UL 1042

STANDARD FOR SAFETY

Electric Baseboard Heating Equipment

UL Standard for Safety for Electric Baseboard Heating Equipment, UL 1042

Fifth Edition, Dated August 31, 2009

Summary of Topics

These revisions of ANSI/UL 1042 dated February 2, 2021 includes replacing the reference to the Standard for Power Conversion Equipment, UL 508C, with reference to the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1; 3.3.4.1 and 17.4

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

The revised requirements are substantially in accordance with Proposal (s) on this subject dated November 6, 2020.

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UL 1042

Standard for Electric Baseboard Heating Equipment

Prior to the first edition, the requirements for the products covered by this standard were included in the Standard for Electric Space Heating Equipment, UL 573.

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The most recent designation of ANSI/UL 1042 as an American National Standard (ANSI) occurred on February 2, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 1042 on August 30, 1986. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover portable and fixed electric baseboard heating equipment rated at 600 volts or less, to be employed in ordinary locations in accordance with the National Electrical Code, ANSI/NFPA 70.

1.2 Baseboard heating equipment includes baseboard heaters and baseboard heater accessories.

1.3 Electric baseboard heating equipment intended for use in a hazardous location is judged on the basis of compliance with the requirements in this standard, together with those recognized requirements applicable to usage in hazardous locations.

1.4 Any air heating appliance sold or recommended for use as a baseboard heater, irrespective of its dimensions or other characteristics, is to be identified as a baseboard heater. It will be categorized as a fixed or portable baseboard heater in accordance with the following:

a) Fixed – A heater is identified as a fixed baseboard heater if:

1) The heater is less than 6 in (150 mm) in overall depth, the ratio of the overall length to the overall height is more than two to one, and the heater can be installed completely within a space of 18 in (460 mm) above the floor; or

2) The heater enclosure is intended to be connected to other heater enclosures to form a system.

Exception: A heater intended for ceiling mounting or suspended mounting or marked "Do Not Install Less Than 6 Feet From Floor" is not considered to be a baseboard heater even if it meets the specifications in (1) or (2) above.

b) Portable – A portable heater is identified as a baseboard heater if, excluding projections of guard or feet, it is less than 5 in (130 mm) in depth and if the ratio of its overall length to its height without the handle is as follows:

Maximum height of heater, feet (mm)	Ratio of length to height
2 (610)	More than 2 to 1
Over 2 (610)	More than 3 to 1

Exception: A portable radiant heater which has a visible glowing heating element and which is not sold or recommended for use as a baseboard heater may be excluded as a baseboard heater even if it meets the dimensional specifications in (b) above. Such a heater may be judged under the requirements for movable air heaters in the Standard for Movable and Wall- or Ceiling-Hung Electric Room Heaters, UL 1278. For this determination, a radiant heater is one in which the visible portion of the heating element attains a temperature of at least 650° C (1200° F) under normal conditions of operation.

2 Units of Measurement

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

2A Glossary

2A.1 For the purposes of this standard the following definitions apply.

2A.2 APPLIANCE COUPLER – A single-outlet, female contact device for attachment to a flexible cord as part of a detachable power-supply cord to be connected to an appliance inlet (motor attachment plug).

2A.3 APPLIANCE INLET (Motor Attachment Plug) – A male contact device mounted on an end product appliance to provide an integral blade configuration for the connection of an appliance coupler or cord connector.

2A.4 APPLIANCE (FLATIRON) PLUG – An appliance coupler type of device having a cord guard and a slot configuration specified for use with heating or cooking appliances.

2A.5 COMPONENT – A device or fabricated part of the appliance covered by the scope of a safety standard dedicated to the purpose. When incorporated in an appliance, equipment otherwise typically field installed (e. g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as thermoplastic or copper, are not considered components.

2A.6 CONTROL CIRCUIT – A circuit that carries the electric signals directing the operation of a controller which, in turn, governs power delivered to a motor or other load. A control circuit does not carry the main power current.

2A.7 CORD CONNECTOR – A female contact device wired on flexible cord for use as an extension from an outlet to make a detachable electrical connection to an attachment plug or, as an appliance coupler, to an equipment inlet.

2A.8 TEMPERATURE CONTROLS – Devices that respond with a change in temperature (thermostatic devices) may be one of the following types:

a) Regulating – Functions only to regulate the temperature of the heater under intended conditions of use, and whose malfunction would not result in a risk of fire.

b) Limiting – Functions only under conditions that produce abnormal temperatures. The malfunction of such a device will result in a risk of fire.

c) Auxiliary – Thermostatic device other than of the regulating or limiting type.

d) Operating Control – A control intended to start or regulate the heater during normal operation. An example would be a temperature-regulating control. An operating control could provide Type 1 or Type 2 action. (See definitions 2A.9 – 2A.12).

e) Protective Control – A control intended to reduce the risk of electric shock, fire, or injury to persons during abnormal operation of the heater. An example would be a temperature limiting control. A protective control always provides Type 2 action. (See definitions 2A.9 – 2A.12).

2A.9 TYPE 1 ACTION – Automatic action for which the manufacturing deviation and the drift of its operating value, operating time, or operating sequence have not been declared and tested to the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

2A.10 TYPE 2 ACTION – Automatic action for which the manufacturing deviation and the drift of its operating value, operating time, or operating sequence have been declared and tested to the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

2A.11 TYPE 2.H ACTION – So designed that the contacts cannot be prevented from opening and which may automatically reset to the closed position if the reset means is held in the reset position. The control shall not reset automatically at any temperature above -35 °C.

2A.12 TYPE 2.J ACTION – So designed that the contacts cannot be prevented from opening, and the control is not permitted to function as an automatic reset device if the reset means is held in the reset position. The control shall not reset automatically at any temperature above -35 °C.

3 Components

3.1 General

3.1.1 A component of a product covered by this standard shall:

a) Comply with the requirements for that component as indicated in 3.2 - 3.10;

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

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

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

Exception No. 1: A component of a product covered by this standard is not required to comply with a specific component requirement that:

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

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

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

Exception No. 2: A component that complies with a UL component standard other than those specified in 3.2 - 3.10 is acceptable if:

a) The component also complies with the applicable component standard specified in 3.2 - 3.10; or

b) The component standard:

1) Is compatible with the ampacity and overcurrent protection requirements in the National Electrical Code, ANSI/NFPA 70, where applicable;

2) Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B; and

3) Any use limitations of the other component standard is identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and complying with the relevant component standard may assume user expertise not common in household applications.

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

3.1.3 A component that is also intended to perform other functions, such as over current protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination

thereof, shall comply additionally with the requirements of the applicable UL standard(s) that cover devices that provide those functions.

Exception: Where these other functions are not required for the application and not identified as part of markings, instructions, or packaging for the appliance, the additional component standard(s) need not be applied.

3.1.4 A component not anticipated by the requirements of this end product standard, not specifically covered by the component standards in 3.2 – 3.10, and that involves a risk of fire, electric shock, or injury to persons, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with 3.1.1 (b) – (e).

3.1.5 With regard to a component being additionally investigated, reference to construction and performance requirements in another UL end product standard is suitable where that standard anticipates normal and abnormal use conditions consistent with the application of this end product standard.

3.2 Attachment plugs, receptacles, connectors, and terminals

3.2.1 Attachment plugs, receptacles, appliance couplers, appliance inlets (motor attachment plugs), and appliance (flatiron) plugs, shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. See 3.2.6.

Exception: Attachment plugs and appliance couplers integral to cord sets or power supply cords that are investigated in accordance with the Standard for Cord Sets and Power Supply Cords, UL 817 are not required to comply with UL 498.

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

3.2.3 Multi-pole splicing wire connectors that are intended to facilitate the connection of hard-wired utilization equipment to the branch-circuit conductors of buildings shall comply with the Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459. See 3.2.6.

3.2.4 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

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

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

3.3 Controls

3.3.1 General

3.3.1.1 Auxiliary controls shall be evaluated in accordance with the applicable requirements of this end product standard unless otherwise specified; see 3.3.1.7.

3.3.1.2 Operating (regulating) controls shall be evaluated in accordance with the applicable component standard requirements specified in 3.3.2 – 3.3.6, if applicable, unless otherwise specified in this end product standard ; see 3.3.1.7.

3.3.1.3 Operating controls that rely upon software for the normal operation of the end product where deviation or drift of the control may result in a risk of fire, electric shock, or injury to persons, such as a speed control unexpectedly changing its output, shall comply with one of the following:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, and the Standard for Software in Programmable Components, UL 1998; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

3.3.1.4 Protective (limiting) controls shall be evaluated in accordance with the applicable component standard requirements specified in 3.3.2 – 3.3.6, unless otherwise specified in this end product standard.

3.3.1.5 Solid-state protective controls that do not rely upon software as a protective component shall comply with one of the following:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, except the Controls Using Software requirements, Clause H 11.12.

3.3.1.6 Solid-state protective controls that rely upon software as a protective component shall comply with one of the following:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, and the Standard for Software in Programmable Components, UL 1998; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

3.3.1.7 An electronic, auxiliary or operating control (e.g. a non-protective control), the failure of which would not increase the risk of fire, electric shock, or injury to persons, need only be subjected to the applicable requirements of this end product standard.

3.3.2 Electromechanical and electronic controls

3.3.2.1 A control, other than as specified in 3.3.3 – 3.3.6, shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873; or

c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

3.3.3 Liquid level controls

3.3.3.1 A liquid level control shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) The Standard for Industrial Control Equipment, UL 508; or

d) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and;

1) *Deleted*

2) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Air Flow, Water Flow and Water Level Sensing Controls, UL 60730-2-15

3.3.4 Motor and speed controls

3.3.4.1 A control used to start, stop, regulate or control the speed of a motor shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A;

b) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

c) The Standard for Industrial Control Equipment, UL 508;

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

e) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

3.3.5 Pressure controls

3.3.5.1 A pressure control shall comply with one of the following:

a) The Standard for Temperature-Indicating and -Regulating, UL 873;

b) The Standard for Industrial Control Equipment, UL 508; or

c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

3.3.6 Timer controls

3.3.6.1 A timer control shall comply with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

3.4 Cords, cables, and internal wiring

3.4.1 A cord set or power supply cord shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817.

3.4.2 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62. Flexible cord and cables are considered to comply with this requirement when pre-assembled in a cord set or power supply cord complying with the Standard for Cord Sets and Power Supply Cords, UL 817.

3.4.3 Internal wiring composed of insulated conductors shall comply with the Standard for Appliance Wiring Material, UL 758.

Exception No. 1: Insulated conductors need not comply with UL 758 if they comply with one of the following:

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

b) The Standard for Thermoplastic-Insulated Wires and Cables, UL 83;

c) The applicable UL standard(s) for other insulated conductor types specified in Chapter 3, Wiring Methods and Materials, of the National Electrical Code, ANSI/NFPA 70.

Exception No. 2: Insulated conductors for specialty applications (e.g. data processing or communications) and located in a low-voltage circuit not involving the risk of fire, electric shock or injury to persons need not comply with UL 758.

3.5 Film-coated wire (magnet wire)

3.5.1 The component requirements for film coated wire and Class 105 (A) insulation systems are not specified.

3.5.2 Film coated wire in intimate combination with one or more insulators, and incorporated in an insulation system rated Class 120 (E) or higher, shall comply with the magnet wire requirements in the Standard for Systems of Insulating Materials – General, UL 1446.

3.6 Printed wiring boards

3.6.1 Printed wiring boards, including the coatings, shall comply with the Standard for Printed Wiring Boards, UL 796.

Exception: A printed-wiring board in a Class 2 nonsafety circuit is not required to comply with the bonding requirements in UL 796 if the board is separated from parts of other circuits such that loosening of the bond between the foil conductor and the base material will not result in the foil conductors or components coming in contact with parts of other circuits of the control or of the end-use product.

3.6.2 A printed-wiring board containing circuitry in a line-connected circuit or a safety circuit shall comply with the direct-support requirements for insulating materials in Electrical Insulation, Section 14 of this end product standard.

3.6.3 Unless otherwise specified, the flammability class and temperature rating shall be that as specified in Electrical Insulation, Section 14 of this end product standard.

3.7 Semiconductors and small electronic components

3.7.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard for Optical Isolators, UL 1577. The Dielectric Voltage Withstand Tests required by UL 1577 shall be conducted applying the requirements of the Dielectric Voltage Withstand Test, Section 50, of this end product standard.

3.7.2 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this end product standard shall comply with the Standard for Optical Isolators, UL 1577. The Dielectric Voltage Withstand Tests required by UL 1577 shall be conducted applying the requirements in Dielectric Voltage Withstand Test, Section 50 of this end product standard.

3.7.3 Except as specified in 3.7.4, component requirements are not specified for small electronic components on printed wiring boards, including diodes, transistors, resistors, inductors, integrated circuits, and capacitors not directly connected to the supply source.

3.7.4 Where an electronic component is determined to be a critical component during the Abnormal Operation Tests, Section 33, one of the following standards shall be applied:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, and as applicable, the Standard for Software in Programmable Components, UL 1998 for controls that rely upon software as a protective component; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

3.7.5 A critical component, as specified in 3.7.4, is a component that performs one or more safety-related functions whose failure results in a condition, such as the risk of fire, electric shock, or injury to persons, in the end product application.

3.7.6 A critical component as specified in 3.7.4, may also be identified using a failure-mode and effect analysis (FMEA) in accordance with the Failure-Mode and Effect Analysis (FMEA) requirements in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

3.7.7 Portions of a circuit comprised of a microcontroller or other programmable device that performs a back-up, limiting, or other safety function intended to reduce the risk of fire, electric shock, or injury to persons shall comply with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, Annex H.

3.8 Supplemental insulation, insulating bushings, and assembly aids

3.8.1 The requirements for supplemental insulation (e. g. tape, sleeving or tubing) are not specified unless the insulation or device is required to comply with 12.3 or a performance requirement of this end product standard. In such cases, the insulation shall comply with the following applicable standards:

a) Insulating tape shall comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510;

b) Sleeving shall comply with the Standard for Coated Electrical Sleeving, UL 1441; or

c) Tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

3.8.2 Wire positioning devices shall comply with the requirements in Electrical Insulation, Section 14. A device that complies with the Standard for Positioning Devices, UL 1565, is considered to comply with this requirement.

3.8.3 Insulating bushings that comply with the requirements in General, Section 3.1, of this end product standard, and the Standard for Insulating Bushings, UL 635 are considered to comply with the requirements of this end product standard. Tests specified in this end product standard (e.g. Strain Relief Test, Section 47) may still need to be performed to confirm the combination of the insulating bushing and the supporting part comply with the intent of the requirements.

3.9 Switches

3.9.1 Switches shall comply with one of the following:

a) *Deleted*

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

c) The Standard for General-Use Snap Switches, UL 20; or

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

Exception: Switching devices that comply with the applicable UL standards for specialty applications (e.g. transfer switch equipment), industrial use (e.g. contactors, relays, auxiliary devices), or are integral to another component (e.g. switched lampholder) need not comply with this requirement.

3.9.2 A clock-operated switch, in which the switching contacts are actuated by a clock-work, by a gear-train, by electrically-wound spring motors, by electric clock-type motors, or by equivalent arrangements shall comply with one of the following:

a) The Standard for Clock-Operated Switches, UL 917; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

3.9.3 A timer or time switch, incorporating electronic timing circuits or switching circuits, with or without separable contacts, shall comply with the requirements for an operating control with Type 1 action for 6000 cycles of operation, or as a manual control for 5000 cycles of operation, in accordance with one of the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

3.9.4 A timer or time switch, incorporating electronic timing circuits or switching circuits, with or without separable contacts, that functions as a protective control, shall comply with the requirements for a protective control; see 3.3.1.3.

3.10 Transformers

3.10.1 General-purpose transformers shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2.

Exception No. 1: A transformer that is completely enclosed within the end product enclosure, and that complies with the applicable construction and performance requirements of this end product standard when tested in conjunction with the end product, complies with the intent of this requirement.

Exception No. 2: A transformer that complies with the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411, and that is used in a circuit involving an audio or video component complies with the intent of this requirement.

3.10.2 Class 2 and Class 3 transformers shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

Exception: Transformers located in a low voltage circuit, and that do not involve a risk of fire, electric shock or injury to persons need not comply with this requirement.

CONSTRUCTION

4 Frame and Enclosure

4.1 The enclosure of baseboard heating equipment shall prevent molten metal, burning insulation, flaming particles, or the like from falling on flammable materials, including the surface upon which the enclosure is supported.

4.2 The enclosure of baseboard heating equipment designed for permanent installation, that is, intended for permanent connection to the power supply, shall be provided with means and instructions for mounting in the intended manner. Any fittings such as brackets, hangers, or the like, necessary for mounting shall be furnished with the equipment.

4.3 The requirement in 4.1 necessitates use of a barrier of nonflammable material:

a) Under a motor unless:

1) The structural parts of the motor or of the heater provide the equivalent of such a barrier;

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

i) Open main winding;

ii) Open starting winding; and

iii) Starting switch short-circuited.

3) The motor is provided with a thermal motor protector (a protective device that is sensitive to both temperature and current) that will prevent the temperature of the motor windings from becoming more than 125°C (255°F) under the maximum load under which the motor will run without causing the protector to cycle, and from becoming more than 150°C (300°F) with the rotor of the motor locked.

b) Under wiring, unless it is of the flame-retardant type. Neoprene- or thermoplastic-insulated wires are of this type.

It also necessitates that a switch, transformer, relay, solenoid, or similar component be individually and completely enclosed except at terminals, unless it is shown that failure of the component does not result in a risk of fire, or unless there are no openings in the bottom of the enclosure. An opening in the bottom of the enclosure is prohibited when it is located directly below field- or factory-made splices or overload or overcurrent protective devices.

4.4 Except as indicated in 4.5, if openings are provided in the enclosure of a heater or in an externally mounted component intended for permanent connection to the power supply, they shall be so located that they will not vent into concealed spaces of a building structure such as into hollow spaces in the wall, when the equipment is installed as intended.

4.5 The requirement in 4.4 does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage) if:

a) No such opening has a dimension more than 17/64 in (6.7 mm) or an area more than 0.055 square inch (34.5 mm^2), and

b) There is no more than one mounting-screw hole for each 12 in (300 mm) of length or fraction thereof in baseboard heating equipment intended for recessed installation.

4.6 Except as noted in 4.7 an opening for ventilation in the enclosure, other than in the bottom, of a heater and an opening associated with the dissipation of heated air from the element shall be provided with one or more baffles that will prevent the emission of flame, molten metal, burning insulation, or the like from the heater.

4.7 In a compartment other than one that houses an overload or overcurrent protective device, the baffles mentioned in 4.6 may be omitted if:

a) No ventilating opening in a vertical wall, other than one associated with the dissipation of heated air from the elements during normal operation of the heater, is more than 3/8 in (9.5 mm) in width, or

b) The heater is so constructed that it is suitable for the purpose, as shown by appropriate investigation.

4.8 Cast- and sheet-metal enclosures shall conform with the requirements of Table 4.1 – Table 4.3.

Exception: A sheet steel enclosure may have a lesser thickness than specified in Table 4.1 but not less than 0.020 in (24 MSG) (0.51 mm) when it is determined that the enclosure of lesser thickness due to its shape and use of reinforcing members affords the required protection.

4.9 Among the factors that shall be taken into consideration when judging the acceptability of nonmetallic materials are resistance to:

a) Mechanical damage,

b) Impact,

c) Moisture absorption,

d) Combustion, and

e) Distortion at temperatures to which the material may be subjected under conditions of normal or abnormal use.

4.10 A polymeric material used for the frame or enclosure shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: The abnormal operation tests in UL 1042 may be conducted in lieu of the Abnormal Operation Test, Section 35, and Severe Conditions Test, Section 24, of UL 746C.

4.11 Sheet metal to which a wiring system is to be connected in the field shall have an average thickness no less than 0.032 in (0.81 mm) if uncoated steel, no less than 0.034 in (0.86 mm) if galvanized steel, and no less than 0.045 in (1.14 mm) if nonferrous.

4.12 At points where the face of an attachment-plug receptacle projects through it, the enclosure shall have a thickness no less than:

a) 0.032 in (0.81 mm) if of ferrous metal,

b) 0.045 in (1.14 mm) if of nonferrous metal, and

c) 0.10 in (2.5 mm) if of insulating material, except that an enclosure of insulating material may be of lesser thickness if so formed or reinforced as to provide adequate physical strength. The insulating material shall be nonflammable.

Table 4.1
Minimum thickness of sheet metal for electrical enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length					
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Uncoated (MSG)		Metal coated (GSG)	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020[d] (24)	(0.51)	0.023[d] (24)	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)				
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026[d] (22)	(0.66)	0.029[d] (22)	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)				
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032 (20)	(0.81)	0.034 (20)	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)				
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042 (18)	(1.07)	0.045 (18)	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)				
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053 (16)	(1.35)	0.056 (16)	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)				

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

1) Single sheet with single formed flanges (formed edges),

2) A single sheet which is corrugated or ribbed, and

3) An enclosure surface loosely attached to a frame, that is, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

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

[d] Sheet steel for an enclosure intended for outdoor use shall comply with the requirements for outdoor use equipment.

Table 4.2
Minimum thickness of sheet metal for electrical enclosures – aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness		
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length				
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(mm)	(AWG)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d]	(0.58)	(22)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)			
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(0.74)	(20)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)			
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(0.91)	(18)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)			
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(1.14)	(16)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)			
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(1.47)	(14)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)			
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(1.91)	(12)
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)			

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

1) Single sheet with single formed flanges (formed edges),

2) A single sheet which is corrugated or ribbed, and

3) An enclosure surface loosely attached to a frame, that is, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

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

[d] Sheet metal for an enclosure intended for outdoor use shall comply with the requirements for outdoor use equipment.

Table 4.3
Cast-metal electric enclosures

Use, or dimensions of area involved[a]	Minimum thickness, inch (mm)	
	Die-cast metal	Cast metal of other than the die-cast type
Area of 24 square inches (155 cm^2) or less and having no dimension greater than 6 inches (152 mm)	1/16 (1.6)	1/8 (32.2)
Area greater than 24 square inches or having any dimension greater than 6 inches	3/32 (2.4)	1/8 (32.2)
At a threaded conduit hole	1/4 (6.4)	1/4 (6.4)
At an unthreaded conduit hole	1/8 (3.2)	1/8 (3.2)

[a] The area limitation for metal 1/16 in (1.6 mm) in thickness may be obtained by the provision of reinforcing ribs subdividing a larger area.

4.13 An electrical part shall be so located or enclosed that protection against unintentional contact with uninsulated live parts will be provided.

4.14 The door or cover of an enclosure shall be hinged:

a) If it gives access to any fuse, circuit breaker, or manually resettable limit control in other than a low-voltage circuit, and

b) If uninsulated live parts are exposed during the replacement of the fuse or resetting of the manually resettable device.

Such a door or cover shall also be provided with an automatic latch (see 4.16) of the equivalent and, if live parts other than the screw shell of a plug fuseholder are exposed inside the enclosure, a captive screw (or equivalent means requiring the use of a tool to open) to secure the door or cover in place.

4.15 A door or cover giving access to any overload-protective device in other than a low-voltage circuit shall be tight-fitting and shall overlap the surface of the enclosure around the opening.

4.16 A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door in place and would require some effort on the user's part to open it, is considered to be an acceptable means for holding the door in place as required in 4.14.

4.17 A component subject to inspection, replacement, cleaning, or other servicing shall be as accessible as practicable, and shall be fully accessible without the use of special tools if it is intended to be manually operated or adjusted or if it will definitely require periodic servicing.

4.18 Parts of baseboard heaters such as an enclosure, frame, guard, or handle, subject to contact in operation and user servicing shall be free of sharp corners, edges, or projections. See 26.11 and 59.35.

4.19 A handle intended to support or carry more than 20 lbs (9.07 kg) shall have a gripping surface at least 4 in (100 mm) long.

4.20 A handle shall be fastened so that it will not be capable of being partly or completely removed without the use of a tool.

4.21 A handle used for support of a portable heater shall be able to sustain four times the weight of the heater. The appropriate load shall be uniformly applied over a 3 in (75 mm) length at the center of the handle, gradually increased to the test value over a period of 5 to 10 seconds, and maintained at the test value for 1 minute. The load shall be supported with no evidence of damage to the handle (separation, cracking, or permanent deformation). For this test the heater may be inverted and supported so that the test weight can be applied directly to the handle.

4.22 If more than one handle is furnished on the heater, the load indicated in 4.21 shall be distributed between the handles. The distribution of the load shall be determined by measuring the percentage of the weight of the heater supported by each handle with the heater in the intended carrying condition.

4.23 If a heater is furnished with more than one handle and the heater can be carried by one handle alone, each handle shall be capable of supporting the load described in 4.21.

5 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

5.1 In determining if an opening in an enclosure is acceptable, consideration is to be given to:

a) The proximity of uninsulated live parts (as determined by applying 5.3 and 5.4) and

b) The possibility of the emission of burning insulation, molten metal, and the like through the opening (as determined by applying 4.1 – 4.7).

5.2 A moving part such as a fan blade, a blower wheel, a pulley, a belt, or the like that may cause injury to persons shall be enclosed or guarded.

5.3 To reduce the likelihood of unintentional contact that may involve a risk of:

a) Electric shock from an uninsulated live part or film-coated wire or

b) Injury to persons from a moving part, an opening in an enclosure shall comply with either (1) or (2).

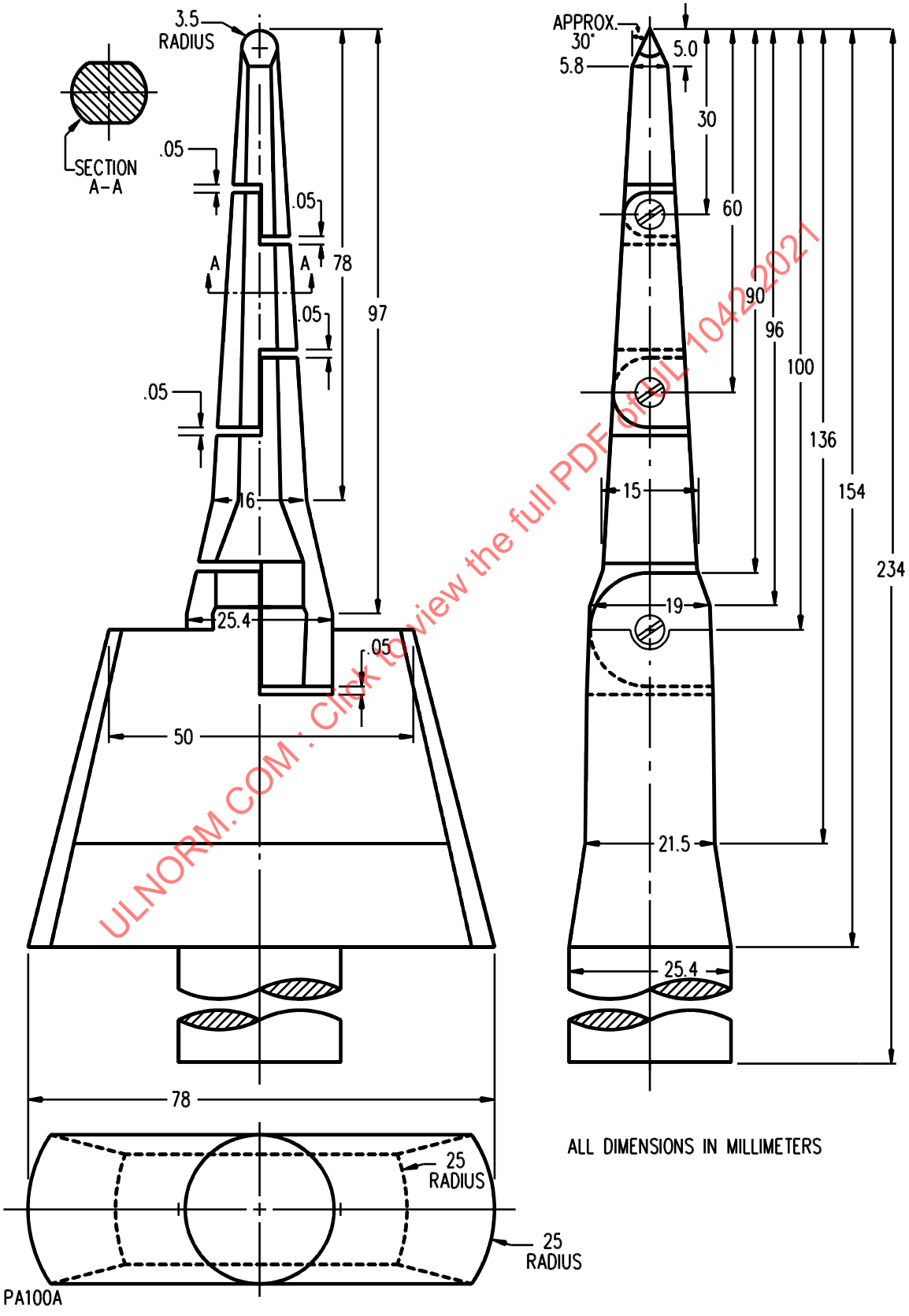
1) For an opening that has a minor dimension (see 5.7) less than 1 in (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 5.1.

2) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 5.1.

Exception: A motor need not comply with these requirements if it complies with the requirements in 5.4.

Figure 5.1

Articulate probe with web stop



5.4 With respect to a part or wire as mentioned in 5.3, in an integral enclosure of a motor as mentioned in the exception to 5.3.

a) An opening that has a minor dimension (see 5.7) less than 3/4 in (19.1 mm) is not acceptable if:

1) A moving part can be contacted by the probe illustrated in Figure 5.2,

2) Film-coated wire can be contacted by the probe illustrated in Figure 5.3,

3) In a directly accessible motor (see 5.8), an uninsulated live part can be contacted by the probe illustrated in Figure 5.4, or

4) In an indirectly accessible motor (see 5.8), an uninsulated live part can be contacted by the probe illustrated in Figure 5.2.

b) An opening that has a minor dimension of 3/4 in or more is acceptable if a part or wire is spaced from the opening as specified in Table 5.1.

5.5 The probes mentioned in 5.3 and 5.4 and illustrated in Figure 5.1 – Figure 5.4 shall be applied to any depth that the opening will permit; and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figure 5.1 and Figure 5.4 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

5.6 The probes mentioned in 5.5 and 5.7 are to be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they are to be applied with the minimum force necessary to determine accessibility.

5.7 With reference to the requirements in 5.3 and 5.4 and Table 5.1, the minor dimension of an opening is the diameter of the largest cylindrical probe that can be inserted through the opening.

5.8 With reference to the requirements in 5.4:

a) An indirectly accessible motor is a motor:

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

2) That is otherwise guarded or enclosed so that it is unlikely to be contacted.

b) A directly accessible motor is a motor:

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

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

Figure 5.2

Probe for moving parts and uninsulated live parts

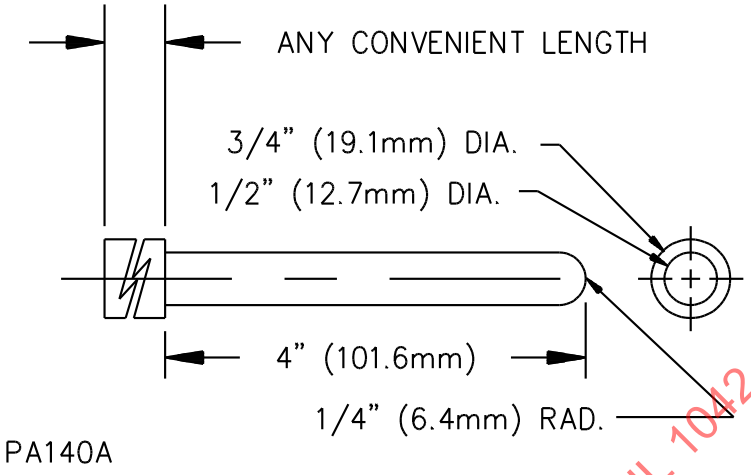


Figure 5.3

Probe for film-coated wire

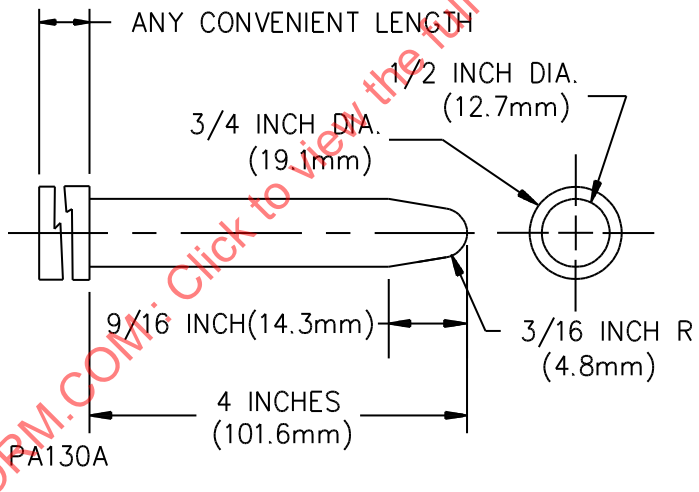


Figure 5.4

Articulate probe

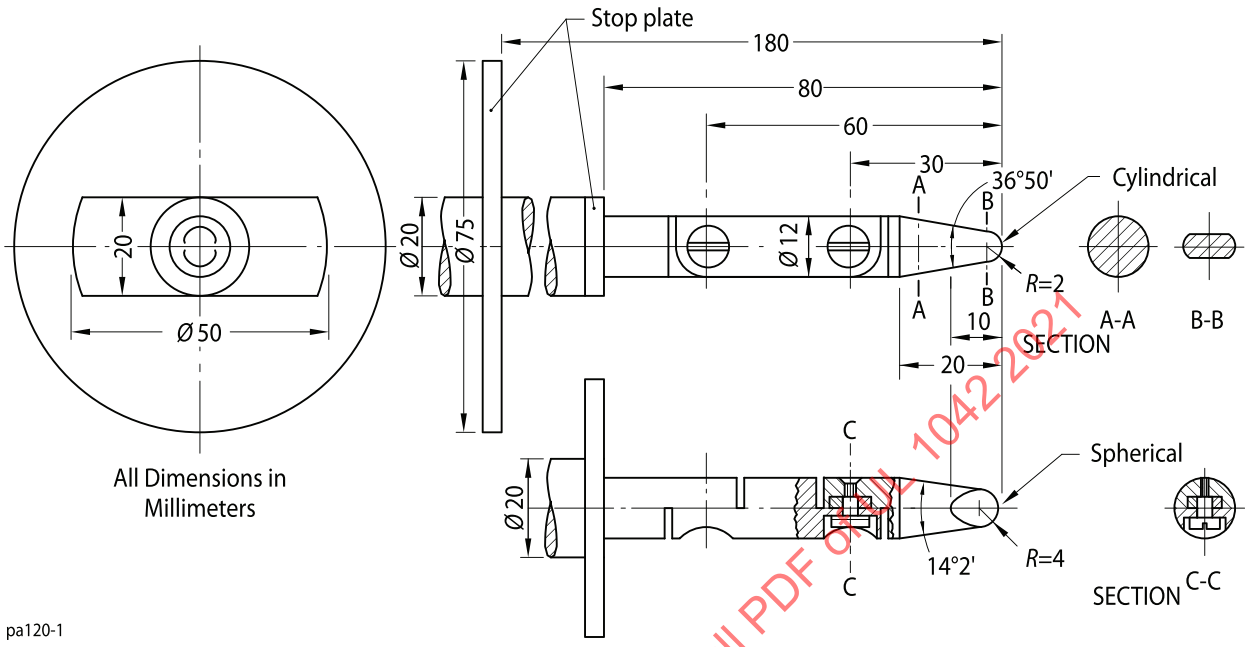


Table 5.1

Minimum acceptable distance from an opening to a part that may involve a risk of electric shock or injury to persons[a]

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

[a] For an opening having a minor dimension between two values specified in the table, the distance from the opening to the part shall not be less than that determined by interpolation between the corresponding values in the right-hand column.

[b] See 5.7.

[c] Any dimension less than 1 inch applies to a motor only.

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

5.9 During the examination of a product to determine whether it complies with the requirements in 5.3 or 5.4, a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

5.10 With reference to the requirements in 5.3 and 5.4, insulated brush caps are not required to be additionally enclosed.

5.11 If the opening or removal of a door, a panel, or a shield will expose any moving part that can cause injury to persons, the opening or removal of the door, panel, or shield shall:

a) Require the use of tools, or

b) Cause an interlocking device not likely to be unintentionally rendered ineffective to stop the moving part.

5.12 A moving part is not to be considered when judging compliance with 5.3 or 5.4 if the part is unlikely to be contacted through the opening because of fixed components, including baffles.

6 Parts Subject to Pressure

6.1 The requirements of 43.1 apply to parts which are 6 in (150 mm) or less in inside diameter.

6.2 For determining criteria for testing see Section 43, Hydro-Static Pressure Test.

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

6.4 Pressure-relief devices (see 6.10), fusible plugs, soldered joints, nonmetallic tubing, or other pressure-relief means or the equivalent may be employed to comply with the requirement in 6.3.

6.5 There shall be no shutoff valve between the pressure-relief means and the part(s) that it is intended to protect.

6.6 A vessel having an inside diameter of more than 3 in (75 mm) and subject to air or steam pressure generated or stored within the appliance shall be protected by a pressure-relief device.

6.7 The start-to-discharge pressure setting of the pressure-relief device shall be no higher than the marked maximum working pressure of the vessel. The discharge rate of the device shall be capable of relieving the pressure.

6.8 A pressure-relief device shall comply with all four of the following:

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

b) Shall be so installed that it is fully accessible for inspection and repair, and cannot be readily rendered inoperative,

c) Shall have its discharge opening so located and directed that the risk of scalding has been reduced to an acceptable degree, and

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

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

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

6.11 If a pressure-relief device is required, the electrical control responsible for limiting the pressure in the vessel shall be capable of performing under rated load for 100,000 cycles of operation and shall prevent the pressure from exceeding 90 percent of the relief-device setting during any of the tests required by this standard.

7 Assembly

7.1 A switch, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or similar component shall be mounted and secured in place and, except as noted in 7.2 and 7.3, shall be prevented from turning. See 7.4.

7.2 The requirement that a switch be prevented from turning may be waived if all four of the following conditions are met:

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

b) The means of mounting the switch is not subject to loosening as the result of its operation.

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

d) The operation of the switch is by mechanical means rather than direct contact by persons.

7.3 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.

7.4 The means for preventing the turning mentioned in 7.1 is to consist of more than friction between surfaces; for example, a lock washer, properly applied, is acceptable as means to prevent turning of a small stem-mounted switch or other device having a single-hole mounting means.

7.5 Uninsulated live parts shall be secured to the base or mounting surface so that they will be prevented from turning or shifting if such motion may result in a reduction of spacings below the minimum acceptable values specified in 24.1 – 24.4.

7.6 Friction between surfaces is not acceptable as a means to prevent shifting or turning of live parts, but a lock washer is acceptable.

8 Protection Against Corrosion

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

Exception: Cast-iron parts are not required to be protected against corrosion. A sheath employed on a heating element operating in air and terminal parts attached directly to the heating element need not be protected against corrosion.

8.2 The aging characteristics of plating or other finish used in a heater shall be such that deterioration of the finish will not result eventually in unacceptable performance of the heater.

8.3 The sheath of an immersion-type heating element shall be of a metal resistant to corrosion by the liquid in which the element is intended to be immersed.

9 Permanently Connected Equipment

9.1 General

9.1.1 Permanently connected equipment (intended for permanent connection to the power supply) shall have provision for connection of one of the wiring systems that, in accordance with the National Electrical Code, ANSI/NFPA 70, would be suitable for the appliance.

9.1.2 The location of a terminal box or compartment in which power-supply connections to permanently connected equipment are to be made shall be such that these connections may be inspected after the equipment is installed as intended.

9.1.3 A terminal compartment intended for the connection of a supply raceway shall be attached to the equipment so as to be prevented from turning with respect to it.

9.1.4 A knockout hole or threaded hub for connection of a conduit field-wiring system to a field-wiring compartment shall accommodate conduit of the trade size determined by applying Table 9.1.

9.1.5 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall or if an equivalent construction is employed, there shall not be 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 attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors that will afford protection to the conductors equivalent to that provided by a standard conduit bushing and will have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

9.1.6 A knockout in a sheet-metal enclosure conforming with the requirements of 9.1.7 shall be capable of being removed without deformation of the enclosure to the extent that it would affect the attachment of a conduit fitting, may result in reduction of electrical spacings below the minimum acceptable values, or both.

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

Table 9.1
Trade size of conduit in inches[a] (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)	3/4	(26.7)	3/4	(26.7)	3/4	(26.7)
8	8.4	3/4	(26.7)	3/4	(26.7)	3/4	(26.7)	1	(33.4)	1	(33.4)
6	13.3	3/4	(26.7)	3/4	(26.7)	1	(33.4)	1-1/4	(42.3)	1-1/4	(42.3)

[a] This table is based on the assumption that all conductors are of the same size and there are no more than six conductors in the conduit. When more than six conductors are involved or when all of them are not of the same size, the internal cross-sectional area of the smallest conduit for which an opening or knockout is to be provided 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.

9.1.8 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 less than those required by this standard. In applying the spacing requirement, the bushing is considered to be part of the enclosure. The area of the flat surface surrounding the opening shall be capable of accommodating the bushing and locknut intended to be used with the largest size conduit that can be installed. See Table 9.2.

9.1.9 In measuring a spacing between an uninsulated live part and a bushing installed in the knockout referred to in 9.1.8, it is to be assumed that a bushing having the dimensions indicated in Table 9.3 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

9.1.10 Space shall be provided in the field wiring outlet box or compartment for installation of the conductors of the number and size required by 9.2.1 – 9.2.6 using Type TW or THW wire (except that other types of conductors may be used when specified in the installation instructions) when at least a 6-in (150 mm) length of each conductor is brought into the wiring compartment. If necessary, a trial installation is to be made.

9.1.11 An opening for the entry of a conductor or conductors in a low-voltage circuit as described in 12.4.11 shall be provided with insulating bushings. The bushings shall either be mounted in place in the opening or be provided with the enclosure so that they are mounted when the equipment is installed.

Exception: A bushing is not required when the heater is marked to indicate that field wiring in the low-voltage circuit is to be installed in Class 1, in accordance with the National Electrical Code, ANSI/NFPA 70.

9.1.12 A bushing of rubber or rubber-like material provided in accordance with 9.1.11 shall be 1/8 in (3.2 mm) or more in thickness. A hole in which such a bushing is mounted shall be free from sharp edges, burrs, or projections which may damage the bushing.

Exception No. 1: The bushing may be not less than 3/64 in (1.2 mm) minimum thickness if the metal around the hole is eyeletted or treated to ensure smooth edges.

Exception No. 2: A tab resulting from removal of a conduit knockout is not considered a burr or projection when applying this requirement.

Table 9.2
Diameter of knockout and width of surrounding flat surface

Trade size of conduit		Knockout diameter[a]		Minimum width of flat surface surrounding knockout	
Inches	(mm OD)	Inches	(mm)	Inch	(mm)
1/2	(21.3)	7/8	(22.2)	0.13	(3.4)
3/4	(26.7)	1-3/32	(27.8)	0.16	(4.1)
1	(33.4)	1-23/64	(34.5)	0.21	(5.2)
1-1/4	(42.3)	1-23/32	(43.7)	0.28	(7.1)

[a] Knockout diameters will be measured other than at point where a tab may remain after removal of knockout.

Table 9.3
Dimensions of bushings

Trade size of conduit		Bushing dimensions			
		Overall diameter		Height	
Inches	(mm OD)	Inches	(mm)	Inch	(mm)
1/2	(21.3)	1	(25.4)	3/8	(9.5)
3/4	(26.7)	1-15/64	(31.4)	27/64	(10.7)
1	(33.4)	1-19/32	(40.5)	33/64	(13.1)
1-1/4	(42.3)	1-15/16	(49.2)	9/16	(14.3)

9.2 Wiring terminals

9.2.1 Equipment intended for permanent connection to the power supply shall be provided with field-wiring terminals or leads for connection of the power-supply conductors. Each terminal or lead shall be sized for connection of a conductor having an ampacity, according to the National Electrical Code, ANSI/NFPA 70, no less than 125 percent of the rated current at the terminal or lead; if such rating is 24 amperes or less, the terminal or lead shall be sized for connection of a 10 AWG (5.3 mm^2) copper wire, except as indicated in 9.2.5 and 59.15. When the equipment is to be field-connected with aluminum conductors, the terminal or lead shall also be rated for connection of a 8 AWG (8.4 mm^2) aluminum wire except as indicated in 9.2.5 and 59.15.

9.2.2 A lead shall be no more than two standard wire sizes smaller than the branch-circuit power-supply conductor (copper) to which it will be connected. See 9.2.5.

9.2.3 A lead intended for connection to an external circuit shall be provided with a strain relief if stress on the leads may cause the lead to separate from its termination, or result in damage to the lead from sharp edges. Connections which are welded, mechanically secured and soldered, or securely crimped, are considered as not likely to separate due to such stress.

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

9.2.5 Equipment rated 16 amperes or less, which is not arranged for connection of 10 AWG (5.3 mm^2) (copper) power-supply conductors, shall be arranged for connection to a 15- or 20-ampere branch circuit, as appropriate for the rating of the equipment, and shall be marked in accordance with 59.15.

9.2.6 When determining the size of the power-supply conductors in equipment intended for connection to multiple power supplies, and when it is likely that more than six such conductors will occupy the same raceway, the additional ampacity adjustment factors given in the National Electrical Code, ANSI/NFPA 70, shall be applied.

9.2.7 For the purpose of these requirements, field-wiring terminals are considered to be the terminals to which power-supply, control, or equipment-grounding connections will be made in the field when the equipment is installed.

9.2.8 A field-wiring terminal or lead for connection of an equipment-grounding conductor shall be provided. See 9.2.22.

9.2.9 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size for the particular application, in accordance with the National

Electrical Code, ANSI/NFPA 70 and as required by 9.2.10 – 9.2.16 and 9.2.21. Sheet-metal screws shall not be used to connect grounding conductors to enclosures.

9.2.10 A field-wiring terminal shall be provided with a pressure wire connector fastened in place by being bolted or held by a screw.

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

9.2.11 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 mortices, by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other equivalent method.

9.2.12 A wire-binding screw at a field-wiring terminal shall not be smaller than 10 (4.8 mm diameter), except that an 8 (4.2 mm diameter) screw may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor, and a 6 (3.5 mm diameter) screw may be used for the connection of a 16 AWG (1.3 mm^2) or 18 AWG (0.82 mm^2) control-circuit conductor.

9.2.13 In accordance with the National Electrical Code, ANSI/NFPA 70, 14 AWG (2.1 mm^2) is the smallest conductor that shall be used for branch-circuit wiring, and thus is the smallest conductor that is anticipated at a terminal for the connection of a power supply wire.

9.2.14 A terminal plate tapped for a wire-binding screw shall be of metal no less than 0.050 in (1.3 mm) in thickness, except that a plate no less than 0.030 in (0.8 mm) in thickness is acceptable if the tapped threads have two or more full threads in the metal, which may be extruded if necessary to provide the threads.

9.2.15 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size mentioned either in 9.2.1, but no smaller than 14 AWG (2.1 mm^2) or in 9.2.9, whichever is applicable, under the head of the screw or the washer.

9.2.16 A wire-binding screw shall thread into metal.

9.2.17 Equipment provided with field-wiring terminals or leads and intended to be connected to a grounded power-supply conductor shall have one terminal or lead identified for the connection of that conductor if necessary because of the requirement in 20.4, 21.1, 22.4, or 23.1.2.

9.2.18 A field-wiring terminal intended for the connection of a grounded conductor shall be of or plated with a metal substantially white in color and shall be distinguishable from the other terminals, or 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 grey color and shall be distinguishable from the other leads.

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

9.2.20 The requirements in 9.2.18 and 9.2.19 relating to color coding of a lead for identification do not apply to internal wiring that is not visible in a wiring compartment in the area in which field connections are to be made. These requirements also do not apply to leads or wiring of low-voltage circuits intended to be field-connected to Class 2 wiring and which are separated or segregated from high-voltage circuit field-wiring connections by barriers.

9.2.21 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal-shaped, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be identified by:

a) Being marked G, GR, Ground, Grounding, or the equivalent;

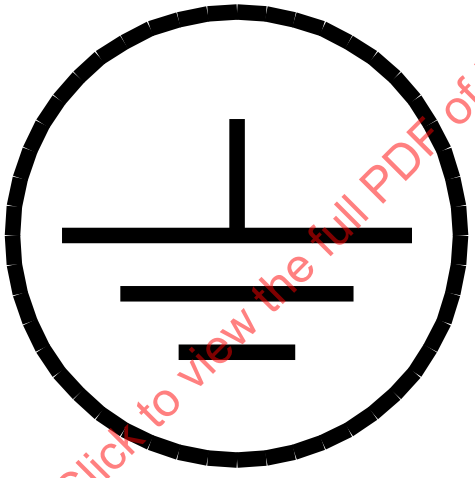
b) A marking on a wiring diagram provided on the equipment; or

c) The symbol shown in Figure 9.1 on or adjacent to the terminal. See 61.5.

The wire-binding screw or pressure wire connector shall be so located that it is unlikely to be removed during servicing of the equipment.

Figure 9.1

Symbol for equipment grounding conductor



9.2.22 Except as noted in 9.2.23 the free length of a lead inside an outlet box or wiring compartment shall be 6 in (150 mm) or more if the lead is intended for field connection to an external circuit.

9.2.23 The lead may be less than 6 in (150 mm) in length if it is evident that the use of a longer lead might result in damage to the lead insulation.

10 Cord-Connected Heaters

10.1 General

10.1.1 A portable heater shall have a mass of no more than 65 lbs (29 kg), and no dimension of such a heater shall be greater than 8 ft (2.4 m).

10.1.2 A portable heater shall be provided with a directly attached flexible cord and an attachment-plug cap shall be provided on the cord for attachment to the supply circuit. The exposed length of the cord (including fittings) shall be no less than 6 feet (1.8 m) and no more than 8 feet (2.4 m). All detachable power-supply cords and attached power-supply cords shall comply with the requirements of the Standard for Cord Sets and Power-Supply Cords, UL 817.

10.1.3 *Deleted*

10.1.4 The flexible cord shall be as indicated in Table 10.1 and must additionally be subjected to the performance test requirements of Sections 53.1 – 56.5.

Table 10.1
Acceptable types of cord

Temperature of more than 121°C (250°F) on any surface liable to be contacted by cord	Temperature of 121°C (250°F) or less on all surfaces liable to be contacted by cord[a]
HPD, HPN, HSJO, HSJOO, HSJ, HSO, HSOO	SP-2, SPT-2, SVO, SV, SVTO, SVT, SJO, SJ, SJTO, SJT
[a] Cords of the types indicated in the first column may also be used.	

10.1.5 The ampacity of the flexible cord shall be not less than the current rating of the heater, and the current rating of the attachment-plug cap shall be no less than 125 percent of the current rating of the heater, except that a 15-ampere cap is acceptable for a heater rated at no more than 1500 watts at 120 volts, or 3000 watts at 240 volts, and a 20-ampere cap is acceptable for a heater rated at no more than 4000 watts at 240 volts.

10.1.6 Supplementary insulation on a flexible cord shall not extend more than 1/2 in (13 mm) outside the heater (unless provided with additional mechanical protection), shall be prevented from fraying or unraveling, and shall not adversely affect the means for providing strain relief.

10.1.7 The size of the flexible cord, based on the current rating of the heater, shall be in accordance with Table 10.2 .

Table 10.2
Cord wire size based on heater current rating[a]

Cord wire size AWG[b]	Attachment plug connection crimped only[c]	Maximum current rating of heater, amperes	
		Attachment plug connection and connections of supply cord to internal wiring of a heater shall be soldered, brazed, or welded[d]	
		Cord types S, SJ, SJO, SJT, SJTO, SO, SP, SPT, SRDT, ST, STO, SV, SVO, SVT, SVTO	Cord types HPD, HPN, HS, HSJ, HSJO, HSO
18	8	10	10
16	10.4	13	15
14	14.4	18	20

[a] This table limits the heater current on the basis of cord wire size, type of cord, type of connection between the cord wires and blades of the attachment plug and connections of power supply cord to internal wiring of a heater. For current limitation based on the attachment plug rating, see 10.1.5.

[b] The maximum current rating for other cord sizes can be determined from Table 400.5(A), Ampacity of Flexible Cords and Cables, National Electrical Code, ANSI/NFPA 70. When the attachment plug is connected by crimping only, the current rating of the heater is not to exceed 80 percent of the rating of the corresponding wire sizes of Type S Cord, regardless of the type of cord used.

[c] Applies to any acceptable cord type.

[d] A soldered connection shall be mechanically secured before being soldered. A soldered connection that is crimped before being soldered is considered to be mechanically secured before soldering. A brazed or welded connection may additionally be mechanically secured before brazing or welding.

10.2 Strain relief

10.2.1 Strain relief shall be provided to prevent a mechanical stress on a flexible supply cord from being transmitted to terminals, splices, or interior wiring. Compliance shall be determined in accordance with Section 47, Strain Relief Test.

10.2.2 Means shall be provided to prevent the supply cord or lead from being pushed into the enclosure of a heater through the cord-entry hole when such displacement results in:

a) Subjecting the supply cord or lead to mechanical damage;

b) Exposing the supply cord or lead to a temperature higher than that for which it is rated;

c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or

d) Damaging internal connections or components.

To determine compliance, the supply cord or lead shall be tested in accordance with Section 48, Push-Back Relief Test.

10.2.3 A knot in the supply cord shall not serve as the strain relief means with a metallic enclosure.

10.3 Bushings

10.3.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be secured in place, and shall have a smooth, rounded surface against which the cord may bear. When Type SP-2, SPT-2, or other cord lighter than Type HSJ is employed, when the wall or barrier is of metal, and when the construction is such that the cord is subjected to strain or motion, an insulating bushing shall be provided. The heat- and moisture-resistant properties of the bushing material shall be rated for the particular application.

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

10.3.3 Ceramic materials and some molded compositions are acceptable for insulating bushings; but a separate bushing of wood, hot-molded shellac-and-tar composition, or rubber material (other than in a motor) is not acceptable. Vulcanized fiber may be employed if the bushing is no less than 3/64 in (1.2 mm) thick and if it is formed and secured in place so that it will not be adversely affected by moisture conditions.

10.3.4 An insulated metal grommet may be accepted in place of an insulating bushing if the insulating material used is no less than 1/32 in (0.8 mm) thick and fills completely the space between the grommet and the metal in which it is mounted.

10.3.5 In a portable heater with a cord of a type for which an insulating bushing is not required, a smooth-edged hole, free from burrs, fins, and the like, is considered to be the equivalent of a bushing.

10.4 Special protection devices

10.4.1 An AFCI or LCDI provided as part of a cord-connected appliance shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699.

10.4.2 The AFCI or LCDI shall be installed as an integral part of the attachment plug or located in the supply cord within 4 in of the attachment plug.

10.4.3 Arc fault detection testing shall include the following as applicable:

a) Carbonized path arc clearing time test;

b) Point contact arc test;

c) Unwanted tripping test – Load Condition I;

d) Unwanted tripping test – Load Condition II – Condition B and C;

e) Unwanted tripping test – Load Condition III – Condition A; and

f) Operation Inhibition - Masking.

Exception: The carbonized path arc clearing time test is not applicable for LCDIs that are provided with shielded power-supply cords.

11 Current-Carrying Parts

11.1 Metal employed for a current-carrying part shall be the following or equivalent:

a) Plated iron or steel, where the intended operating temperature of the part is more than 100°C (212°F); or

b) Stainless steel or other corrosion-resistant alloy, regardless of the part's intended operating temperature.

However, plain (unplated) iron or steel shall not be used, regardless of temperatures attained by the part.

Exception: Ordinary iron or steel having no additional protection against corrosion may be employed for a heating-element terminal part in accordance with 8.1, and ordinary iron or steel having a corrosion-resistant coating may be used for any current-carrying part, regardless of its operating temperature, as follows:

a) Within a motor or associated governor.

b) On a control device such as a combination tip-over and thermostat control.

c) For a welded-on connection to any terminal of a control device referenced in (b) or to terminals of a heating element assembly.

12 Internal Wiring

12.1 General

12.1.1 The internal wiring shall consist of wires of a size and of a type or types that are rated for the particular application, when considered with respect to the temperature and voltage to which the wiring is liable to be subjected, with respect to its exposure to oil or grease, and with respect to other conditions of service to which it is liable to be subjected. The thickness of the insulation shall be 1/32 in (0.8 mm) or more: except that it may be no less than 1/64 in (0.4 mm) if the wire is provided with a braid or jacket no less than 1/64 in thick, or is a standard building wire provided with a braid or jacket.

12.1.2 For the purpose of these requirements, the internal wiring of baseboard heating equipment is considered to be all the wiring beyond the point where the power-supply cord of a cord-connected heater enters the enclosure, or beyond the wiring terminals or leads for power-supply connection of a permanently connected heater, even though some of such wiring may not be completely enclosed and even though some of it may be in the form of flexible cord.

12.1.3 There is no temperature limit applicable to a conductor (except as noted in C2 and C3 of Table 32.1) provided with beads of noncarbonizable material or the equivalent.

12.1.4 Insulated wire employed for internal wiring shall be standard building wire, fixture wire, appliance-wiring material, or flexible cord rated for the particular application.

12.2 Protection of wiring

12.2.1 The internal wiring (see 12.1.2) shall be protected or enclosed, except that a length of flexible cord may be employed for external connections, or for internal connections that may be exposed during servicing, if flexibility of the wiring is essential.

12.2.2 The wiring between the end of the element and the wiring compartment need not be enclosed in a metal raceway if:

a) It is enclosed:

1) In impregnated-glass fiber sleeving no less than 0.015 in (0.38 mm) thick, with the impregnation rated for the temperature attained on the wire,

2) In unimpregnated-glass fiber sleeving no less than 0.020 in (0.51 mm) thick, or

3) In other equivalent sleeving or tubing, and

b) The wiring insulation is no less than 1/32 in (0.8 mm) thick and the exposed length of wiring is no more than 1 in (25.4 mm).

12.2.3 Internal wiring that is exposed through an opening in the enclosure is considered to be protected as required in 12.2.1 if, when judged as though it were enamel-insulated wire, the wiring would be acceptable according to 4.13 and Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 5. Internal wiring within an enclosure is acceptable if, even though it can be touched with the probe, it is so protected or guarded that it cannot be grasped or hooked in such a manner that it could be subjected to stress.

12.2.4 If the wiring is so located that it may be in proximity to flammable material or may be subjected to physical damage, it shall be in metal-clad cable, rigid metal conduit, electrical metallic tubing, metal raceway, or shall otherwise be equivalently protected.

12.2.5 Wiring shall be protected from sharp edges (including male screw threads), burrs, fins, moving parts, and other agencies that might abrade the insulation on conductors.

12.2.6 A hole by means of which insulated wires pass through a sheet-metal wall within the overall enclosure shall be provided with a smooth rounded bushing or shall have smooth well-rounded surfaces upon which the wires may bear, to prevent abrasion of the insulation. A flexible cord used for external interconnection as mentioned in 12.2.1 shall be provided with bushings and strain relief in accordance with 10.2 and 10.3.1 – 10.3.4 unless the construction is such that the cord will be protected from stress or motion.

12.2.7 When relative motion occurs between insulated wire and metal through which the wire passes because of expansion and contraction resulting from changes in temperature, the opening shall be fitted with an insulating bushing or the equivalent.

12.3 Splices

12.3.1 All electrical connections, such as wire nuts, splicing wire connectors, quick-connect terminals, terminal connectors, multi-pin and other forms of wire connectors, shall comply with the following standards:

a) The Standard for Electrical Quick-Connect Terminals, UL 310;

b) The Standard for Wire Connectors, UL 486A-486B;

c) The Standard for Splicing Wire Connectors, UL 486C;

d) The Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E; or

e) The Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977.

Exception No. 1: This requirement is not applicable to current-carrying connections that are located in a low-voltage circuit (see 12.4.11).

Exception No. 2: This requirement is not applicable to the following types of connections:

a) Brazed or welded connections;

b) Soldered connections on printed circuit boards located in a low-voltage circuit (see 12.4.11); or

c) Connections on small components that are mounted on printed circuit boards located in a low-voltage circuit (see 12.4.11).

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

12.3.3 Insulation consisting of two layers of friction tape, of two layers of thermoplastic tape, or of one layer of friction tape wrapped over one layer of rubber tape is acceptable on a splice. Thermoplastic tape wrapped over a sharp edge is not acceptable.

12.3.4 The means of connecting stranded internal wiring to a wire-binding screw shall be such that loose strands of wire will be prevented from contacting other live parts not always of the same polarity as the wire and from contacting dead metal parts. This may be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire, or the like.

12.4 Separation of circuits

12.4.1 Conductors of different circuits used in internal wiring, including insulated wires used in a terminal box or compartment, shall either be:

a) Provided with insulation rated for the highest voltage involved, or

b) Shall be separated by a barrier or spacing from an uninsulated live part connected to a different circuit.

12.4.2 Low-voltage and high-voltage circuits, for example, are considered to be different circuits with reference to the requirement in 12.4.1.

12.4.3 Segregation of insulated conductors may be accomplished by clamping, routing, or an equivalent means that ensures permanent separation from insulated or uninsulated live parts of a different circuit.

12.4.4 Except as noted in 12.4.5 and 12.4.6, barriers shall be provided to separate conductors that will be field-installed from:

a) Conductors of any other circuit that will be field-installed,

b) Conductors of any other circuit that are factory-installed,

c) Uninsulated live parts of any other circuit, and

d) Live parts of the same circuit if unsafe operation can result from short-circuiting of the live parts.

12.4.5 The barriers mentioned in 12.4.4 (a) and (b) are not required if the conductor involved are, or will be, insulated for the maximum voltage of either circuit.

12.4.6 The barriers mentioned in 12.4.4 (c) and (d) are not required if the field-installed conductors will be rated for general wiring or fixture wires rated for 600 volts.

12.4.7 If the field-installed conductors will have insulation less than that for the conductors described in 12.4.6, the barrier mentioned in 12.4.4 (d) is not required if the circuit is low-voltage and if short-circuiting of the live parts will not result in a risk of fire or electric shock.

12.4.8 With respect to 12.4.4 (a) and (b) a removable barrier or one having openings for the passage of conductors may be employed, provided instructions for the use of the barrier are a permanent part of the appliance. If complete instructions, in conjunction with a wiring diagram, will provide for the designated separation of the high-voltage and low-voltage circuits, the barrier may be omitted.

12.4.9 Segregation of field-installed conductors from other field-installed conductors and from uninsulated live parts of the heater connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors, with respect to the terminals or other uninsulated live metal parts, so that there is no likelihood of the intermingling of the conductors or parts of different circuits.

a) If the number of openings in the enclosure does not exceed the minimum required for the intended wiring of the heater and if each opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 12.4.4, that the conductors entering each opening will be connected to the terminals opposite the opening.

b) If more than the minimum number of openings are provided, there shall be no likelihood of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit.

12.4.10 To determine if a heater complies with the requirement in 12.4.4, it is to be wired as it would be in service. In so doing, slack is to be left in each conductor within the enclosure, and this slack is to be stowed in the wiring compartment.

12.4.11 A circuit classified as low-voltage is one involving a potential of not more than 30-volts, alternating-current (42.4 peak) or direct current and supplied by a primary battery or by a Class 2 transformer or by a combination of transformer and fixed impedance which, as a unit, complies with all the performance requirements for a Class 2 transformer.

12.4.12 A circuit derived from a source of supply classified in 12.4.13 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 as described in 12.4.11.

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

12.4.14 A metal barrier shall have a thickness at least as great as the required thickness of the enclosure metal. A barrier of insulating material (see Section 14, Electrical Insulation) shall have a minimum thickness of 0.028 in (0.71 mm).

12.4.15 Unclosed openings in a barrier for the passage of conductors shall be no larger in diameter than 1/4 inch (6.4 mm) and shall not exceed in number, on the basis of one opening per conductor, the number of wires that will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may be in contact with it; and the area of any such opening, with the closure removed, shall be no larger than required for the passage of the necessary wires.

13 Heating Elements

13.1 A heating element shall be supported so as to prevent sagging, loosening, and other adverse conditions of the element resulting from:

a) Continuous heating, or

b) Flexing of the element supports or related wiring due to alternate heating and cooling of the element.

13.2 A sheath type heating element shall comply with the requirements in:

a) The Standard for Sheathed Heating Elements, UL 1030; or

b) The Standard for Electric Heating Appliances, UL 499, except the minimum sheath thickness shall be 0.016 in. (0.33 mm) for stationary products.

14 Electrical Insulation

14.1 Material for the mounting of current-carrying parts shall be of moisture resistant material such as porcelain, phenolic, or cold-molded composition.

14.2 Vulcanized fiber may be used for the insulating bushings, washers, separators, and barriers but not as the sole support for uninsulated live parts of other than low-voltage circuits.

14.3 Magnesium oxide compounds are capable of being used as electrical insulation only when protected against mechanical damage and absorption of moisture such as in sheathed heater elements.

15 Thermal Insulation

15.1 Thermal insulation shall be of such nature and so located and mounted or supported that it will not be adversely affected by any intended operation of the heater. See also 32.1.11.

15.2 Thermal insulation that is not rigid shall be so mounted or supported that it will not sag. Adhesive material employed for mounting thermal insulation shall be rated for use at the temperature to which it may be subjected.

15.3 Determination of the quality of an adhesive may be omitted if the thermal insulation is mechanically supported by at least one rivet or the equivalent per square foot of material (at least 11 rivets or the equivalent per square meter of material).

15.4 Flammable thermal insulation shall not be acceptable if it is so located that it may be in a current of air within the heater.

15.5 Flammable or electrically conductive thermal insulation shall not make contact with uninsulated live parts of a heater.

16 Motors

16.1 A motor shall comply with the Standard for Rotating Electrical Machines - General Requirements, UL 1004-1.

16.2 A motor winding shall resist the absorption of moisture. Enameled wire is not required to be additionally treated to prevent absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials shall be provided with impregnation or otherwise treated to prevent moisture absorption.

17 Motor Overload Protection

17.1 Thermal protection devices integral with the motor shall comply with one of the following:

a) The Standard for Overheating Protection for Motors, UL 2111;

b) The Standard for Thermally Protected Motors, UL 1004-3; or

c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2 Particular Requirements for Thermal Motor Protectors, UL 60730-2-2; in conjunction with the Standard for Thermally Protected Motors, UL 1004-3 (to evaluate the motor-protector combination).

17.2 Impedance protection shall comply with one of the following:

a) The Standard for Overheating Protection for Motors, UL 2111; or

b) The Standard for Impedance Protected Motors, UL 1004-2.

17.3 Electronic protection integral to the motor shall comply with the Standard for Electronically Protected Motors, UL 1004-7.

17.4 Except as indicated in 17.3, electronically protected motor circuits shall comply with one of the following. See 3.3.4 for basic control requirements:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. When the protective electronic circuit is relying upon software as a protective component, it shall comply with the requirements in the Standard for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software Class 1;

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1. If software is relied upon to perform a safety function, it shall be considered software Class B; or

c) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1.

Exception: Compliance with the above standards is not required for an electronically protected motor circuit if there is no risk of fire, electric shock, or injury to persons during abnormal testing with the motor electronic circuit rendered ineffective; compliance with the applicable requirements of this end product standard is then required.

18 Overcurrent Protection

18.1 A heater rated at more than 48 amperes shall have the heating elements subdivided. Each subdivided circuit shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

18.2 The overcurrent protective devices required by 18.1 shall be provided as an integral part of the equipment or shall be provided as a separate assembly (for independent mounting) for use with the equipment. See 59.11.

18.3 The overcurrent protection mentioned in 18.1 – 18.3, 18.7, and 18.8 shall be of a type recognized in the National Electrical Code, ANSI/NFPA 70, for branch-circuit protection.

18.4 A motor, except as indicated in 18.5, in a heater rated at more than 16 amperes shall be protected by an overcurrent device having a maximum ampere rating in accordance with the National Electrical Code, ANSI/NFPA 70. Such overcurrent protection shall be provided as a part of the heater unless it is determined that equivalent overcurrent protection is incorporated as a branch-circuit protective device.

18.5 The requirement in 18.4 does not apply to a motor rated at 1/8 horsepower (93 W) or less connected to a circuit having overcurrent protection at 50 amperes or less.

18.6 Ordinarily, a motor having thermal protection that complies with the requirements for such devices is acceptable with respect to the requirement in 18.4, if, in the equipment, it will be connected in series with a branch-circuit overcurrent-protective device of the same type and having a current rating no more than that with which the motor-protector combination was tested during the investigation of the protector.

18.7 Overcurrent protection at not more than 20 amperes shall be provided by a circuit breaker or fuses, as a part of the equipment, for each general-use duplex receptacle circuit, for each transformer primary circuit (except as indicated in 18.9), and for each lampholder circuit independent of a heating element included in the heater, unless the equipment would be properly connected in accordance with the National Electrical Code, ANSI/NFPA 70, to a branch circuit rated at 20 amperes or less.

18.8 Overcurrent protection at no more than 15 amperes shall be provided by a fuse or circuit breaker for each general-use single receptacle, unless the equipment would be properly connected in accordance with the National Electrical Code, ANSI/NFPA 70, to a branch circuit rated at 15 amperes or less.

18.9 The overcurrent protection may be omitted from the primary of a Class 2 transformer, and may be omitted from the primary of any other transformer if there is no emission of flame or molten metal from the heater enclosure when the transformer is operated under the conditions described in 18.10 and 18.11.

18.10 The transformer is to be operated continuously at the test voltage indicated in Table 32.2 and at rated frequency with the enclosure grounded. Except as noted in 18.11, the load connected to the output terminals is to be a resistance of such value that three times the full-load rated current will be drawn from the secondary winding; and operation is to be continued until constant temperatures are indicated by a thermocouple on the enclosure unless burnout occurs earlier. The circuit on which the transformer is tested is to be protected by fuses rated at no less than that required for the heater.

18.11 The burnout test is to be conducted with the output terminals of the transformer short-circuited if such condition results in less than three times rated current being drawn from the secondary. If the transformer controls a motor and the motor locked rotor load plus the additional load on the transformer is greater than three times the full-load rated current, the test is to be conducted with the output terminals connected to the motor with the rotor locked, and the other loads in parallel. If the transformer does not control a motor, the load imposed on the transformer by the coils of any solenoids, relays, or the like, with the armature of the largest such device blocked open is determined; and the test is to be conducted with an equal resistance load substituted for the coils if this load is greater than three times the full-load rated

current. If accessible fuses are provided on the transformer, they are to be replaced with dummy fuses, but inaccessible fuses are to remain in the circuit.

18.12 A fuseholder or circuit breaker shall be of a type rated for the particular application and shall not be accessible from outside the enclosure without opening a door or cover, except that the operating handle of a circuit breaker may project outside the enclosure. A plug fuseholder shall be so designed and installed that uninsulated live parts other then the screw shell will not be exposed to contact by persons removing or replacing fuses.

18.13 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1; and the applicable UL 248 Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another applicable UL standard(s) for fuses are considered to comply with this requirement.

18.14 Fuseholders shall comply with one of the following:

a) *Deleted*

b) The Standard for Fuseholders - Part 1: General Requirements, UL 4248-1, and the applicable Part 2 (e.g. UL 4248-9).

18.15 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

Exception: Circuit breakers used in telecommunications circuitry that comply with the Standard for Circuit Breakers For Use in Communications Equipment, UL 489A, need not comply with UL 489.

18.16 Circuit breakers having integral ground fault circuit interrupter capability for protection against electrical shock shall additionally comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

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

19 Thermal Links

19.1 A thermal-link shall be secured in place and so located that it will be accessible for replacement without damaging other connections or internal wiring. See 59.22.

19.2 A thermal-link shall 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 when the heater is connected to a circuit having a voltage in accordance with 32.1.21 and operated in a normal position to cause abnormal heating.

19.3 To determine if a thermal-link complies with the requirement in 19.2, the heater is to be operated five times with separate cutoffs as described above, and with any other thermally operated control devices in the heater short-circuited. Each thermal-link is required to perform acceptably. During the test, the enclosure is to be connected through a 3-ampere fuse to ground.

19.4 A thermal-link that is depended upon to reduce the risk of fire or electric shock due to overheating of a heater during abnormal operation shall comply with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691, in addition to the requirements specified in this standard.

Exception: A type-2 action thermal cut-out, as specified in the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls for

Household and Similar Use; Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9, is considered to comply with the requirements of UL 873.

20 Receptacles and Transfer Switches

20.1 Except as noted in 20.2, an attachment-plug receptacle for general use provided on a heater designed to be connected with other similar units to form a heating system shall not be in electrical connection with the heating-element supply terminals, that is, shall be supplied from a separate circuit.

20.2 If a combination receptacle and transfer-switch accessory is provided, the receptacle may be energized from the heater branch-circuit provided that the receptacle and the heater are not connected simultaneously to the same branch-circuit.

20.3 With reference to 20.2, the transfer-switch accessory shall be adequate for connection to the proper size branch-circuit to which the receptacle-switch combination is intended to be connected. See 59.16.

20.4 If a heater or accessory intended for permanent connection to the power supply contains a polarized attachment-plug receptacle, the heater or accessory shall be so wired that the receptacle contact intended for connection to the grounded circuit conductor is connected to an identified field-wiring terminal or lead.

20.5 Except as indicated in 20.6, in a receptacle accessory for use in or with a permanently mounted heater or heater system, either designed to be mounted in the heater or supplied as a separately enclosed unit, the attachment-plug receptacle shall be provided and shall be of the grounding type.

20.6 With reference to 20.5, the receptacle need not be provided under either of the following conditions, provided the accessory is marked in accordance with 59.34.

a) The receptacle need not be provided if the heater and accessory comply with the requirements of 4.1 – 4.3 and 12.2.1 – 12.2.7, both with and without the receptacle installed.

b) The receptacle need not be provided if the openings for installation of the receptacle are closed by knockouts.

21 Lampholders

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

21.2 Except as noted in 21.3, a lampholder shall be so designed and installed that uninsulated live parts other than the screw shell will not be exposed to contact by persons removing or replacing lamps in service.

21.3 The requirement in 21.2 does not apply if, in order to remove or replace a lamp, it is necessary to dismantle the heater by means of tools. See 59.22.

22 Switches

22.1 A switch or other control device shall have a current and voltage rating no less than that of the circuit (load) which it controls.

22.2 A switch shall be so located or protected that it will not be subjected to physical damage in intended use. A through-cord switch shall not be provided.

22.3 A switch shall be of the indicating type, or the switch function, for example, ON – OFF, HIGH – LOW, and the like, shall be otherwise indicated with marking that is visible when the switch is made accessible.

22.4 A switching device that interrupts the main power-supply circuit to a fixed heater shall be such that, when open, the device will disconnect all ungrounded conductors of the power-supply circuit if the switching device itself (or the pilot device that controls the switching device) has a marked "on" or "off" position.

22.5 A switch or other means of control intended to permit the use of a limited number of elements at one time shall be so located or of such a type that the connections to permit the use of more elements than intended are not apparent.

22.6 A manually operable motor-control switch shall be provided in a heater intended for connection to the power-supply circuit by flexible cord and an attachment-plug cap and employing a motor rated at more than 1/3 horsepower (249 W).

22.7 The disconnecting means of a fixed electric baseboard heater shall have an ampere rating not less than 125 percent of the total load of the motors and the heaters and shall simultaneously disconnect the heater, motor controller (s), and supplementary overcurrent protective devices from all ungrounded conductors.

23 Automatic Controls and Control Circuits

23.1 General

23.1.1 A control circuit shall comply with the requirements in 12.4.

23.1.2 If an auxiliary control device (thermostat or combination thermostat and control switch) in a fixed heater has a marked "off" position, or another wording (such as "no heat," "cold," "O," or the like) that conveys the same meaning as the word "off," it shall disconnect the element or elements it controls from all ungrounded conductors of the power-supply circuit when placed in that position (that is, when not cycling).

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

23.1.4 A safety control or a temperature-limiting control (one designed to prevent unsafe operation of a heater) shall be operative whenever the heater is connected to its power supply. Operation of such a control shall interrupt power to a sufficient number of heating elements to reduce temperature to comply with the requirements of 33.3.

23.1.5 A component such as a pilot light, capacitor, or resistor shall not be connected across the contact terminals of a safety control or a temperature limiting control.

23.1.6 A contactor actuated by a limit control shall comply with the requirement for a limit control if it is a part of the limit-control circuit.

23.1.7 A temperature-limiting control for use with baseboard heaters shall not function during the Continuity of Operation Test. See 32.2.1.

23.1.8 If a thermostat (or combination thermostat and control switch) has a marked position as described in 23.1.9, it shall not function as a thermostat, that is, it shall not respond to temperature changes, while the actuating member is in that position.

23.1.9 The requirement in 23.1.8 applies to a thermostat (or combination thermostat and control switch) that is marked:

a) With an "off" position, or

b) With another wording such as "no heat," "cold," "O," or the like that conveys the same meaning as the word "off."

23.1.10 A thermostat that does not reclose (remains open) when cooled to a temperature of minus 35°C (minus 31°F) is acceptable with respect to the requirements in 23.1.8.

23.2 Terminals and actuating members of safety devices

23.2.1 The terminals of a safety device within the enclosure of a heater shall be so located or further enclosed that they will be protected against accidental short-circuiting or damage.

23.2.2 The bulb, capillary tubing, or other sensing element of a thermostat or limit switch that is depended upon to prevent hazardous operation of the heater shall be so located or guarded as to be protected from physical damage during installation and use of the heater.

23.2.3 In connection with the requirement in 23.2.2, particular attention is to be paid to a heater that, when being installed, requires partial disassembly or permits rearrangement of internal parts.

24 Spacings

24.1 Except as noted in 24.2 and 24.3, the spacings in a heater shall be in accordance with Table 24.1 – Table 24.3.

24.2 The spacings specified in Table 24.1 and Table 24.2 do not apply to the inherent spacings of a component part of a heater.

24.3 At closed-in points only, such as the screw-and-washer construction of an insulated terminal mounted in metal, a spacing of 3/64 in (1.2 mm) is acceptable in a heater rated at 250 volts or less.

24.4 The spacings within a motor connected across a portion of a resistance element or in series with a reactor or an autotransformer shall be based on the full rated voltage of the heater.

24.5 Except as indicated in 24.6, 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 1/32 in (0.8 mm) in thickness, and shall be so located or of such material that it will not be adversely affected by arcing; except that fiber no less than 1/64 in (0.4 mm) in thickness may be used in conjunction with an air spacing of no less than 50 percent of the spacing required for air alone.

24.6 Unless protected from physical abuse during assembly and the intended functioning of the heater, a barrier of mica shall be 0.01 in (0.25 mm) or more in thickness.

Table 24.1
Minimum acceptable spacings at field-wiring terminals and at fuseholders and thermal-links[a,b]

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

[a] The spacings do not apply to connecting straps or busses extending away from wiring terminals, fuseholders or thermal-links. Such spacings are to be judged under Table 24.2.

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

[c] A spacing of not less than 3/8 in (9.5 mm), through air and over the surface, is acceptable at wiring terminals in a wiring compartment or terminal box if the compartment or box is integral with a motor.

Table 24.2
Minimum acceptable spacings through air or over the surface at points other than field-wiring terminals, fuseholders, thermal-links, or inside motor[a]

Parts involved	Potential involved, volts	Inch	(mm)
Between live metal parts of opposite polarity; and between a rigidly mounted uninsulated live metal part and a dead metal part other than the enclosure that either is exposed for persons to contact or may be grounded	0 – 250	1/6	1.6
	251 – 600	1/4[b,c]	6.4[b,c]
Between uninsulated live metal parts and the metal enclosure	0 – 600	1/4	6.4

[a] If an uninsulated live metal part is not rigidly supported, or if a movable dead metal part is in proximity to an uninsulated live metal part, the construction shall be such that at least the minimum acceptable spacing is maintained under all operating conditions and under all normal conditions of handling.

[b] Enamel-insulated wire is considered to be an uninsulated live metal part. However, a spacing of not less than 3/32 in or 2.4 mm (over the surface and through air) is acceptable between a dead metal part and enamel-insulated wire rigidly supported and held in place on a motor coil.

[c] A spacing of 1/16 in (1.6 mm) is permissible at the heating element only in a heater rated for 300 volts or less.

Table 24.3
Minimum acceptable internal motor spacings at other than field-wiring terminals

Potential at the points between which the spacings are measured, volts	Parts involved	Diameter of motor frame, inches (mm)	Through air		Over the surface	
			inch	(mm)	inch	(mm)
0 – 125	Commutator or collector rings	7 (178) or less[a]	1/16	(1.6)	1/16	(1.6)
		More than 7 (178)[a]	1/8[b]	(3.2)[b]	3/16[b]	(4.8)[b]
	Elsewhere in the motor	7 (178) or less[a]	3/32[c]	(2.4)[c]	3/32[c]	(2.4)[c]
		More than 7 (178)[a]	1/8[b,d]	(3.2)[b,d]	1/4[b,d]	(6.4)[b,d]
126 – 250	Commutator or collector rings	7 (178) or less[a]	1/16	(1.6)	1/16	(1.6)

Table 24.3 Continued on Next Page

Table 24.3 Continued

Potential at the points between which the spacings are measured, volts	Parts involved	Diameter of motor frame, inches (mm)	Through air		Over the surface	
			inch	(mm)	inch	(mm)
251 – 600	Elsewhere in the motor	More than 7 (178)[a]	3/16[b]	(4.8)[b]	3/16[b]	(4.8)[b]
		7 (178) or less[a]	3/32	(2.4)	3/32	(2.4)
	Commutator or collector rings and live parts of the bruch rigging	More than 7 (178)[a]	1/4[b,d]	(6.4)[b,d]	1/4[b,d]	(6.4)[b,d]
		7 (178) or less[a]	1/4[e]	(6.4)[e]	1/4	(6.4)
	Elsewhere in the motor	More than 7 (178)[a]	1/4	(6.4)	3/8	(9.5)
		7 (178) or less[a]	1/4[d]	(6.4)[d]	1/4[d]	(6.4)[d]
		More than 7 (178)[a]	3/8[d]	(9.5)[d]	3/8[d]	(9.5)[d]

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

[b] Spacings of no less than 3/32 in (2.4 mm) are acceptable throughout a universal motor.

[c] For a motor rated at 1/3 horsepower (249 W output) or less, these spacings may be no less than 1/16 in (1.6 mm).

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

[e] Spacings involving a collector ring may be no less than 1/8 in (3.2 mm).

25 Grounding

25.1 In a heater or accessory intended for permanent connection to the power-supply circuit, all exposed dead metal parts and all dead metal parts inside the enclosure that are exposed to contact during any servicing operation (including maintenance and repair) and that are subject to becoming energized shall be electrically connected to the equipment-grounding terminal or lead and be conductively connected to the point of attachment of the wiring system.

25.2 Sections of heaters and accessories intended to be interconnected to form a heating system supplied by a single branch circuit shall have provision for maintaining continuity of a metal-to-metal grounding bond between adjacent sections.

25.3 On a portable heater where grounding is provided, whether required or not, the power supply cord shall include a grounding conductor which shall be:

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

b) Connected to the grounding blade of an attachment-plug cap of a grounding type,

c) Connected to the enclosure of the appliance by means of a screw not subject to being removed during ordinary servicing, or by other equivalent means. Solder alone is not acceptable for making this connection (see also 25.5), and

d) Bonded to all exposed dead metal parts and all dead metal parts exposed during any servicing operation (including maintenance and repair) that are subject to becoming energized.

25.4 A cord-connected heater rated more than 150 volts shall have provision for grounding, in accordance with 25.3.

25.5 With reference to 25.3 (c), a grounding connection that is mechanically crimped before being soldered is to be tested for acceptability as a connection without the solder in place.

26 Guarding of Heating Elements

26.1 The heating element and any part of the element assembly such as an element support or sheath, shall be so guarded that flammable material as well as persons will be protected against contacting it.

26.2 The adequacy of a guard is judged with respect to its general serviceableness and with respect to the shape and/or size of the openings in it, in conjunction with the distance of the guard from the heating element and the other high-temperature parts mentioned in 26.1. Except as noted in 26.4, an opening in a guard is considered to be acceptable if, with the heater in any intended operating position, the following conditions are met:

a) The shape and size of an opening are such that a test gauge in the form of a right-circular cone having a base diameter of 2-3/4 in (70 mm) and an altitude of 5-1/2 in (140 mm) is prevented from touching the heating element and the other high-temperature parts mentioned in 26.1 when the gauge is inserted, apex first, in any manner. See 26.3.

b) The shape and size of an opening which permits the vertically downward entrance of a bar 1/2 in (12.7 mm) wide and 1/16 in (1.6 mm) thick are such that a test gauge 1/16 in in thickness and in the form of an isosceles triangle having a base of 2-3/4 in (70 mm) and an altitude of 5-1/2 in (140 mm) is prevented from touching the heating element and the other high-temperature parts mentioned in 26.1 when the gauge is inserted, apex first, in any manner. The testing of an opening with the triangle gauge applies also where the vertically downward insertion of the bar is prevented by the construction of the guard and/or the use of an additional barrier, unless the vertically applied bar tends to be deflected outward, that is, away from the guard.

c) The area of an opening in a substantially vertical face of a guard is no more than 3-1/4 square inches (2100 mm^2) if the size and/or shape of the opening permits the entrance from any horizontal direction of a vertical rod 1/16 inch in diameter and 2-3/4 in long.

26.3 The fins of a metal-clad element are considered to be element-guarding members, and need not comply with the provisions in 26.2 (a) if the temperature of the exposed edges (outer perimeter) of the fins is no more than 280°C (536°F) under conditions of continuous operation.

26.4 For a heater of other than the panel type in which the temperature of the heating element is no higher than 280°C (536°F) under conditions of intended operation, and for a fan-type heater in which the fan is always in operation when the heating element is "on" (energized) and the air current prevents clothing and the like from entering the guard, openings in the guard are acceptable if they comply only with 26.2 (a). For a panel-type heater in which the heating-element temperature is no higher than 280°C under conditions of continuous operation, 26.7 applies.

26.5 If a heater is required to have a guard, and if the guard is removable, the heater and the guard shall be contained in the same carton as shipped from the factory. See also 59.32.

26.6 A heater in which the heating element is designed for intended operation only in an air current, shall be so wired or controlled that the element can be operated only when under the cooling effect of the air stream. A heater in which the cooling effect of the motion of a part is necessary to prevent excessive temperatures shall be so wired or controlled that the element cannot be operated without such motion.

26.7 Except as noted in 26.8, a panel-type heater shall be provided with a guard that will prevent a test surface, in the form of a 6-inch square (a square 150 mm on a side) parallel to the element panel, from being brought closer than 1/2 in (13 mm) to the plane of the front of the heater, excluding the guard.

26.8 The requirement in 26.7 does not apply to a heater having an element panel operating at a temperature higher than 280°C (536°F) and required by 26.1 and 26.2 to have more effective guarding.

26.9 A slot opening in the outer enclosure of a heater that is more than 6 inches (150 mm) in length shall be provided with wire guards or the equivalent at intervals such that no section of the slot is uninterrupted for a distance of more than 6 inches (150 mm).

Exception: The guarding is not required when the heater complies with the Shredded Paper Test, Section 42.

26.10 An opening resulting from intentional manufacturing tolerances needed to permit assembly of enclosure parts does not constitute a slot opening as mentioned in 26.9.

26.11 If parts of the heating element assembly have sharp corners, edges, or projections, such parts shall be guarded in accordance with the provisions of 26.2 (a), irrespective of the temperatures of the fins. See 59.35.

Exception: Parts of the heating element assembly which are so guarded that they cannot be touched by the probe illustrated in Figure 5.1 are considered to be protected against contact.

27 Floor Heaters

27.1 A floor-insert heater shall be so constructed to permit cleaning and to minimize the possibility of the accumulation of flammable dirt and litter where it might become ignited.

27.2 A heater intended to be installed flush with or beneath a floor shall be provided with an automatic temperature control other than a thermal-link. The control shall comply with the requirements in 23.1.2 – 23.1.10.

27.3 There shall be no openings in wiring compartments through which objects such as nails or pins may penetrate and contact uninsulated live parts.

PERFORMANCE

28 General

28.1 If a portable heater is intended to be shipped with the legs detached or arranged in other than the intended operating position, the tests are to be conducted with the legs in place as well as detached or in the shipping position. See 32.1.13 and note (e) to Table 32.1. Assembly instructions shall be furnished. See 61.4.

Exception: The tests with the legs detached or in the shipping position need not be conducted if the heater is marked in accordance with 59.24.

29 Power Input Test

29.1 The power input to a heater shall not be more than 105 percent of its marked rating.

29.2 Power input is to be measured with the heater at the intended operating temperature under full-load conditions and while connected to a supply circuit of rated voltage in accordance with 32.1.21. If a heater employs a nonmetallic element (such as carbon), the power input is to be determined when the element is new.

30 Leakage Current Test

30.1 The leakage current of a cord-connected heater shall be not more than:

a) 0.5 milliampere for a heater having a nominal 120 volt rating, and

b) 0.75 milliampere for a heater having a nominal 208 or 240 volt rating.

Exception: For a heater having a metal sheathed heating element, during the period beginning 5 seconds after energization (closure of S1), the leakage current may exceed the value specified in (a) or (b) for a period not exceeding 5 minutes, but shall not exceed 2.5 milliamperes. The 5-minute period is measured during the warm-up period and again during the cool-down period from the first excursion above the value of (a) or (b) until the value is less than and remains less than the value in (a) or (b).

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

30.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from the surfaces are to be measured to the ground supply conductor individually as well as collectively where simultaneously accessible and from one surface to another where simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure considered acceptable for protection against risk of electric shock as defined in 4.13 and Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 5. Surfaces are considered to be simultaneously accessible where they can be contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at low-voltages as defined by 12.4.11.

30.4 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area of 10 by 20 cm (4 by 8 in) in contact with the surface. Where the surface is less than 10 by 20 cm the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the heater.

30.5 The measurement circuit for leakage current is to be as shown in Figure 30.1. The measurement instrument is defined in (a) – (d). The meter which is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

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

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

c) Over a frequency range of 0 to 100 kilohertz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) equal to the ratio of the impedance of a 1500 ohm resistor shunted by 0.15 microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 milliampere, the measurement is to have error of not more than 5 percent at 60 hertz.

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

30.6 A sample of a heater is to be tested for leakage current starting with the as-received condition with all switches and thermostats closed, but with the grounding conductor, if any, opened at the attachment plug. The as-received condition is without prior energization, except as may occur as part of the production-line testing. However, a cord-connected heater that complies with the Humidity Conditioning Test, Section 51, need not be tested in the as-received condition, but instead may be tested after the

conditioning specified in Section 51. The supply voltage is to be 120 or 240 volts, depending upon the voltage rating of the heater. The test sequence, with reference to the measuring circuit, Figure 30.1, is to be as follows:

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

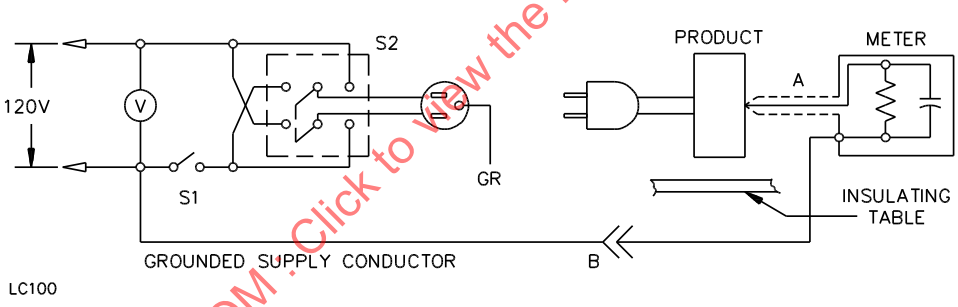
b) Switch S1 is then to be closed, energizing the heater, and within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2 and with the heater operated at maximum heat setting of controls.

c) Leakage current is to be monitored until thermal stabilization under the maximum heat condition. Both positions of switch S2 are to be used. The equivalent of thermal stabilization is considered to be attained as in the Continuous Operation Test, 32.3.1 and 32.3.2. If any adjustable thermostat does not cycle at the maximum heat setting, it is to be adjusted until it does cycle before the final measurements at thermal stabilization are taken. Measurements are to be made with the thermostat, if any, open and closed.

d) If the heater employs a single pole switch or a control thermostat for adjusting temperatures, then monitoring of leakage current is to continue until the leakage current stabilizes or decreases after the heater is turned off.

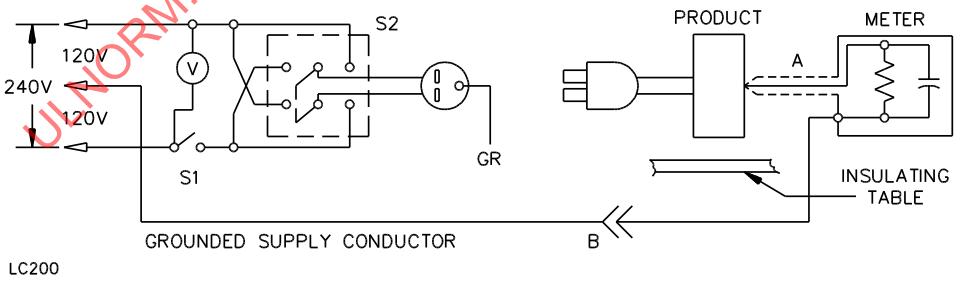
Figure 30.1

Leakage-current measurement circuits



LC100

Product intended for connection to a 120 volt power supply.



LC200

Product intended for connection to a 240 or 208 volt power supply.

a) Probe with shielded lead – under some circumstances where higher frequency components are present, shielding of measuring instrument and its leads may be necessary.

b) Separated and used as clip when measuring currents from one part of product to another.

31 Continuity of Grounding Connection Test

31.1 The resistance of the grounding path between all exposed dead metal parts and all dead metal parts exposed during any servicing operation (including maintenance and repair) that are liable to be energized, and the equipment-grounding terminal or lead or the point of attachment of the wiring system or the grounding blade of an attachment plug, shall be no more than 0.1 ohm.

31.2 The resistance may be determined by any convenient method except that when referee measurements are necessary, either a direct or alternating current at a potential of no more than 12 volts, and equal to the maximum current rating of the branch-circuit overcurrent protection device that may be employed with the heater is to be passed from the equipment grounding terminal or the point of attachment of the wiring system or the grounded blade of the attachment plug to the dead metal part, and the resulting drop in potential in volts divided by the current in amperes passing between the two points is to be calculated to obtain the resistance.

32 Temperature Test

32.1 General

32.1.1 An automatic temperature-regulating control is to be shunted out of the circuit during all Continuous Operation and Abnormal Operation Tests. If its operation is so affected by the temperature of the external ambient air that a hazardous condition may result, a temperature-limiting control is also to be shunted out of the circuit unless the heater is subjected to the tests specified in 32.1.2.

32.1.2 The temperature-limiting control need not be shunted out of the circuit if all of the Abnormal Operation Test (overvoltage, tip over, drape, stalled fan, cheesecloth drape, padded surface and blanketing usually performed on the heater) are repeated while the heater is located in a room having an average temperature of 0°C (32°F).

32.1.3 For both Continuous Operation and Abnormal Operation Tests, a portable heater and sections of fixed heaters are to be mounted in the intended manner in a wall angle as described in 32.1.9. The sections are to be installed as close to the floor as their construction will permit unless they are marked in accordance with 59.30.

32.1.4 The test installation of a baseboard-type heater system is to employ at least three heater sections and one or more accessory section, unit, or fitting intended for use with the system, such as receptacle, thermostat, or corner sections. An accessory section is to be connected between two heater sections. If an inside corner section is supplied, it is to connect two heater sections as intended.

32.1.5 The felt mentioned in 32.1.14 and 40.2 is to be 100-percent standard-weight, all-cattle-hair, punched felt with center reinforcement consisting of burlap having a mass of 5 ounces per square yard (170 g/m^2). Felt 1 in (25 mm) thick has a mass of 105 ±15 ounces per square yard (3.56 ±0.51 kg/m^2). Felt 3/4 in (19 mm) thick has a mass of 79 ±9 ounces per square yard (2.68±0.31 kg/m^2).

Exception: SAE J314, Grade F-11, minimum 1 inch (25 mm) thick wool felt may be used as a substitute for the all-cattle-hair mat.

32.1.6 Wherever cheesecloth is mentioned in connection with either a Normal- or an Abnormal-Temperature Test, the cloth is to be bleached cheesecloth 36 in (910 mm) wide, running 14 – 15 yards per pound (approximately 28 – 30 m/kg), and having what is known to the trade as a "count of 32 x 28," that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 threads in the other direction).

32.1.7 The blanket material mentioned in 40.3 is 100 percent unbleached cotton flannelette sheet blanket, and is generally available in the 80-by-108-in (2-by-2.7-m) size.

32.1.8 The white duck material mentioned in 41.2 is to have a mass of 8 ounces per square yard (0.27 kg/m^2).

32.1.9 A heater is to be mounted or placed in the intended manner on or against the black-painted surface of a wall consisting of 3/8 in (9.5 mm) thick plywood fastened to both shorter sides of trade size "2 x 4" (38 x 89 mm) vertical wooden studs on 16-in (405-mm) centers. Two or more such walls are to be fastened together to form a 90-degree angle, and the height and length of the walls are to be such that they extend not less than 2 ft (610 mm) beyond the physical limits of the heater, see 41.2. The heater is to be located as close to the sides of the wall angle as its construction will permit, and it is to be so placed relative to the walls that maximum heating will occur on the latter.

32.1.10 In addition, an individual wall-insert heater is to be mounted in a box-like structure of 3/8-in (9.5-mm) plywood or the equivalent with the internal dimensions such that the walls make a close fit with the heater shell on the four sides and rear (but the walls of the box are to be perpendicular to its back) and having a flat front surface simulating the wall surface in which the heater is designed to be mounted. The assembly of the heater and the plywood box is to be mounted in an appropriate opening in the wall mentioned in 32.1.9. The depth of the wall is to be increased if necessary to accommodate the heater and box-like structure.

32.1.11 Unless it has been determined that it will remain in position during the handling of the heater prior to and during installation and after the heater has been installed, external thermal insulation, such as mats of woven glass fiber or mineral wool, is to be removed from the heater before it is installed in or on the surfaces of the test enclosure.

32.1.12 Rubber or other material similarly subject to deterioration is to be removed from feet or other supports of a portable heater if the removal of the material is liable to result in higher temperatures being attained on the heater.

32.1.13 If the removal of feet or other supports results in operation of protective devices during the Continuous Operation Test, such operation is not considered to be unacceptable if, when the test is repeated with the parts replaced in the intended manner, there is no operation of the protective devices.

32.1.14 To simulate carpeting, 3/4-in (19-mm) thick felt pads are to be used and are to be located as specified in 32.1.15.

32.1.15 A heater shall be tested under the applicable conditions in accordance with 32.1.14 and the following:

a) If carpeting or equivalent material can be laid flat on the floor within its lower opening, the heater shall be tested with such materials so placed and pushed as far back as the construction will permit.

b) If guards or other design features prevent carpeting or equivalent material from being laid flat on the floor within the lower opening of the heater, the test shall be made with such material as close to the heater as the heater construction will permit.

c) If marked in accordance with 59.30, a fixed heater shall be mounted with its lower edge of the specified distance above the floor, and the test shall be made with carpeting or equivalent material placed close to the wall below the heater.

32.1.16 Temperatures are to be measured by thermocouples consisting of wires no larger than 24 AWG (0.21 mm^2) and no smaller than 30 AWG (0.05 mm^2) except that a coil temperature may be determined by

the change-of-resistance method if the coil is inaccessible for mounting thermocouples (see 32.1.18). When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wire and a potentiometer-type instrument; and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

32.1.17 A temperature is considered to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test (but no less than 5-minute intervals), indicate no change. The thermocouple wire is to conform with 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.

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

32.1.19 A thermocouple is to be used for determining temperature of a coil or winding when it can be mounted, without removal of encapsulating compound or the like:

a) On the integrally applied insulation of a coil without a wrap; or

b) On the outer surface of a wrap that is no more than 1/32 in (0.8 mm) thick and consists of cotton, paper, or rayon (but not thermal insulation).

The change-of-resistance method is to be used when the thermocouple measurement cannot be conducted in accordance with the foregoing considerations. For a thermocouple-measured temperature of a motor coil, the thermocouple is to be mounted on the integrally applied insulation on the conductor.

32.1.20 At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by means of a thermocouple may be higher by the following amount than the maximum indicated in Table 32.1, if the temperature rise of the coil measured by the resistance method is no greater than specified in Table 32.1.

Item in Table 32.1	Additional thermocouple rise, degree C (F)
A.1.a	5 (9)
A.2.a and B.1.a	15 (27)
A.3.a	10 (18)
A.4.a	20 (36)

32.1.21 To determine if a heater complies with these requirements, it is to be operated continuously until constant temperatures have been reached. The test voltage is to be as indicated in Table 32.2, except that if the application of the indicated test voltage does not result in the measured wattage input to the heater being equal to or more than the marked rating, the test voltage is to be increased until the measured wattage input equals the marked rating.

Table 32.1
Maximum temperature rises

Materials and components	Degrees	
	C	F
A. Motor[a]		
1. Class A insulation systems on coil windings of alternating-current motors 7 in (178 mm) or less in diameter (not including universal motors).		
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 more than 7 in (178 mm) in diameter and of direct-current and universal motors:		
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 7 in (178 mm) or less in diameter (not including universal motors):		
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 systems on coil windings of alternating-current motors more than 7 in (178 mm) in diameter and of direct-current and universal motors:		
a. In open motors;		
Thermocouple	85	153
Resistance method	95	171
b. In totally enclosed motors;		
Thermocouple	90	162
Resistance method	100	180
B. Components		
1. Relay, solenoid, transformer, and other coils with:		
a. Class 105 insulation system;		
Thermocouple method	65	117
Resistance method	85	153
b. Class 130 insulation system;		
Thermocouple method	85	153
Resistance method	105	189
c. Class 155 insulation system:		
Class 2 transformers;		
Thermocouple method	95	171
Resistance method	115	207

Table 32.1 Continued on Next Page

Table 32.1 Continued

Materials and components	Degrees	
	C	F
Power transformer;		
Thermocouple method	110	198
Resistance method	115	207
d. Class 180 insulation system:		
Class 2 transformer;		
Thermocouple method	115	207
Resistance method	135	243
Power transformer;		
Thermocouple method	125	225
Resistance method	135	243
2. Other components and materials:		
a. Fiber used as electrical insulation or required bushings	65	117
b. Varnished cloth insulation	60	108
c. Thermoplastic material	25°C (77°F) less than its temperature rating	
d. Phenolic composition used as electrical insulation or as parts where failure will result in non-compliance with the other requirements in this standard[b]	125	225
e. Wood or other combustibles	65	117
f. Sealing compounds	40°C (77°F) less than the melting point	
g. Fuses	65	117
C. CONDUCTORS		
1. Flexible cord and wire	25°C (77°F) less than its temperature rating[c]	
2. Copper conductor, bare or insulated without tinning, nickel coating, or silver plating, except as noted in item 3	175	315
3. Termination of copper conductor in a pressure terminal connector, unless both are tinned, nickel-coated, or silver-plated	125	225
D. GENERAL		
1. Any point on a surface adjacent to a permanently connected product or to a cord-connected heater (including the surface on which it is mounted), specified points on test surfaces and enclosures at designated clearances from the product, a metal surface of the product at the point of contact with the test surface, and the exterior surface of a recessed product that may come into contact with combustible material within the test enclosure	65	117
2. Any point within a terminal box or wiring compartment of a permanently connected appliance in which field-installed conductors are to be connected, including such conductors themselves, unless the appliance is marked in accordance with 59.25	35	63
3. Register temperatures floor insert heater:		
a. Metallic grille	44	80
b. Nonmetallic grille	50	90
4. Knobs and handles, or buttons likely to be contacted by the user during normal operation, and the surfaces likely to be contacted by hands or fingers in grasping handles or buttons[d,e]		
a. Metal	35	63

Table 32.1 Continued on Next Page

Table 32.1 Continued

Materials and components		Degrees	
		C	F
	b. Nonmetallic[f]	60	108
5.	All exposed exterior surfaces of heaters which are not defined by (3) and (4)[e,g]	60	108

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

[b] The limitations on phenolic composition do not apply to compounds which have been investigated and found to have special heat-resistant properties.

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

[d] Points likely to be contacted by a hand or fingers include those points on the gripping surface and adjacent surfaces close enough to be touched while supporting the heater in the normal intended manner. The length of a normal gripping surface is to be considered 4 in (102 mm). Points on a surface are not to be considered likely to be contacted if protected by a barrier not less than 5/8 in (15.9 mm) wide on which the temperature rise does not exceed the value indicated in (D4) or if a through air spacing of not less than 1-1/2 in (38 mm) at the index finger is provided from the gripping surface to the hot part.

[e] For portable heaters which are shipped with the legs detached, these temperature limitations are applicable only when the heater is operated with the legs in place. See 28.1.

[f] A knob, handle, or button made of nonmetallic material which is plated or clad with metal having a thickness of 0.005 in (0.13 mm) or less is considered to be and is judged as a nonmetallic part.

[g] Exposed exterior surfaces of heaters are to be defined as the surfaces making contact with a circular disc gage 8 in (203 mm) in diameter and 1/16 in (1.6 mm) thick when the gage is rolled around the contour of the heater, perpendicular to the horizontal axis of the heater. This determination is to be made with the heater unmounted, but is to exclude those surfaces in contact with the intended mounting surfaces of the heater.
Exception: On heaters which are marked as indicated in 59.2, this temperature limit does not apply within 1 in (25.4 mm) as measured over surface from the outermost edge of any opening through which heated air passes. The outermost edge of such an opening is considered to be the location closest to the opening contacted by the disc gage, and the 1 in (25.4 mm) is to be measured in a direction away from the opening. See Figure 32.1.

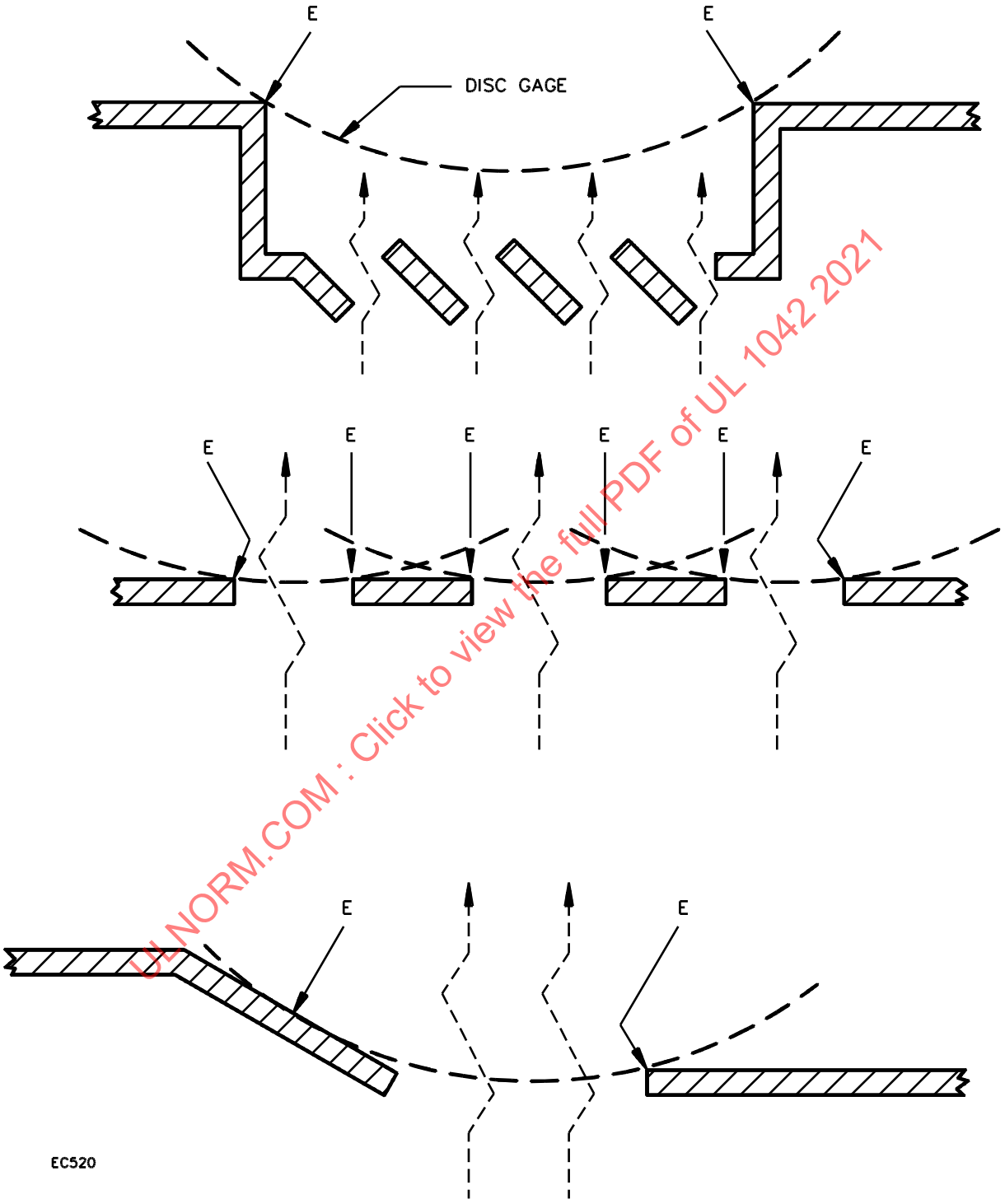
Table 32.2
Voltage for temperature test[a]

Marked voltage rating	Test potential in volts
Value within one of the specified ranges	Highest value of corresponding specified ranges
Value not within one of the specified ranges	Rated Voltage

[a] "Specified range" refers to any of the ranges of voltage mentioned in 59.1.

Figure 32.1

Typical outlet air openings – "outermost edges" indicated by "E"



32.1.22 If a heater employs a motor in addition to a heating element, the voltage applied to an integrally connected motor is to be the marked voltage rating of the heater, in accordance with 59.1. A motor supplied from a separate circuit is to be operated at a voltage (depending upon the motor rating) as specified for an integrally connected motor.

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

32.1.24 Temperatures on the register of floor insert heaters are to be obtained after equilibrium outlet air temperatures are attained. Surfaces of the register, in an essentially horizontal plane, and likely to be contacted by a person walking or falling upon the grille are then to be explored with a surface pyrometer to determine the single point attaining the highest temperature rise. The thermocouple is then to be attached at this point and this temperature is to be recorded until an equilibrium temperature condition is attained. See (D.3) of Table 32.1 for the application temperature rise limit.

32.2 Continuity of operation test

32.2.1 The limit control of a heater shall not function when the heater is operated under the conditions of the Continuous Operation Test, at room ambient temperature. A room ambient temperature of 25°C (77°F) is assumed. The test may be conducted at a higher ambient temperature provided the limit control does not operate (open circuit).

32.3 Continuous operation test

32.3.1 Baseboard heating equipment shall not attain a temperature at any point as to constitute a risk of fire or to damage any material employed in the heater, nor show temperature rises at specific points greater than those indicated in Table 32.1.

32.3.2 All values in Table 32.1 are based on an assumed ambient (room) temperature of 25°C (77°F), but a test may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F).

33 Abnormal Operation Test

33.1 The applied voltage and method of mounting shall be in accordance with 32.1.21 – 32.1.23, during all Abnormal Operation Tests. In most cases, continuous operation for 7 to 8 hours will be necessary in order to make sure that the ultimate results have been observed.

33.2 When operated under such abnormal conditions, a heater is considered to involve a risk of fire if any of the temperatures measured on the flammable material exceed the maximum limits indicated in 33.3, if there is any emission of flame or molten metal, or if there is glowing or flaming of the flammable material upon which the heater is placed or, in the case of a permanently installed heater, of flammable material that is in proximity to the device as installed.

33.3 During the abnormal tests covered by Sections 37, 38, 40, and 41, the temperatures of the cheesecloth or blanket material shall not exceed 175°C (347°F), except that during the initial 5 cycles of operation of the limit control or 2 hours, whichever comes first, a temperature of 200° C (392° F) is permitted. The temperature of the cheesecloth is to be measured by thermocouples located between the layers of the cheesecloth, and the temperature of the blanket is to be measured by thermocouples located between the two layers of blanket closest to the heater.

33.4 After having been subjected to an abnormal test, a cord-connected heater is considered to involve a risk of electric shock if:

a) It appears to be useable, and

b) The insulation resistance is less than 50,000 ohms.

33.5 If a motor is connected across a portion of a resistance element, the heater shall not create a risk of fire and shall emit neither flame nor molten metal as the result of an open circuit in that portion of the element that is in parallel with the motor.

34 Overvoltage Test

34.1 A heater shall be capable of operating for 2 hours without creating a risk of fire, while connected to a supply circuit of the intended capacity and having a potential 12 percent more than the rated voltage of the heater.

34.2 The heater is to be operated at a voltage in accordance with 32.1.21 until constant temperatures are attained, following which it is to be operated for 2 hours at a 12 percent higher voltage.

35 Motor Switch Overload

35.1 A switch or other device that controls a motor, unless so interlocked that it will never have to break the locked-rotor motor current, shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation, making and breaking the locked-rotor current of the motor.

35.2 A switch or other control device is to be connected to a grounded supply circuit of rated frequency and of voltage in accordance with 32.1.21, with the rotor of the motor locked. During the test, exposed dead metal parts of the heater are to be connected to ground through a 3-ampere fuse, and the current-rupturing device, if single-pole, is to be located in an ungrounded conductor of the supply circuit. If the heater is intended for use on direct current, or on direct current as well as alternating current, the test is to be conducted with direct current and exposed dead metal parts are to be so connected as to be positive with respect to a single-pole, current-rupturing device. The device is to be operated at the rate of 10 cycles per minute, except that a faster rate of operation may be employed if agreeable to all concerned. The performance is unacceptable if the fuse in the grounding connection is blown during the test.

35.3 The switch or device shall be mechanically and electrically operable at the conclusion of the test, at which time the device shall be capable of performing its intended function and shall show no wear, loosening of parts, or defects of any other description which will diminish the reliability of the device.

36 Stability Test

36.1 A portable heater shall return to its intended at-rest position on a level surface after being subjected to the following separate conditions:

a) Tipped in any direction to an angle of 10 degrees from horizontal, and

b) Subjected to a force of 4 lbs (17.8 N) or 25 percent of the weight of the heater, whichever is less, externally applied in a horizontal direction to the point on the heater providing the greatest tendency to overturn it.

36.2 The tests are to be conducted on the units when placed under the most unfavorable conditions. The heater shall be arranged with all doors and other appurtenances in the position tending to decrease stability. The legs or other points of support may be blocked to prevent the unit from sliding during the application of the externally applied force.

37 Tip Over Test

37.1 A cord-connected heater overturned in any position on a softwood surface covered with a double layer of cheesecloth, shall not cause the cloth or wood to glow or flame.

37.2 A heater is to be operated under the most severe conditions that would result when it comes to rest, without further guiding or propping, after having been pushed over. The heater is to be operated as in the Continuous Operation Test until the temperatures stabilize before being tipped over. See also 33.4.

38 Cheesecloth Drape Test

38.1 A heater covered with a double layer of cheesecloth shall not cause the cloth to glow or flame.

38.2 The entire length of the heater is to be initially covered and the lower end of the cheesecloth is to be arranged to conform as closely as possible with the contour of the heater, see Figure 38.1 and Figure 38.2. The heater shall be at approximately room ambient temperature at the start of this test. The test is to be repeated by operating the heater until constant temperatures are attained before covering it with the double layer of cheesecloth. The temperature limitations specified in 33.3 are not applicable during this repeated portion of the test.

38.3 In a test to determine whether or not a combination heater and motor-drive fan complies with the requirement in 38.1 the fan is to be operated when the heater is covered with cheesecloth.

Figure 38.1

Cheesecloth drape

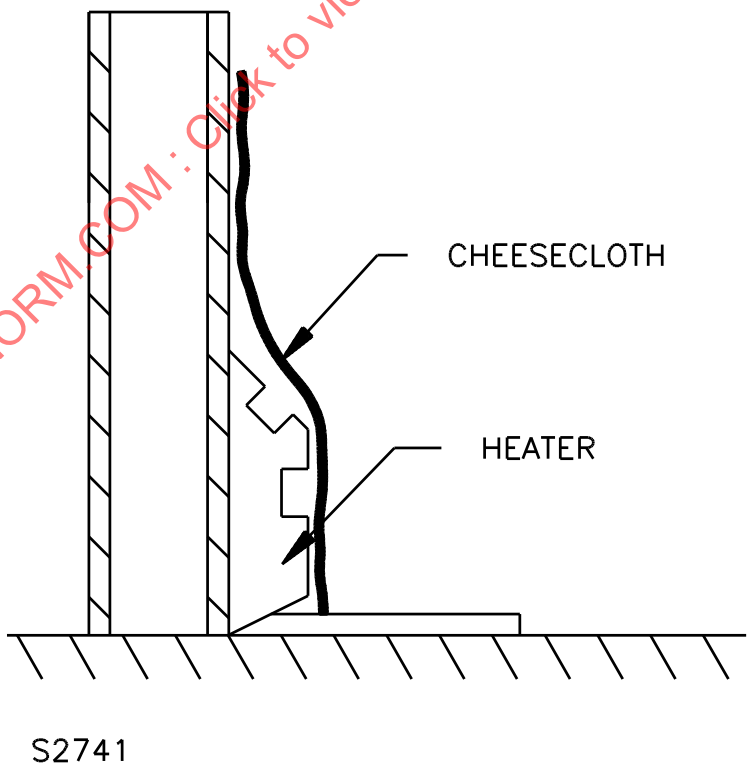
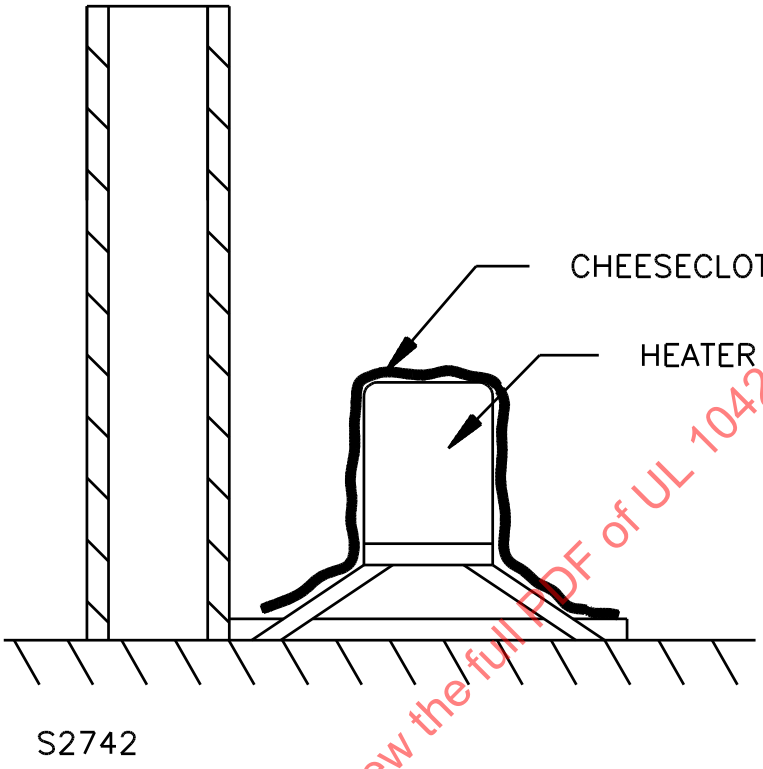


Figure 38.2

Cheesecloth drape



39 Stalled Fan Test

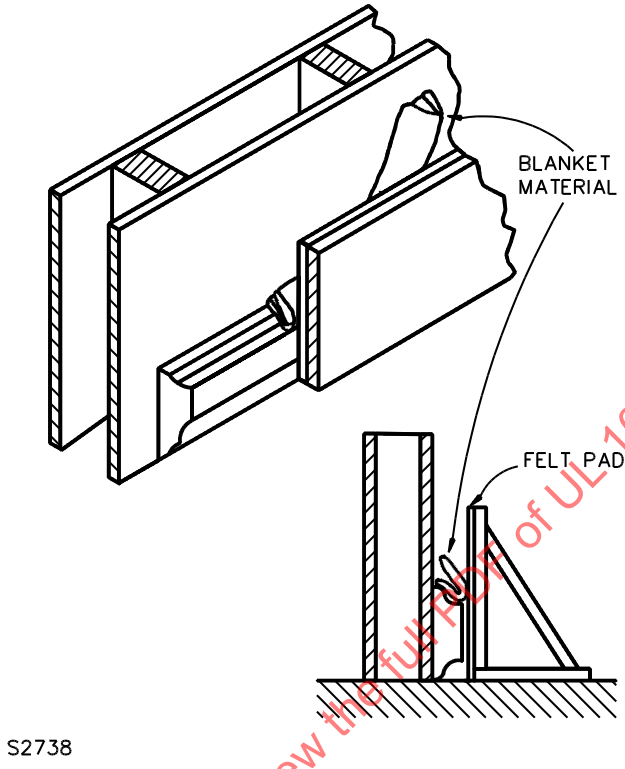
39.1 A combination heater and motor-driven fan shall not create a risk of fire and shall emit neither molten metal (excepting melted solder) nor flame with the fan motor stalled and without any cheesecloth covering the appliance.

40 Padded Surface and Blanketing Test

40.1 When tested in accordance with 40.2 and 40.3, a heater shall not cause the cheesecloth, felt, blanket material, or wood to glow or flame. The heater shall be at approximately room ambient temperature at the start of the Padded Surface Tests and at the start of the Blanketing Tests. See also 33.4.

Figure 40.1

Test of baseboard – type heater



40.2 A wood surface covered with a 1 in (25 mm) thick felt pad, and with the pad, in turn, covered by a double layer of cheesecloth, is to be supported in a vertical position as near the heater as the construction of the latter will permit. The heater sections are to be covered to such an extent as to produce maximum heating of the cheesecloth, and the padded surface is to extend at least 3 in (76 mm) above the top surface of the heater. During the test, the covered wood surface is to be moved horizontally 1/2 in (13 mm) away from its initial position and operation continued until temperatures stabilize. If it is determined that its temperature increases when the surface is moved horizontally, the test is to be repeated with the surface in the new position starting with the heater at approximately room ambient temperature. The wood surface is to be of sufficiently rigid construction so that it will not change shape (bow or warp) during the test.

40.3 With the padded vertical surface in its initial position in front of the heater, four thicknesses of loosely folded cotton blanket material are to be introduced into the space between the vertical padded surface and the vertical wall on which the heater is mounted in such a manner that the upper slot of the heater is blocked. The folded blanket material is to be located at any points along the length of the heater installation in such a manner that any sensing device provided is so exposed as to produce the most adverse operating conditions. A length of folded material up to a maximum of 80 in (2 m) is to be used, but a shorter length of the material may be introduced into the space at any one time (see Figure 40.1) to obtain the most adverse operating conditions possible. Operation in any one blocked condition is to be continued until constant temperatures are obtained, or until glowing or flaming of the cotton blanket material results.

41 Curtain Drape Test

41.1 A heater shall not cause a curtain draped in front of it to glow or flame. See also 33.4.

41.2 The upper edge of a simulated curtain at least 3 ft (0.9 m) high, but long enough to be supported at least 1 ft (300 mm) above the heater in any case, is to be continuously attached to the wall at the base of which the heater is installed. The curtain is to consist of white duck as specified in 32.1.8 and an overlay of a double layer of cheesecloth on the side facing the heater, and is to be hung so that the lower edge just touches the floor. During the test, the entire length of the heater is to be initially covered and the curtain is to be arranged to conform as closely as possible with the contour of the heater. See Figure 41.1 and Figure 41.2. Those sections judged to be least likely to affect the operation of the limit control are to be covered. This test shall then be repeated with first:

a) 3/4 of the heater covered, then with

b) 1/2 of the heater covered, and then with

c) 1/4 of the heater covered.

Each test shall be conducted with the heater at room ambient at the start of the test.

Figure 41.1

Curtain drape

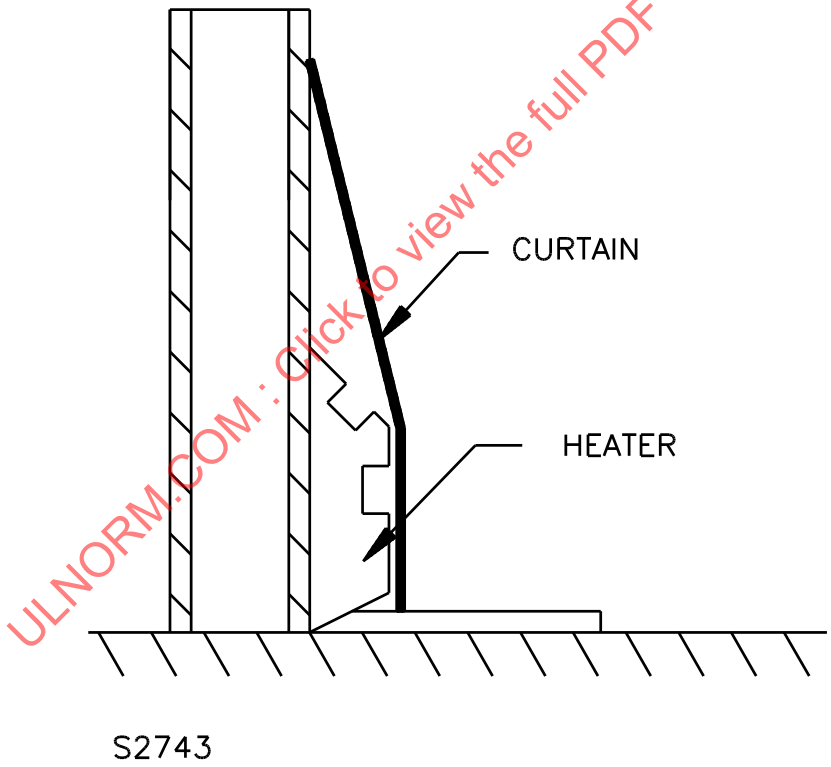
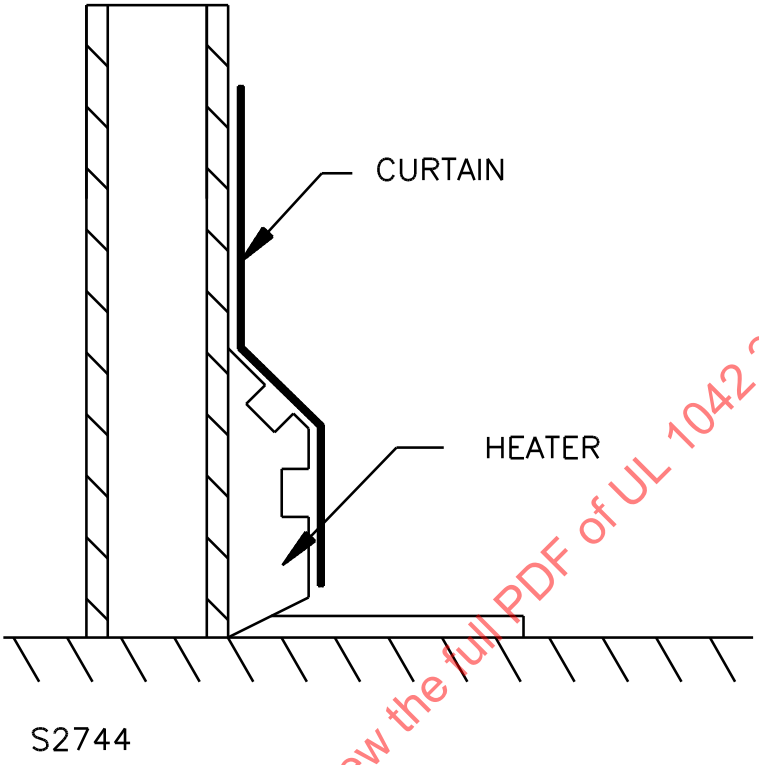


Figure 41.2

Curtain drape



42 Shredded Paper Test

42.1 When the guard described in 26.9 is not provided, there shall be no glowing or flaming of dry, shredded newspaper while a heater is in operation under otherwise intended conditions. The newspaper is to be introduced in any quantity and position in the open slots to attain the most adverse operating conditions.

42.2 A floor insert heater is to be operated as described in 32.1.1, 32.1.2, 32.1.9, 32.1.10, and 32.1.24. Two sheets of newspaper having face dimensions equal to the grille of the heater are to be shredded into strips and the strips are then to be slowly (over a period of 5 minutes) inserted through the heater's grille. There shall be no glowing or flaming of the dry, shredded paper while the heater is operated for 7 hours or until the ultimate results have been observed.

43 Hydro-Static Pressure Test

43.1 Except as noted in 43.2, a part that is subject to air or vapor pressure (including the vapor pressure in a vessel containing only a superheated fluid) during intended or abnormal operation shall withstand without failure a pressure equal to the highest of the following that is applicable:

a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the assembly, but no more than five times the marked maximum supply pressure from an external source and no more than five times the pressure setting of a pressure-relief device provided as part of the assembly.

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

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

d) Five times the working pressure marked on the part, if so marked.

e) Five times the maximum pressure developed within the part during any of the applicable operation tests covered by this standard.

43.2 A test need not be performed to determine whether or not a part complies with the requirement in 43.1, if study and analysis indicate that the strength of the part is adequate for the purpose as a result of its material and dimensions, for example, copper or steel pipe of standard size provided with standard fittings.

43.3 If a test is necessary to determine if a part complies with the requirement in 43.1, two samples of the part are to be subjected to a hydrostatic-pressure test. Each sample is to be so filled with water as to exclude air and is to be connected to a hydraulic pump. The pressure is to be raised gradually to the specified test value, and is to be held at that value for 1 minute. The results are not acceptable if either sample bursts or leaks, except as indicated in 43.4.

43.4 Leakage at a gasket during the hydrostatic-pressure test is not considered to constitute failure unless it occurs at a pressure 40 percent or less of the required test value.

44 Static Load Test

44.1 The register of a floor-insert heater shall withstand a static load of 300 pounds (660 kg) applied to a surface area of 1 square foot (0.093 m^2) at the center of the register without any permanent deflection and without distortion of the register support.

45 Water Splash Test

45.1 There shall be no dielectric failure in a floor insert heater as a result of splashing with water and the insulation resistance shall be at least 50,000 ohms.

45.2 A cotton mop, which has been completely immersed in a pail of water for at least 5 minutes, is to be immediately upon removal from the pail swabbed across the heater's grille five times with the heater initially energized. Immediately following a last swabbing operation, the insulation resistance measurement and Dielectric Voltage Withstand Tests are to be performed.

46 Impact Test

46.1 A panel of glass or similarly brittle material employed in a heater shall withstand, without cracking or breaking, the impact resulting from the test described in Figure 46.1.

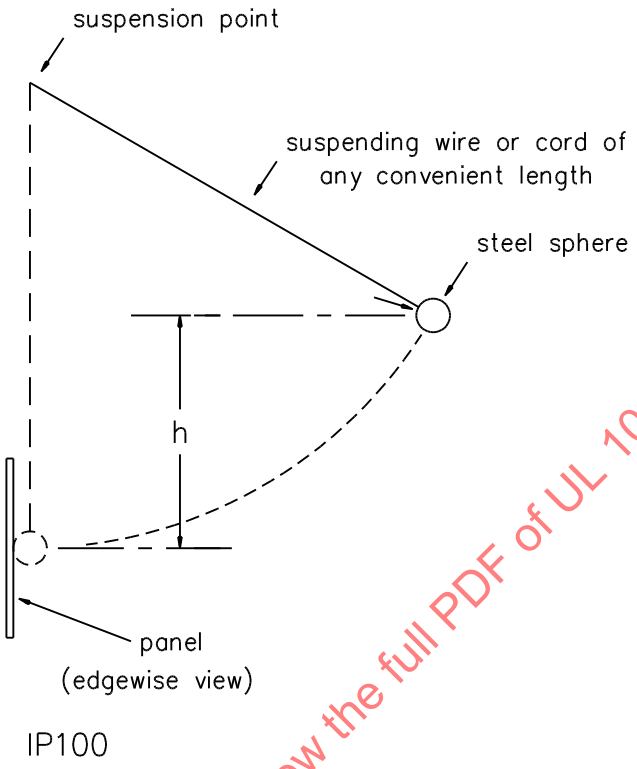
46.2 A panel of glass or similarly brittle material employed in a heater shall withstand, without cracking or breaking, while in a fully heated condition, the application of:

a) A wet cloth, fully saturated with water at room temperature, wiped across the surface of the panel; and

b) After the panel has returned to normal operating temperature, a fine spray of water played across the surface of the panel.

Figure 46.1

Impact test



47 Strain Relief Test

47.1 When tested in accordance with 47.2, the strain-relief means provided on the flexible cord shall withstand for 1 minute, without displacement, a direct pull of 35 pounds force (156 N) applied to the cord, with the connections within the heater disconnected.

47.2 The force specified in 47.1 is to be applied to the cord and supported by the heater so that the strain-relief means will be stressed from any angle that the construction of the heater permits. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is sufficient movement of the cord to indicate the stress on the connections would have resulted.

48 Push-Back Relief Test

48.1 To determine compliance with 10.2.2, a product shall be tested in accordance with 48.2 without occurrence of any of the conditions specified in 10.2.2 (a) – (d).

48.2 The supply cord or lead is to be held 1 in (25.4 mm) from the point where the cord or lead emerges from the product and is then to be pushed back into the product. The cord or lead is to be pushed back into the product in 1 in (25.4 mm) increments until the cord buckles or the force to push the cord into the product exceeds 6 pounds-force (26.7 N). The supply cord or lead within the product is to be manipulated to determine compliance with 10.2.2.

49 Burnout Test (Solid-State Components)

49.1 If a heater employs one or more rectifiers, transistors, or similar solid-state components, no hazardous condition shall develop when the circuit between any two terminals of any such component is

open-circuited or short-circuited. If the heater employs a capacitor in combination with one or more of the above-mentioned components, no hazardous condition shall develop when the capacitor is short-circuited. Only one of the simulated fault conditions described above is to be imposed at one time. See 49.2 – 49.6.

49.2 If an electron-tube rectifier is employed, all of its plate and cathode terminals are to be connected together. The test is to be repeated with only the cathode and heater terminals connected together if this condition was not represented by the first test.

49.3 If a semiconductor rectifier is employed, three samples are to be tested with the rectifier terminals connected together. Three additional samples are to be tested with the terminals of the electrolytic capacitor connected together.

49.4 Three complete tests are to be made under each of the conditions described in 49.2 and 49.3, using new components in each test.

49.5 An unacceptable condition is considered to exist if flame is emitted from the overall enclosure of the equipment or if a permanently conductive path is established between live parts and exposed dead metal.

49.6 The test described in 49.1 – 49.3 may be omitted if one or both of the following conditions exist:

a) There is 10,000 ohms or more additional series impedance in a circuit in which the voltage is 125 or less.

b) There is 20,000 ohms or more additional series impedance in a circuit in which the voltage is more than 125 but is no more than 250.

50 Dielectric Voltage Withstand Test

50.1 A heater or electrical accessory shall withstand for 1 minute without breakdown the application of a 60 hertz essentially sinusoidal potential between live parts and dead metal parts, with the heater at its maximum normal operating temperature. The test potential shall be 1000 volts for a heater rated at 250 volts or less, and 1000 volts plus twice rated voltage for a heater rated at more than 250 volts.

50.2 A transformer, the output voltage of which is essentially sinusoidal, can be varied and can maintain the specified high potential voltage at the equipment during the duration of the test, is to be used to determine compliance with the foregoing. 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.

51 Humidity Conditioning Test

51.1 The requirements in Section 51 pertain to a heater employing:

a) Thermal insulation such as mineral wool in contact with an uninsulated live part, or

b) Insulating material, such as magnesium oxide, that may be adversely affected by moisture under conditions of intended use.

51.2 Following the conditioning specified in 51.3, a heater:

a) Having a nominal voltage rating of 240 volts or less, shall comply with the requirements for leakage current in 30.1 when tested as described in 51.4.

b) Having a nominal voltage rating above 240 volts, shall have an insulation resistance, determined as specified in 51.5, of not less than 50,000 ohms between live parts and interconnected dead metal parts.

51.3 A sample of a heater is to be heated to a temperature just above 34° C (93° F) to reduce the likelihood of condensation of moisture during conditioning. The heated sample is to be placed for 48 hours in a humidity chamber having air with a relative humidity of 88 ±2 percent at a temperature of 32 ±2°C (90 ±4°F).

51.4 Leakage current is to be determined as described in 30.6 (a), (b), and (c), except that a heater intended for permanent connection to a 120-volt power supply is to be tested with switch S2 of Figure 30.1 only in the position that corresponds to the intended field supply connection. The test is to be discontinued when the leakage current stabilizes or decreases.

51.5 Insulation resistance is to be determined as follows (see Figure 51.1) or by another method that is equally accurate. A direct current potential of approximately 250 volts is to be applied between live parts and interconnected dead metal parts. Two voltmeters are to be used; one voltmeter is to be connected across the supply line and the other connected in series with one of the leads to the heater being tested. With the supply voltage adjusted so that the difference in the voltage readings of the two meters is approximately 250 volts, the insulation resistance is to be calculated using the equation:

$$Insulation\ \ Resistance\ = \frac{(V_1 - V_2)\,R_2}{V_2}$$

in which:

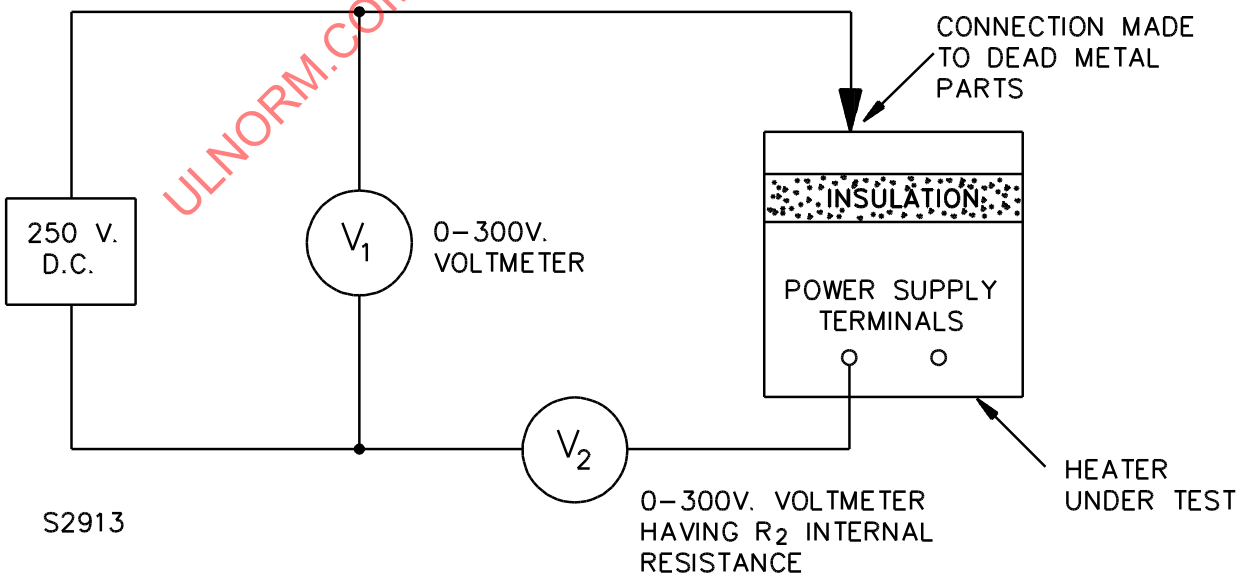
V_1 is the measured supply line voltage, in volts.

V_2 is the voltage measured by a voltmeter in series with one of the leads of the heater being tested, in volts.

R_2 is the resistance of the voltmeter measuring V_2, in ohms.

Figure 51.1

Schematic for determining insulation resistance



52 Marking Plate Adhesion Tests

52.1 General

52.1.1 To determine if a marking plate secured by cement or adhesive complies with 59.37, representative samples are to be subjected to the following tests. In each test, three samples of the marking plates are to be applied to the same test surfaces as employed in the intended application. The marking plate is to be applied to the test surface no less than 24 hours prior to testing.

52.1.2 The marking plate is considered to comply with the requirements if immediately following removal from each test medium and after being exposed to room temperature for 24 hours following removal from each test medium:

a) Each sample demonstrates complete adhesion and the edges are not curled,

b) The marking plate resists defacement or removal as demonstrated by scraping across the test panel with a flat metal blade 1/16 in (1.6 mm) thick, held at a right angle to the test panel, and

c) The printing is legible and is not defaced by rubbing with thumb or finger pressure.

52.2 Oven aging

52.2.1 Three samples of the marking plates under test are to be placed in an air oven maintained at the temperature indicated below for 240 hours.

Maximum normal operating temperature of surface of applied label, degrees C (F)	Air oven test temperature, degrees C (F)
60 (140) or less	87 (189)
80 (176) or less	105 (221)
100 (212) or less	121 (250)
125 (257) or less	150 (302)
150 (302) or less	180 (356)

52.3 Immersion

52.3.1 Three samples of the marking plates under test are to be immersed in water at a temperature of 23 ±2°C (73.4 ±3.6°F) for a period of 48 hours.

52.4 As-received

52.4.1 Three samples of the marking plates under test are to be tested as-received.

53 Supply Cord Abrasion

53.1 Five cord specimens shall be subjected to an abrasion motion as described in 53.2 – 53.4 for 5,000 cycles. Upon completion of the test, there shall not be:

a) Exposure of the copper conductors, or

b) Exposure of the internal shield of a Leakage Current Detection-Interrupter.

53.2 Cord specimens shall be tested without any conditioning. The apparatus and the specimens shall be in thermal equilibrium with the surrounding air at a temperature of 25.0 ± 5.0° C (77.0 ± 9.0° F) throughout the test.

53.3 One end of each specimen shall be attached to a horizontal, reciprocating table while the table is at one end of its travel. The other end of each specimen shall be attached to a weight that exerts a force of 12.0 ± 0.5 ozf (3.3 ± 0.1 N or 340 ± 13 gf). Each specimen shall be laid over a quarter cylinder to whose outer surface an unused sheet of Medium (Grade 1/2) emery cloth is attached. The radius of the surface of the emery cloth shall be 3.5 in (90 mm). The longitudinal axis of the cylinder shall be horizontal and perpendicular to each of the vertical planes that contain the specimens as they move on and are abraded by the emery cloth.

53.4 The table shall be started in its horizontal reciprocating motion (simple harmonic motion) at the rate of approximately 28 cycles per minute, each cycle consisting of one complete back-and-forth motion, with a stroke of approximately 6-1/4 in (160 mm). The table shall be stopped every 800 cycles and the emery cloth shall be shifted slightly to one side or replaced, so that in subsequent cycles each specimen is abraded by a fresh surface of the cloth.

53.5 The samples shall withstand 5,000 cycles of abrasion testing without failure.

54 Supply Cord Pinching – Mandrel

54.1 Five cord specimens shall be subjected to a pinching force as described in paragraphs 54.2 – 54.6 until ultimate conditions are observed. Ultimate conditions are defined as contact between:

a) One or more circuit conductors and the flat horizontal surface;

b) One or more circuit conductors and the mandrel;

c) One or more circuit conductors and the grounding conductor; or

d) The two circuit conductors.

54.2 Cord specimens shall be tested without any conditioning. The apparatus and the specimens shall be in thermal equilibrium with the surrounding air at a temperature of 25.0 ± 5.0° C (77.0 ± 9.0° F) throughout the test.

54.3 The cord is to be pinched between a flat horizontal steel surface and the corner of a rigid steel mandrel. The mandrel shall have a right-angle corner with a corner radius of 3/64 in (1.19 mm). See Figure 54.1 and Figure 54.2.

54.4 A sample length of the cord is to be laid flat with the length of the cord at a right angle to the longitudinal axis of the mandrel.

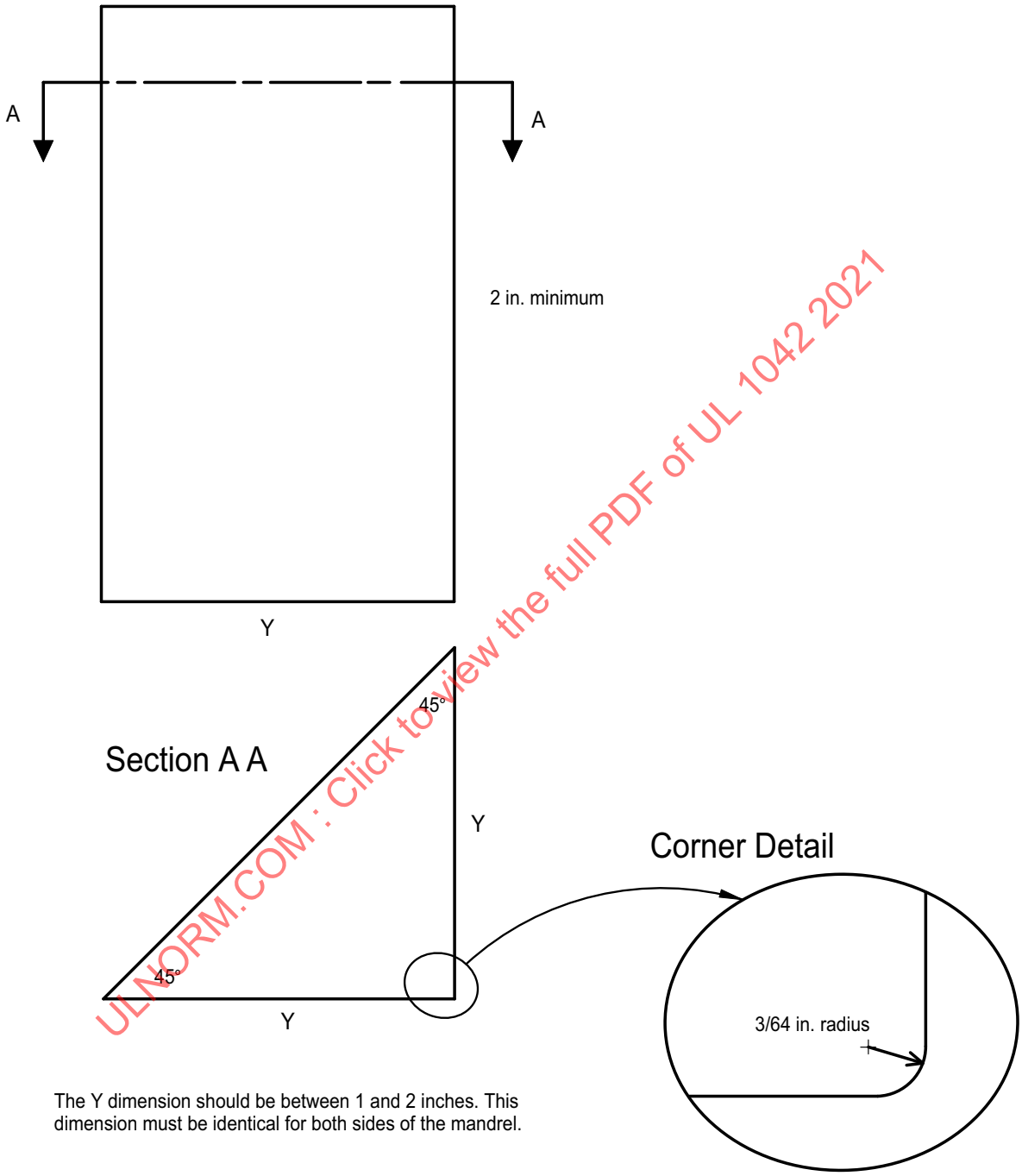
54.5 The circuit conductors, steel surface, and mandrel are to be connected to low-voltage indicators (buzzers or the like) and to power supplies. The steel surface, mandrel, and any grounding conductor are to be connected together. The indicators are to provide a signal whenever contact is established between one or more of the circuit conductors and the steel surface, mandrel, or grounding conductor. An additional low-voltage indicator shall be connected in order to sense contact between the circuit conductors.

54.6 The head of a compression testing machine is to be started moving toward the bed at a rate of 0.20 ± 0.05 in/min (5.1 ± 1.27 mm/min). The travel is to be continued until the mandrel pushes through the insulating materials of the cable and the indicator signals.

54.7 The samples shall withstand a pinching force of 500 pounds (2,000 N) without failure.

Figure 54.1

Rigid steel mandrel



The Y dimension should be between 1 and 2 inches. This dimension must be identical for both sides of the mandrel.

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