



UL 2683

STANDARD FOR SAFETY

Electric Heating Systems for Floor and Ceiling Installation

UL Standard for Safety for Electric Heating Systems for Floor and Ceiling Installation, UL 2683

First Edition, Dated February 25, 2020

Summary of Topics

This reaffirmation of ANSI/UL 2683 dated May 19, 2025 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated March 14, 2025.

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UL 2683

Standard for Electric Heating Systems for Floor and Ceiling Installation

First Edition

February 25, 2020

This ANSI/UL Standard for Safety consists of the First Edition including revisions through May 19, 2025.

The most recent designation of ANSI/UL 2683 as a Reaffirmed American National Standard (ANS) occurred on May 19, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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PART 1 – ALL SYSTEMS

INTRODUCTION

1 Scope

1.1 These requirements cover indoor fixed electric heating systems for use on system voltages not exceeding 600 V.

1.2 The heating systems covered by this Standard are intended for installation in accordance with the National Electrical Code, NFPA 70, Article 424.

1.3 These requirements cover the following electric heating systems:

- a) Heating cable systems;
- b) Heating mat systems;
- c) Heating panel systems;
- d) Modular flooring heating systems; and
- e) Low voltage systems including power units.

With the following types of insulated heating elements:

- f) Heating cable elements;
- g) Laminate elements; and
- h) Flat strip elements.

Of the following types:

- i) Constant wattage elements;
- j) Self-regulating elements; and
- k) Low voltage elements.

1.4 These requirements cover electric heating systems permanently installed as follows:

- a) WOOD SUBFLOORS – Installed above (on top of) or under (adjacent to rafters or joists);
- b) CONCRETE SUBFLOORS – Installed above (on top of), inside (embedded), or under (in earth or sand bed);
- c) CEILINGS – Installed inside (embedded), above (attic or between floors of a building adjacent to ceiling rafters or joists), or under (room side);
- d) In WET LOCATIONS – Locations where the heating element may be subject to saturation with water after installation;
- e) Embedded systems;
- e) Underneath and in direct contact with floor coverings (non-embedded), while above wood or concrete subfloors;

- f) Modular flooring heating systems installed above wood or concrete subfloors; and
- g) Shower benches.

1.5 These requirements do not cover electric heating systems that are covered under the following standards:

- a) Electrical Resistance Heat Tracing for Commercial and Industrial Applications, UL 515;
- b) Movable and Wall- or Ceiling-Hung Electric Room Heaters, UL 1278;
- c) Fixed and Location-Dedicated Electric Room Heaters, UL 2021; and
- d) Electric Heating Appliances, UL 499.

1.6 These requirements do not cover the following products:

- a) Heating systems connected to the supply by use of a flexible cord with attachment plug;
- b) Heating systems that are portable or easily moved after installation;
- c) Heating systems with integral means of producing air flow;
- d) Heating systems intended for snow melting/deicing or pipe maintenance;
- e) Heating systems intended to be installed outdoors; and
- f) Heating systems intended to be installed in a dropped or suspended ceiling.

1.7 These requirements do not cover the use of electrical heating systems installed in environmental air-handling spaces.

1.8 These requirements do not cover surface burning characteristics performance requirements that may be required by building codes.

2 Units of Measurement

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

3 Normative References

3.1 The following documents are referenced in this Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. References to UL standards are not included in this list and are referenced throughout this Standard.

ASTM International

ASTM C39, *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*

ASTM B193, *Standard Test Method for Resistivity of Electrical Conductor Materials*

ASTM B258, *Standard Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors*

ASTM C665, *Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing*

ASTM C1396 / C1396M, *Standard Specification for Gypsum Board*

IEC 60695-2-11, *Standard for Fire hazard testing – Part 2-11: Glowing/hot wire based test methods – Glow-wire flammability test method for end-products*
IEC 60695-2-12, *Standard for Fire hazard testing – Part 2-12: Glowing/hot wire based test methods – Glow-wire flammability test method for materials*
IEC 60695-2-13, *Standard for Fire hazard testing – Part 2-13: Glowing/hot wire based test methods – Glow-wire ignitability test method for materials*
IEC 60335-2-96, Edition 1.2, *Standard for Household and similar electrical appliances – Safety – Part 2-96: Particular requirements for flexible sheet heating elements for room heating*
IEC 60335-2-106, Edition 1, *Standard for Household and similar electrical appliances – Safety – Part 2-106: Particular requirements for heated carpets and for heating units for room heating installed under removable floor coverings*
IEC 60529, *Degrees of Protection Provided by Enclosures (IP Code)*
IEEE 515.1-2012, *IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications*
NFPA 70, *National Electrical Code (NEC), 2017 Edition*

4 Glossary

4.1 For the purpose of this standard, the following definitions apply.

4.2 **ASSEMBLY KIT** – Part(s) needed in the field installation for assembly of a heating system provided by the heating system manufacturer. Common assembly kits include splice connection kit, end seal kit, securement hardware kit, etc.

4.3 **BONDING** – The joining of metallic parts to form an electrically conductive path that provides electrical continuity and the capacity to conduct any current likely to be imposed without a risk of electric shock, fire, or injury to persons.

4.4 **CARRIER (SCRIM OR MESH)** – Part of a cable-based mat product, such as a mesh, fabric, or similar material, used to bind or arrange the cable in a preset configuration at the factory. Serves to maintain spacing of heating cable between adjacent runs and to facilitate installation. A carrier may provide some mechanical protection for the product but does not serve as an electrical or fire enclosure. Applied to one or both sides of the product. The heating cable is either visible or fully covered after being mated with the carrier.

4.5 **COMBUSTIBLE MATERIAL** – A material used under the conditions anticipated, will ignite and burn or will add appreciable heat to an ambient fire. A material that is not inherently resistant to ignition and flame spread, used in buildings for subfloors and ceiling. Includes gypsum board, wood, adhesives, etc. May include underlayment, floor coverings, carrier, etc.

4.6 **COMBUSTION RESISTANT MATERIAL** – A material used and under the conditions anticipated, will not ignite and burn or add appreciable heat to an ambient fire. A material known to be resistant to ignition and flame spread used in buildings for subfloors, floor coverings, ceilings, and adjacent walls. Includes metal, concrete, masonry, cement board, thinset, floor leveler, etc.

4.7 **CONDUCTORS, EXPOSED** – With reference to a low voltage heating system. Current carrying wire, bus bars, and heating elements that are located in an occupied space, located at least 2.2 m (7 ft) above a floor, and are connected to a power unit that is provided with integral protection against shorting and overloading, and that complies with the Exposed current carrying parts test, [74.8](#).

4.8 **CONSTANT WATTAGE HEATING ELEMENT** – A heating element that has approximately the same power consumption over a temperature range of a typical heating system installation. The element has thermal coefficient of resistance less than or equal to copper as per ASTM B193. Examples include elements made with resistance wire.

4.9 EMBEDDED – Fully covered on top and bottom with combustion resistant material used for the installation of a heating system, such as thinset, mortar, sand, concrete, etc. A heating system not covered on all surfaces is not considered embedded. This does not pertain to metal and metal foil layers that are provided with or as part of a heating system.

4.10 ENCLOSURE – The part of a heating system that does one or more of the following:

- a) Renders inaccessible all or any part(s) of the heating system that may present a risk of electric shock.
- b) Retards propagation of flame initiated by electrical disturbances occurring within the heating system.

4.11 FLOOR COVERING – A finished top surface of a floor exposed to the room, such as hardwood, tile, stone, linoleum, laminate, decorative concrete, or carpet. Intended to be a permanent part of the building.

4.12 FLOATING (FLOOR COVERING) – A finished top surface of a floor exposed to the room, that does not need to be nailed, adhered, or otherwise secured to the subfloor. Often consist of panels of tile, stone, laminate, wood, vinyl, or the like. The panels may incorporate an underlayment. The panels are mechanically secured together by interlocking or adhesive.

4.13 GROUND (GROUNDING) – A connection (conductor) between an electrical circuit or accessible metal part of a heating system and the earth. A direct physical conducting connection to the earth.

4.14 GROUND-FAULT CIRCUIT-INTERRUPTER (GFCI) – A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device. Class A ground-fault circuit interrupters trip when the current to ground is 6 mA or higher and do not trip when the current to ground is less than 4 mA. For further information, see UL 943, Standard for Ground-Fault Circuit Interrupters. These devices are intended for use on alternating current (AC) circuits of 120 V, 208Y/120 V, 120/240 V, 127 V, or 220Y/127 V, 60 Hz circuits.

4.15 GROUNDING COMPONENT – A metal covering, sheath, or braid that is to be connected to protective earth ground and intended to operate a circuit protection device in the event live parts are short circuited to the grounding component. Intended to reduce the risk of electric shock.

4.16 HEATING CABLE ELEMENTS (HEATING CABLE) – A insulated cable that is intended to heat by means of electrical resistance.

4.17 HEATING CABLE SYSTEM – A complete system that may consist of non-heating leads, heating cable, integral components, mounting hardware, power unit (for a low voltage heating system), installation instructions, and marking labels. The system can be provided on a spool or attached to a carrier. A heating cable system is considered a heating panel system when it is installed in a rigid or non-rigid enclosure.

4.18 HEATING ELEMENT – The portion of the electric heating system that, by means of electrical resistance, is provided for the intent of heating. Can be a heating cable, flat strip, heating ribbon, or laminate heating element.

4.19 HEATING PANEL SYSTEM – A rigid or non-rigid heating panel assembly employing a heating element and non-heating leads or a terminal junction assembly identified as being suitable for connection to a wiring system. A complete system that consists of non-heating leads, heating cable, integral components, mounting hardware, power unit (for a low voltage heating system), installation instructions, and marking labels.

4.20 HEATING SYSTEM – A complete system may consist of non-heating leads, heating element, integral components, a power unit (for a low voltage heating system), installation instructions, and marking labels. The system may be provided with any associated controls, protective devices, and installation hardware or materials. Can employ heating cable elements or laminate heating elements.

4.21 INTEGRAL COMPONENT – Assemblies such as end seals and splices which may be exposed to the same environments as the rest of the heating system. The assemblies typically consist of connectors, and insulation, such as shrink tubing enclosure or a molded enclosure. May be assembled at a factory or in the field.

4.22 ISOLATED – Electrically separated from line voltage via an isolating transformer such that no common ground reference is shared between the primary and secondary side of the isolating device. An isolating transformer has the primary and secondary windings galvanically / electrically separated with basic insulation, and also includes a protective partition between primary and all secondary circuits.

4.23 LAMINATE HEATING ELEMENT (LAMINATE ELEMENT) – An insulated electric heating panel composed of layers of electrical insulating material (as required) enclosing a metallic or carbon-based heating material and is intended to provide heat. Examples of heating material include carbon ink, extruded carbon polymer, carbon nanotube, and carbon fiber.

4.24 LOW VOLTAGE – For the purpose of this standard, low voltage is limited to 25 amperes and operates at or below the risk of electric shock voltages. May still present a risk of fire. See RISK OF ELECTRIC SHOCK, [4.35](#), [Table 4.1](#). See RISK OF FIRE, [4.36](#).

4.25 LOW VOLTAGE HEATING SYSTEM – See Heating System. Additionally, limited to 25 amperes, operates at or below the risk of electric shock voltage and is intended to be powered by a low voltage supply. The system may be provided with associated controls, protective devices, and installation hardware or materials. The power source may consist of a means for connecting to building supply power, together with a power unit to convert from line voltage to low voltage, or by a direct dc low voltage source (e.g. solar, battery, etc.). Low voltage heating systems may still present a risk of fire. See RISK OF ELECTRIC SHOCK, [4.35](#), [Table 4.1](#). See RISK OF FIRE, [4.36](#).

4.26 MEMBRANE – A layer of material used in the installation of a heating system. Often provided to serve as a vapor barrier, cushioning, flame barrier, to provide mechanical protection, crack prevention, or as a sound reducer.

4.27 MODULAR FLOORING HEATING PANEL SYSTEM (MODULAR FLOORING SYSTEM) – A solid-surface panel intended to be a floor covering that incorporates a heating element. The materials used can provide mechanical protection to electrical components and may consist of tile, stone, wood laminate, wood, vinyl, or the like. The panels are mechanically secured together by interlocking or adhesive.

4.28 NON-HEATING LEADS – The leads of a heating system that are not intended to consume electrical energy for the purpose of heating, usually used to connect the heated portion to the source of power.

4.29 OCCUPIED SPACE – For the purpose of this standard, a room or enclosed space designed for human occupancy or use (i.e. kitchens, bedrooms, bathrooms, rooms, hallways, etc.).

4.30 PARALLEL HEATING ELEMENT (SERIES/PARALLEL ELEMENT) – A heating element that is constructed electrically in parallel; or in discrete zones of series heating elements (series/parallel element).

4.31 PERM VALUE – A measure of the ability to pass water vapor through a specific material. Usually used for building materials such as a vapor barrier, membrane, or plywood. A lower perm value allows less moisture to pass through, thus providing better resistance to moisture. A perm is a measure of the

number of grains of water vapor passing through a square foot of material per hour at a differential vapor pressure equal to one inch of mercury (1" W.C.). 1.0 US perm = 1.0 grain/square-foot·hour·inch of mercury $\approx$ 57 SI perm = 57 ng/s·m²·Pa. Any material with a perm rating of less than 1.0 is considered to be impermeable.

4.32 POWER UNIT – The equipment that powers low voltage heating systems. For the purpose of this standard, a power unit has all of the following characteristics:

- a) An isolating transformer or isolating electronic power supply of output voltage not exceeding the risk of electric shock voltage; and
- b) Employs a suitable enclosure; and
- c) Is intended for field installation; and
- d) Each secondary circuit is limited to 25 amperes under described loading conditions.

NOTE: Reference; NEC NFPA 70, Section 424.101(A).

4.33 R VALUE – The degree of thermal resistance of a material, expressed in the U.S. as $R = \text{ft}^2 \cdot ^\circ\text{F} \cdot \text{h/Btu}$. Commonly used with reference to building materials (insulation, wood, floor coverings, etc.), where materials with a higher R value provide a higher insulating value.

4.34 RIGID AND SEMI-RIGID FLOORING – For the purpose of this standard, decorative floor coverings having a solid or multiple layer product structure that provide some level of mechanical protection for a heating system. Can be plank or tile format. Can be floating, nailed, or adhered to the subfloor. Can incorporate an underlayment. Intended to be mechanically secured together by interlocking or adhesive. Does not include carpet.

4.35 RISK OF ELECTRIC SHOCK – A risk of shock exists between any two uninsulated conductive parts, or between an uninsulated conductive part and earth ground, if the continuous current flow through a 1500 ohm resistor in parallel with a 0.015 μF capacitor connected between the two points exceeds 0.5 mA and if the open circuit voltage exceeds the following limits in [Table 4.1](#) under normal use and abnormal use conditions.

Table 4.1
Risk of electric shock voltage limits

Waveform type ^a	Maximum voltage, dry locations
Sinusoidal ac	30 V rms
Non-sinusoidal ac	42.4 V peak
Continuous dc ^b	60 V
10 – 200 Hz interrupted dc ^c	24.8 V
^a For a combined ac + dc waveform, the dry and damp location voltage limit shall be the non-sinusoidal ac limit where the dc voltage is no more than 20.9 V, and shall be $(33 + 0.45 \text{ Vdc})$ where the dc voltage is greater than 20.9 V. ^b If the peak-to-peak ripple voltage on a dc waveform exceeds 10% of the dc voltage, the waveform shall be considered a combined waveform per footnote a above. ^c Contact with interrupted dc at a lower or higher frequency shall be permitted only after a special investigation based on the specific waveform parameters.	

4.36 RISK OF FIRE – A risk of fire is considered to exist between any two points in a circuit where the open circuit voltage is more than risk of electric shock values and the energy available to the circuit under any condition of load including short circuit, results in a current of 8 A or more after one minute of operation.

4.37 SELF-REGULATING (ELEMENT) – A heating element made with a conductive material for which the resistance varies with temperature. The power consumption varies in response to an increase or decrease in the actual temperature in the immediate vicinity of the element. Typically, self-regulating heating elements have a positive temperature coefficient (PTC) characteristic; resistance increases with an increase in temperature.

4.38 SERIES HEATING ELEMENT – A heating element that uses a high resistance conductor in order to generate heat through electrical resistance. The total resistance varies with length due to being constructed electrically in series. At all temperatures, the total wattage varies with length while the wattage per foot remains approximately constant.

4.39 SUBFLOOR – A structural layer of a floor on top of which a floor covering is commonly installed. Common subfloor materials include plywood, wood, concrete, or similar materials.

4.40 TEMPERATURE REGULATING DEVICE – A component, control, or device that regulates the temperature of the floor, the room, or both, and turns the power on and off to the heating system when the area being monitored reaches a set point temperature. Typically separate from the system but installed at the same time as the system installation.

4.41 TEMPERATURE STABILIZATION – A temperature is considered to be stabilized when three successive readings taken at 15 minute intervals are within 1°C of one another and are not rising.

4.42 THINSET – Also called thinset mortar, thinset cement, thinset adhesive. A blend of cement, sand, and a water retention compound that allows the cement to properly hydrate and set. Considered to provide protection and secureness for a heating systems.

4.43 UNDERLAYMENT – A material that is placed under floor covering and above the subfloor and is an intended barrier for waterproofing, thermal insulation, sound dampening, crack prevention or to protect the heating system from physical damage.

4.44 VAPOR BARRIER – A layer of material used during installation to prevent or reduce moisture from passing through. Also known as a vapor diffusion retarder (when the perm value is less than 1) or water barrier.

4.45 WATT DENSITY – The electrical power consumption at a defined temperature of a heating element in watts per unit area. Given in units of W/ft² or W/m². Often used as an indicator of heat output (higher watt density equals higher heat output).

4.46 WET LOCATION – Locations subject to saturation with water after installation. For the purposes of this standard, a wet location is considered to include installations underground, in concrete slabs that are in direct contact with the earth, or in shower areas depending on the installation.

5 Application of Requirements

5.1 This Standard is comprised of two parts. Part 1 consists of requirements that are to be applied to all heating systems unless otherwise specified. Part 2 consists of requirements for specific system designs and for specific system installation locations and methods. The requirements contained in Part 2 supplement or modify the requirements in Part 1 as specified. A specific system design and installation may result in the application of more than one set of requirements in Part 2.

CONSTRUCTION – ALL HEATING SYSTEMS

6 General

6.1 Also see Part 2 for requirements for specific heating system designs and installations.

6.2 A heating system shall be provided as a complete system as defined by [4.20](#).

6.3 The heating system shall be designed such that the installation can be done in a consistent and controlled manner. Any permitted variations with the installation within the intended parameters shall not increase risk of fire, risk of electric shock, or risk of injury to persons.

6.4 Low voltage systems are not prohibited from being evaluated to line voltage requirements.

6.5 A heating system intended to be installed in any of the following locations shall be supplied from a Class A, ground-fault circuit-interrupter (GFCI) upon installation.

- a) Installed inside concrete subfloor of bathrooms, kitchens, or hydromassage bathtub locations; or
- b) Installed under floor coverings and above a subfloor; or
- c) Installed in wet locations; or
- d) Modular flooring heating panel systems.

NOTE: Reference; NEC NFPA 70, Section 424.44(E), 424.45(E), 424.99(B)(5).

6.6 An underlayment that is installed between a subfloor and the heating system and is relied on to protect electrical parts from physical damage must be provided with the system or be an inherent part of the system. The heating product with underlayment shall meet mechanical tests in this standard when specified.

6.7 A heating system can be factory assembled or field assembled or a combination of the two. Field assembly shall not require the soldering of electrical connections.

6.8 A heating system shall be assembled so as not to increase risk of fire, electric shock, or injury to persons. Parts shall be suitably secured to prevent loosening and displacement that may increase the risk of fire, electric shock, or injury to persons.

6.9 A field-assembled heating system shall be provided with suitable parts and clear and detailed instructions for proper assembly.

7 Components

7.1 General

7.1.1 A component of a heating system covered by this Standard shall comply with all of the following:

- a) Comply with the requirements for that component as indicated in subsequent items of this section; and
- b) Be used in accordance with its rating(s) established for the intended conditions of use; and
- c) Be used within its established use limitations or conditions of acceptability; and

d) Additionally comply with the applicable requirements of this end product Standard.

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

Exception No. 1: A component of a heating system 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 system; or*
- b) Is superseded by a requirement in this standard; or*
- c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.*

Exception No. 2: A component complying with a component standard other than those cited in [7.1.2](#) – [7.8](#), or in other sections of this standard is acceptable if the component standard:

- a) Is compatible with the ampacity and overcurrent protection requirements in the National Electrical Code (NEC), NFPA 70, where appropriate; and*
- b) Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B; and*
- c) Any use limitation 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.*

7.1.2 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 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.

7.1.3 A component not anticipated by the requirements of this Standard, not specifically covered by the component standards covered by this Standard, and that involves a potential risk of electric shock, risk of fire, or personal injury, shall be additionally investigated in accordance with the applicable standard, and shall comply with [7.1.1](#) (b) – (d).

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

7.2 Controls

7.2.1 A control shall comply with the Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1. Protective temperature controls shall additionally comply with Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

7.3 Gaskets and seals

7.3.1 Gaskets and seals shall comply with the Standard for Gaskets and Seals, UL 157.

7.4 Ground-fault circuit-interrupters

7.4.1 Ground-Fault Circuit-Interrupters (GFCI) for protection against electrical shock shall comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

7.5 Internal wiring

7.5.1 Wiring within an enclosure composed of insulated conductors shall comply with one of the following standards.

- a) Appliance Wiring Material, UL 758; or
- b) Thermoset-Insulated Wires and Cables, UL 44; or
- c) Thermoplastic-Insulated Wires and Cables, UL 83; or
- d) The applicable UL standard(s) for other insulated conductor types specified in Chapter 3, Wiring Methods and Materials, of the National Electrical Code (NEC), NFPA 70.

7.6 Overcurrent protection

7.6.1 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 any another appropriate UL standard for the fuse are considered to fulfill this requirement.

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

7.6.3 Circuit breakers that have an integral ground-fault circuit-interrupter (GFCI) capability for protection against electrical shock shall additionally comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

7.6.4 Circuit breakers that have an integral Arc-Fault Circuit-Interrupter (AFCI) capability for protection against electrical arc faults shall additionally comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699.

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

7.7 Insulation, insulating bushings, and assembly aids

7.7.1 The requirements for insulation (e.g. tape, sleeving, tubing, bushings, assembly aids) are not specified unless the insulation or device is required to comply with Electrical Insulation, Section [20](#), or a performance requirement of this Standard. In such cases, the insulation shall comply with the following standards as applicable:

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

7.7.2 Wire positioning devices (cable ties, zip-ties, fixing devices) shall comply with the Standard for Positioning Devices, UL 1565.

7.7.3 Insulating bushings shall comply with the requirements in [7.1.1](#) or the Standard for Insulating Bushings, UL 635. Tests specified in this end product Standard 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.

7.8 Connectors and terminals

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

7.8.2 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B.

7.8.3 Splicing wire connectors shall comply with the Standard for Splicing Wire Connectors, UL 486C.

7.8.4 Quick-connect terminals, both connectors and tabs, for use with one or two 22 to 10 AWG copper conductors, having nominal widths of 2.8, 3.2, 4.8, 5.2, and 6.3 mm (0.110, 0.125, 0.187, 0.205, and 0.250 in), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

7.8.5 Multipole splicing wire connectors that are intended to facilitate the connection of hard-wired utilization equipment to the branch-circuit conductors of buildings or that are intended for consumer connection within and between parts of electrical equipment, shall comply with the Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459.

7.8.6 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.

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

8 Enclosures

8.1 General

8.1.1 Electrical parts shall be provided with or within an enclosure that complies with the requirements in this section, unless otherwise specified in this Standard.

8.1.2 Enclosure requirements for power supply conductors, heating cable elements, and laminate elements are not covered under this section and are covered under Sections [13](#) to [15](#), respectively.

8.1.3 Integral components with molded enclosures are covered under this section.

8.1.4 Integral components with insulating tubing enclosures and the like are also covered under [7.7](#), Insulation, insulating bushings, and assembly aids.

8.1.5 A carrier that is part of a heating cable system that is intended to provide mechanical protection is covered under this section. This includes systems employing metal foil carriers intended to be used as a grounding component. The requirements for a carrier not intended to provide mechanical protection are not specified.

8.1.6 The enclosure of a heating system shall be so formed and assembled so that it will have the strength necessary to resist the abuses likely to be encountered during its installation and intended use. The enclosure shall be resistant to damage, reduction of electrical spacings, loosening or displacement of parts, and other serious defects which create a risk of fire, electric shock, or injury to persons.

8.1.7 The factors taken into consideration when an enclosure is being judged for acceptability are its mechanical strength, resistance to impact, moisture-absorption properties, flammability, resistance to corrosion, and resistance to distortion or delamination at temperatures at which the enclosure may be subjected to under conditions of intended or abnormal use.

8.1.8 Adhesives used to secure parts together and relied upon to maintain the proper functioning of the device with regard to the likelihood of risk of fire, or risk of electric shock, and injury to persons, shall meet Section 39 of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: An enclosure need not meet the adhesive requirements in UL 746C for parts of a heating system that is required to be embedded in combustion resistant material during installation.

Exception No. 2: Adhesive used in the construction of a modular floor heating system need not meet the adhesive requirements in UL 746C if degradation of the adhesive is not likely to result in non-compliance with this Standard.

8.2 Openings

8.2.1 All splices, open coil devices, capacitors, leads, terminals for field connection of supply wires, other arcing live parts and current carrying parts involving a risk of fire or risk of electric shock, shall be provided with an enclosure without any open holes.

Exception: Openings are able to be used when all uninsulated current carrying parts or splices involving a risk of electric shock as are not accessible by the accessibility probe shown in [Figure 9.1](#).

8.2.2 An enclosure containing a fuse mounted in an open type fuseholder shall have no openings unless the opening is located 152 mm (6 in) or more from the fuse, measured horizontally, when the device is mounted as intended.

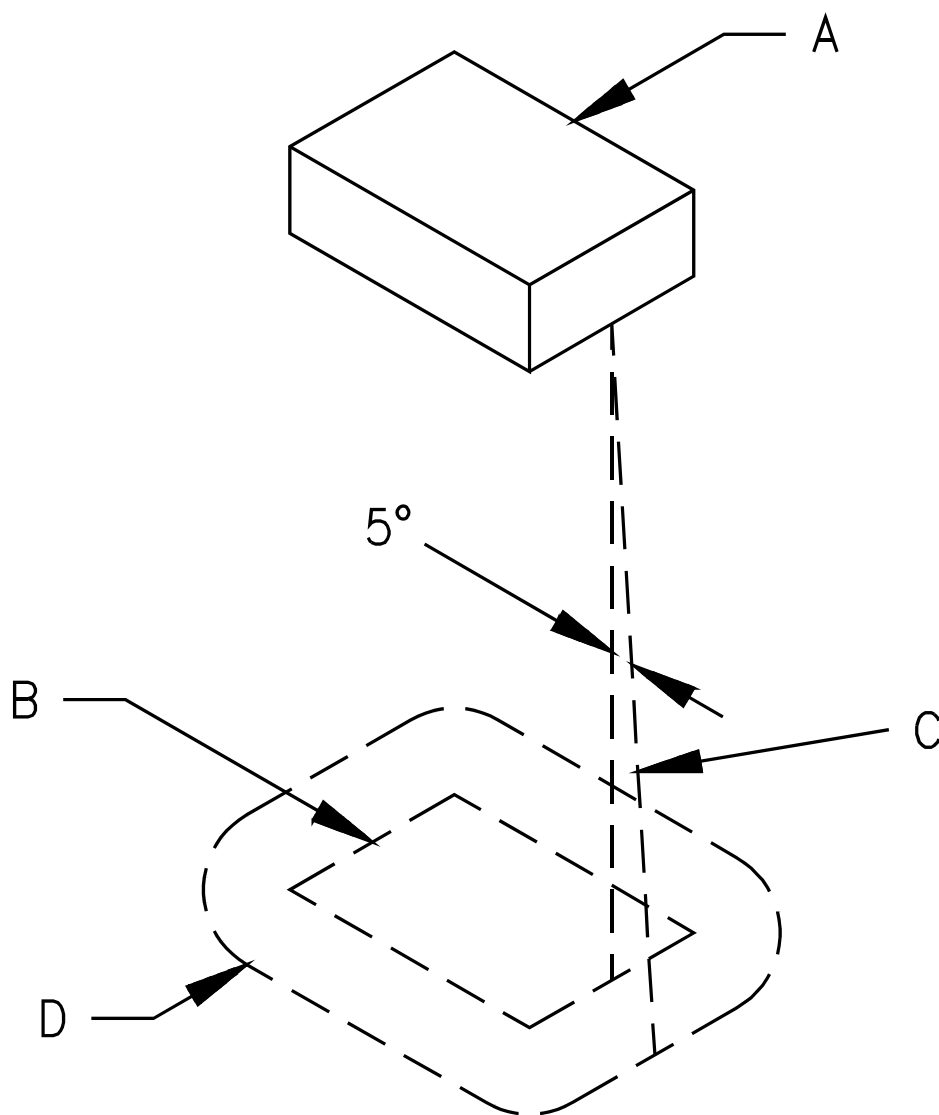
8.2.3 An enclosure shall have no openings or shall be provided with a barrier as described under [8.2.4](#) under any of the following locations:

- a) Under a transformer; or
- b) Under wire, unless the wire complies with the requirements of the Vertical Wires test in the Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581, and is marked VW-1; or
- c) Under a switch, relay, solenoid, or similar component unless a short circuit or overload in the component does not result in a risk of fire.

8.2.4 The requirements in [8.2.3](#) necessitate the use of a metal barrier or a non-metallic barrier of a material having a zero flame spread rating when tested as described in the Standard for Tests for Surface Burning Characteristics of Building Materials, UL 723. The barrier shall be horizontal, shall be located as illustrated in [Figure 8.1](#), and shall have an area in accordance with the illustration. Openings for ventilation,

and the like, shall not be employed in the barrier unless such openings do not permit molten metal, burning insulation, or similar material, to fall onto flammable material.

Figure 8.1
Barrier



EB120A

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

B – Projection of outline of component on horizontal plane.

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

- 1) Tangent to the component; and
- 2) 5 degrees from the vertical; and
- 3) So oriented that the area traced out on a horizontal plane is maximum.

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

8.3 Metal Enclosures

8.3.1 Cast and sheet metal portions of the enclosure shall be a minimum thickness as indicated in [Table 8.1](#) unless the enclosure is found to be acceptable when judged under [8.3.2](#).

Exception: A metallic material used as a functional part of the heating system for mechanical protection, heat sink, grounding, etc. and that does not enclose uninsulated live parts is not required to meet this section.

8.3.2 In reference to [8.3.1](#), other than a surface on an enclosure to which a wiring system is to be connected to in the field, an enclosure of sheet metal can be thinner than specified in [Table 8.1](#) when judged for its acceptability for a particular application and use of the heating system with respect to its size, shape, and the thickness of metal.

Table 8.1
Minimum acceptable thickness of enclosure metal

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

^a Thinner sheet metal may be employed if found to be acceptable when the enclosure is judged under considerations such as those mentioned in [8.3.2](#).

8.4 Nonmetallic enclosures

8.4.1 A polymeric enclosure shall comply with the applicable requirements in accordance with Table 4.1, Path III of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The requirements that apply shall be based on the enclosure type and location of use. For flammability requirements see Flammability, Section [10](#).

8.4.2 Heating systems employing a nonmetallic laminate fiberglass enclosure shall comply with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials used in Printed Wiring Boards, UL 746E. For flammability requirements see Flammability, Section [10](#).

9 Accessibility of Live Parts

9.1 An electrical part of a heating system, installed in accordance with the manufacturer's installation instructions, shall be located or enclosed to provide protection against unintentional contact with uninsulated live parts that may involve a risk of electric shock.

9.2 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from an uninsulated live part, an opening in an enclosure shall comply with one of the following:

- a) For an opening that has a minor dimension of 25.4 mm (1 in) or more, such a part or wire shall be spaced from the opening as specified in [Table 9.1](#); or
- b) For an opening that has a minor dimension less than 25.4 mm (1 in), such a part or wire shall not be contacted by the probe illustrated in [Figure 9.1](#).

NOTE: The minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

Table 9.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension of opening ^a		Minimum distance from opening to part	
mm ^b	(in) ^b	mm ^b	(in) ^b
25.4	(1)	165.0	(6-1/2)
31.8	(1-1/4)	190.0	(7-1/2)
38.1	(1-1/2)	318.0	(12-1/2)
47.6	(1-7/8)	394.0	(15-1/2)
54.0	(2-1/8)	444.0	(17-1/2)
c	c	762.0	(30)

^a See [9.2](#).

^b Between 19.1 mm (3/4 in) and 54 mm (2-1/8 in), interpolation is to be used to determine a value between values specified in the table.

^c More than 54 mm (2-1/8 in), but not more than 152 mm (6 in).