



UL 1042

STANDARD FOR SAFETY

Electric Baseboard Heating Equipment

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

Fifth Edition, Dated August 31, 2009

Summary of Topics

The revisions dated June 3, 2013 have been issued for the Standard for Safety for Electric Baseboard Heating Equipment, UL 1042, to incorporate the proposals dated April 19, 2013. These proposals include the following:

- ***Correction to Paragraph 22.7.***
- ***Alternative Temperature Test material.***

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated April 19, 2013.

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that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

The following table lists the future effective dates with the corresponding reference.

Future Effective Date	References
February 11, 2011	10.1.2, 10.1.3, 10.1.4, 10.1.7, Table 10.2, Section 10.4, 12.3.1, 32.2.1, Sections 53 – 57, Section 60, Section 61
August 31, 2011	25.1
March 20, 2015	22.7

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ANSI/UL 1042-2013

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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.

First Edition – June, 1972
Second Edition – March, 1979
Third Edition – September, 1987
Fourth Edition – April, 1994

Fifth Edition

August 31, 2009

This ANSI/UL Standard for Safety consists of the Fifth Edition including revisions through June 3, 2013.

The most recent designation of ANSI/UL 1042 as an American National Standard (ANSI) occurred on June 3, 2013. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or effective date information.

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 <http://csds.ul.com>.

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APPENDIX A

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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 added January 28, 2013

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.

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- 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 for Household and Similar Use, Part 1: General Requirements, UL 60730-1A.

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 for Household and Similar Use, Part 1: General Requirements, UL 60730-1A.

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 revised January 28, 2013

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;*

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- 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 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 for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

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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 for Household and Similar Use; 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 for Household and Similar Use: 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 for Household and Similar Use; 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 for Household and Similar Use; Part 1: General Requirements, UL 60730-1, and;
 - 1) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Water Level Controls of the Float Type for Household and Similar Applications, UL 60730-2-16A; or
 - 2) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Water and Air Flow Sensing Controls, Including Mechanical Requirements, UL 60730-2-18.

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 Power Conversion Equipment, UL 508C; or
- e) The Standard for Automatic Electrical Controls for Household and Similar Use; 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 for Household and Similar Use; Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

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 for Household and Similar Use; Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for 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 Safety 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 Safety 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 for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

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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 for Household and Similar Use; 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) The Standard for Special-Use Switches, UL 1054;
- 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 for Household and Similar Use; Part 1: General Requirements, UL 60730-1, and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for 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 for Household and Similar Use; Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for 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: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers: 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: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers: 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 mm²), 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 Tables 4.1 – 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 ^c	Uncoated (MSG)	Metal coated (GSG)
Inches (cm)	Inches (cm)	Inches (cm)	Inches (cm)		
4.0 (10.2)	Not limited	6.25 (15.9)	Not limited	0.020 ^d (0.51)	0.023 ^d (0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)	(24)	(24)
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026 ^d (0.66)	0.029 ^d (0.74)
7.0 (17.8)	8.75 (22.2)	10.0 (25.4)	12.5 (31.8)	(22)	(22)
8.0 (20.3)	Not limited	12.0 (30.5)	Not limited	0.032 (0.81)	0.034 (0.86)
9.0 (22.9)	11.5 (29.2)	13.0 (33.0)	16.0 (40.6)	(20)	(20)
12.5 (31.8)	Not limited	19.5 (49.5)	Not limited	0.042 (1.07)	0.045 (1.14)
14.0 (35.6)	18.0 (45.7)	21.0 (53.3)	25.0 (63.5)	(18)	(18)
18.0 (45.7)	Not limited	27.0 (68.6)	Not limited	0.053 (1.35)	0.056 (1.42)
20.0 (50.8)	25.0 (63.5)	29.0 (73.7)	36.0 (91.4)	(16)	(16)

^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.

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 Figures 5.1 – 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 Figures 5.1 and 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

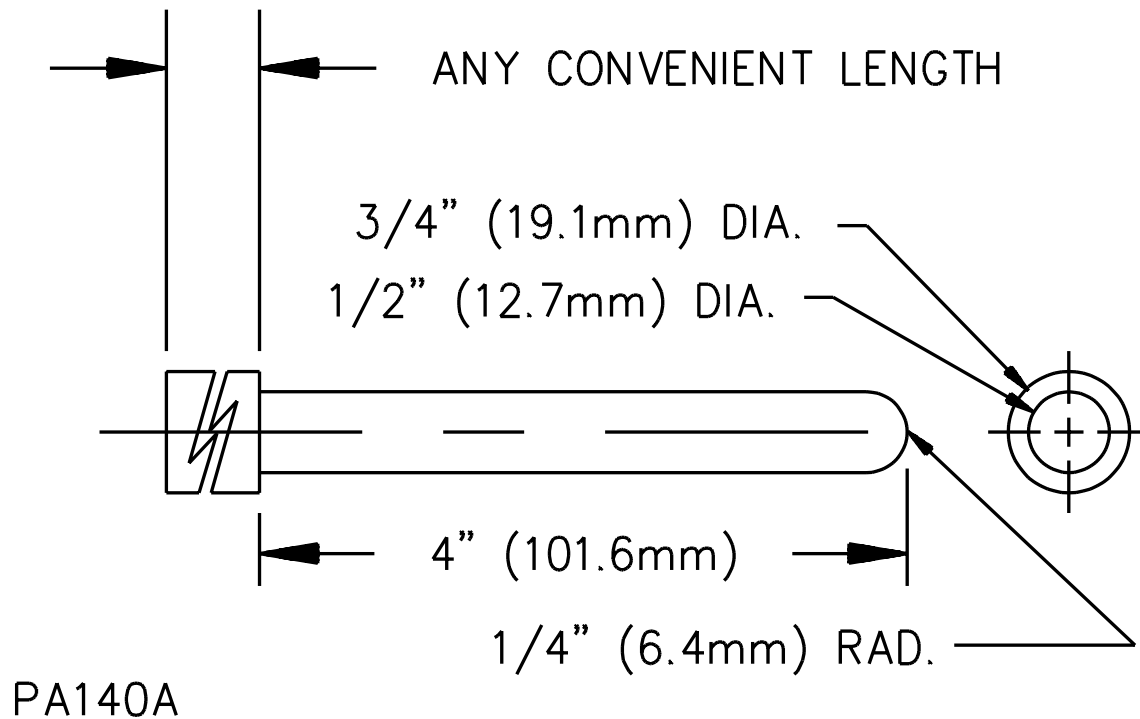
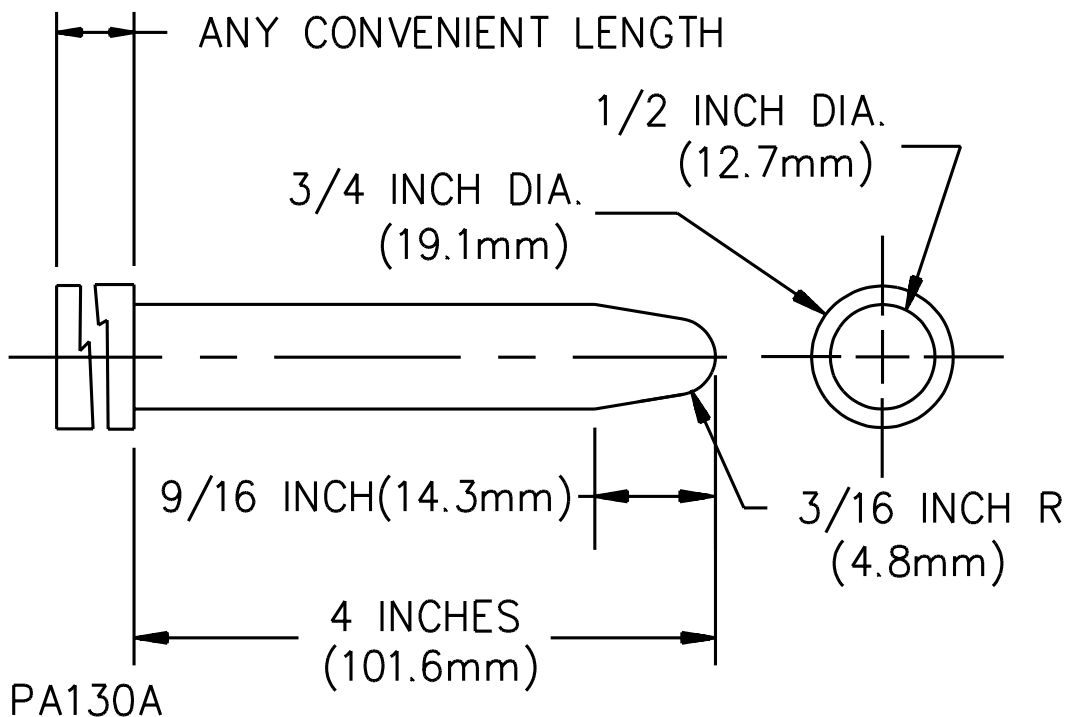


Figure 5.3
Probe for film-coated wire

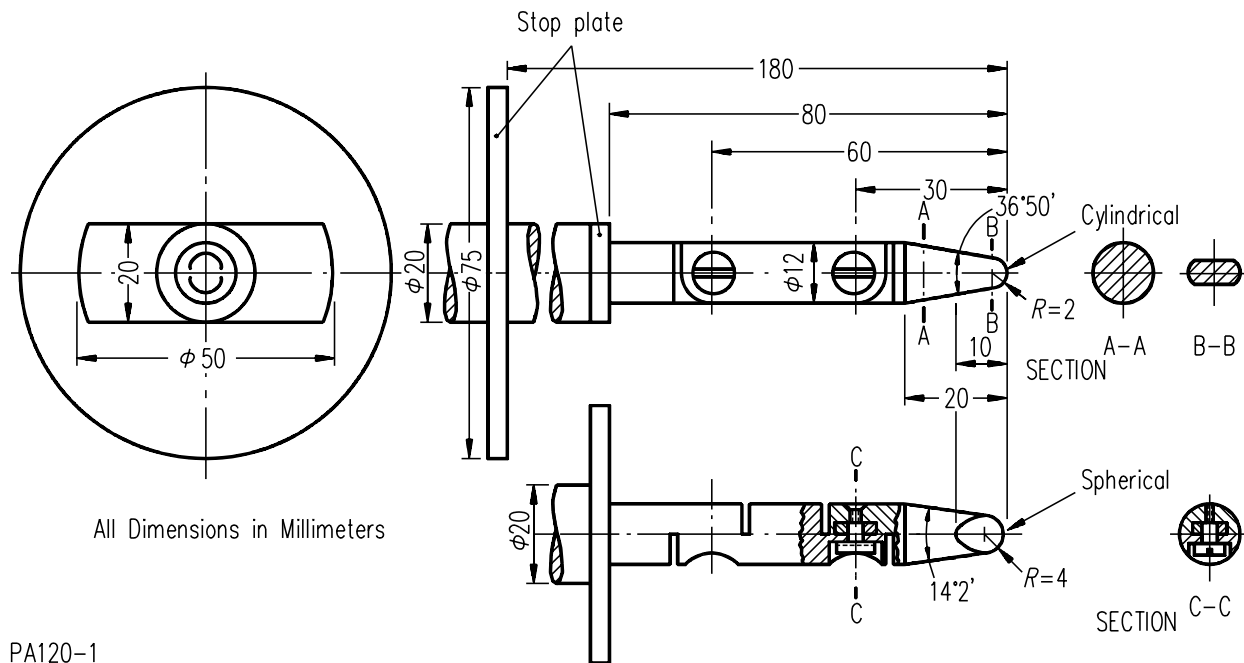


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Figure 5.4
Articulate probe



PA120-1

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		Bushings 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 mm²) 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 mm²) 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.