure that the ultimate result has been observed. A cord connected product is to be placed on white tissue paper on a softwood surface.

55.1.3 Extractor type fuses that are accessible for operator (user) servicing shall be effectively defeated during each test. However, fuses which are soldered in place or are located to be accessible only to qualified service personnel and marked in accordance with 66.3.1 may be left in the circuit under test. Similarly, other overcurrent (overload) protective devices not subject to user-replacement may be left in the circuit.