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 First Edition of ANSI/UL 2683 dated February 25, 2020 covers indoor fixed electric heating systems for use on system voltages not exceeding 600 V.

The new requirements are substantially in accordance with Proposal(s) on this subject dated June 21, 2019 and November 29, 2019.

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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.

The most recent designation of ANSI/UL 2683 as an American National Standard (ANSI) occurred on February 25, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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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 at 23°C 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 ≈ 57 SI perm = 57 ng/s·m^2·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 = ft$^{2\cdot}$°F·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 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/ft^2 or W/m^2. 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 additional 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

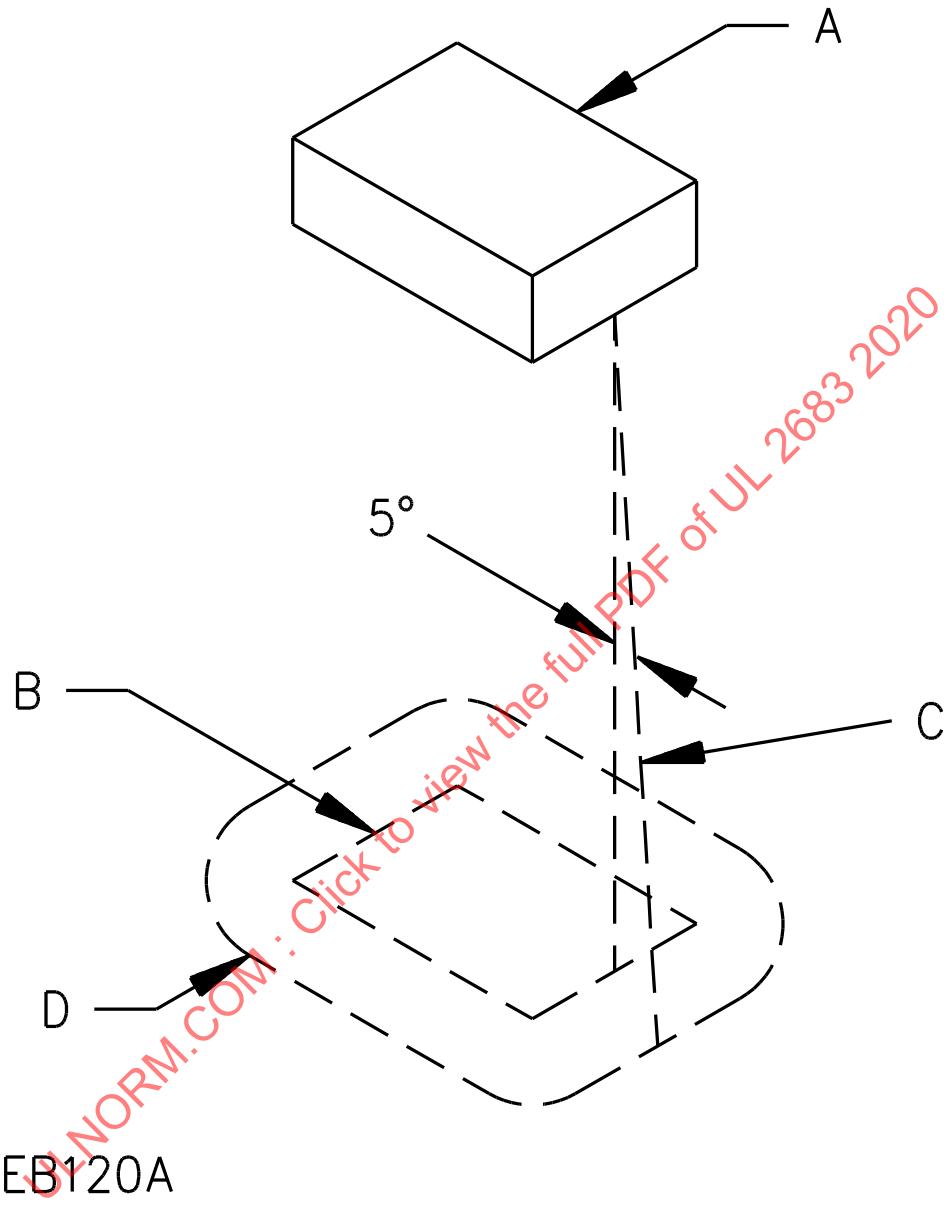
c) Under a switch, relay, solenoid, or similar component unless a short circuit or overload in the component does not result in a risk of fire.

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



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.

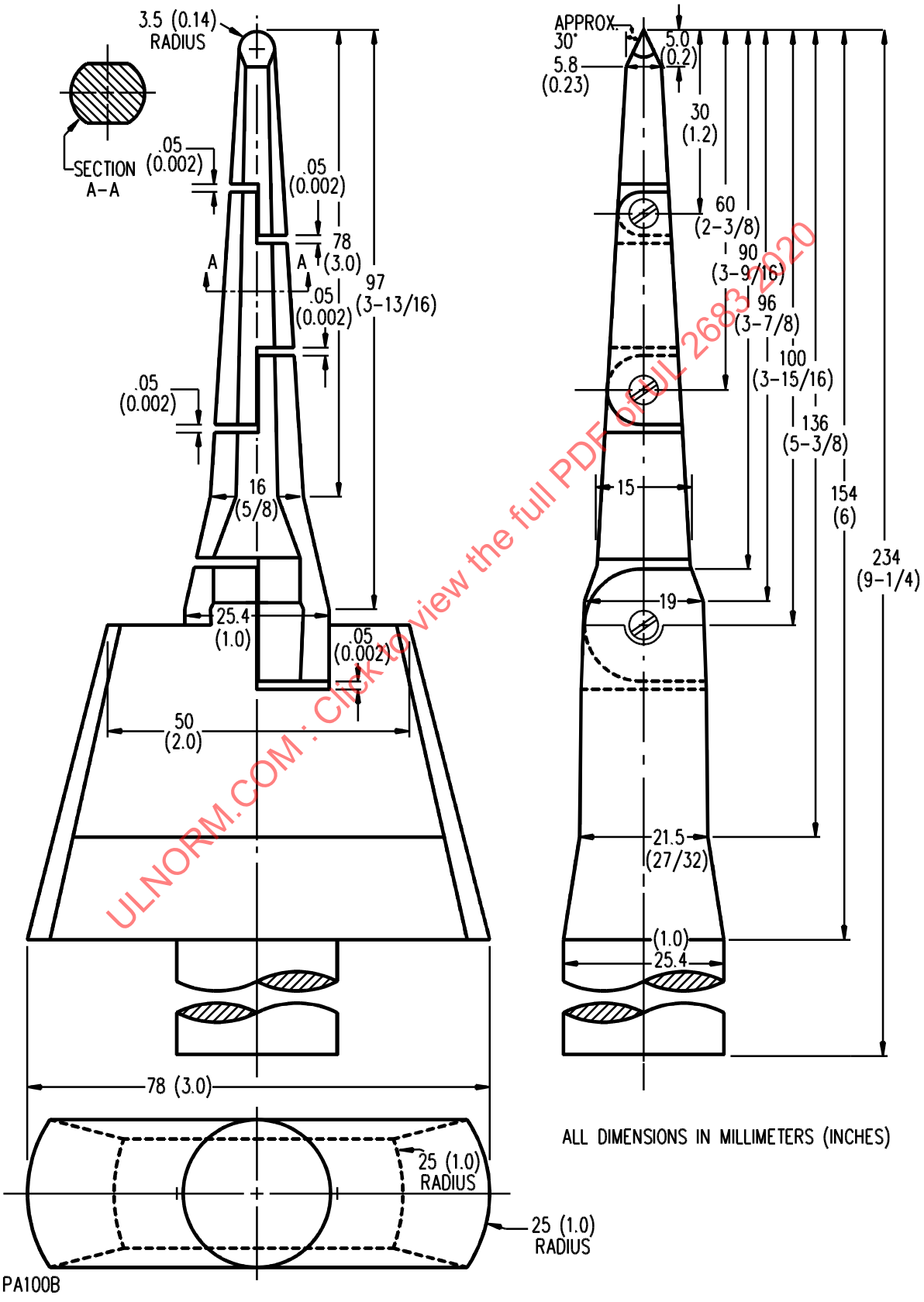
Table 9.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

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).

Figure 9.1

Articulate probe with web stop



9.3 The probe illustrated in Figure 9.1 shall be used as a measuring instrument to judge the accessibility provided by an opening, and not as an instrument to judge the strength of a material; it shall be applied with the minimum force necessary to determine accessibility.

10 Flammability

10.1 General

10.1.1 These requirements apply to all heating systems based on the construction described below. The requirements for the heating element, non-heating leads, and integral components may differ and shall be evaluated accordingly.

10.1.2 Heating systems employing nonmetallic materials including adhesives that are relied on for compliance with this Standard are to be subjected to the applicable test in this section and shall be tested as an assembly.

Exception No. 1: The carrier of a heating cable that is not serving as electrical insulation need not be part of the test.

Exception No. 2: Parts of a modular flooring heating system that are not serving as electrical insulation need not be part of the test.

10.1.3 The use of an applied flame-retardant coating shall be evaluated to and comply with Section 20 of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

10.2 Heating cables, non-heating leads, and integral components

10.2.1 Heating cables, non-heating leads, and integral components shall meet one of the following:

a) Have a flame class rating of VW-1 in accordance with the Standard for Electrical Wires, Cables and Flexible Cords, UL 1581; or

b) Meet the FV-2/VW-1 Flame Test, in accordance with the Standard for Wire and Cable Test Methods, UL 2556.

Exception No. 1: Heating cables, non-heating leads, and integral components that are intended to be embedded in combustion resistant material, or intended to be covered in combustion resistant material and not in contact with combustible materials during installation need not comply with 10.2.1.

Exception No. 2: Heating cables, non-heating leads, and integral components that are intended to be installed inside or under a concrete subfloor need not comply with 10.2.1.

10.3 Laminate heating elements

10.3.1 A laminate heating element shall meet one of the following. Integral components shall comply with 10.2.

a) Have a flame class rating of 5VA in accordance with the Standard for Safety for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; or

b) The assembly shall meet the 127 mm end-product flame test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

c) All layers shall have a minimum Glow Wire Flammability Index (GWFI) of 750°C in accordance with IEC 60695-2-12; or

d) All layers shall have a minimum Glow Wire Ignition Temperature (GWIT) of 775°C in accordance with IEC 60695-2-13; or

e) The assembly shall meet the Glow Wire End Product Test (GWEPT) of 750°C in accordance with IEC 60695-2-11.

Exception No. 1: A laminate heating element intended to be embedded in combustion resistant thinset during installation shall be considered to satisfy this requirement when one of the following are met:

a) All layers shall have a flame class rating of minimum HB or HBF in accordance with the Standard for Safety for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; or

b) The assembly shall meet the 12 mm or 20 mm end-product flame test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

c) All layers shall have a minimum Glow Wire Flammability Index (GWFI) of 550°C in accordance with IEC 60695-2-12; or

d) All layers shall have a minimum Glow Wire Ignition Temperature (GWIT) of 575°C in accordance with IEC 60695-2-13; or

e) The assembly shall meet the Glow Wire End Product Test (GWEPT) of 550°C in accordance with IEC 60695-2-11.

Exception No. 2: A laminate heating element that is intended to be installed inside or under a concrete subfloor floor need not comply with 10.3.1.

10.4 Laminate heating elements – in direct contact with carpet

10.4.1 In addition to 10.3, a laminate heating element that is in contact with carpet shall also meet the Spark emission test, 67.7. Integral components shall comply with 10.2.

10.5 Nonmetallic enclosures

10.5.1 A nonmetallic enclosure that is either provided with or inherent to a heating system shall have a flame class rating of 5VA in accordance with the requirements of the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: In lieu of the 5VA flame class rating, a polymeric enclosure may be subjected to the 127 mm end-product flame test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

11 Large Surface Flame Spread

11.1 Heating systems that have optionally been evaluated in accordance with the Standard for Tests for Surface Burning Characteristics of Building Materials, UL 723, can specify the flame spread and/or smoke density ratings in the installation instructions and/or product markings.

12 Grounding and Bonding

12.1 Grounding

12.1.1 The following heating systems need to be provided with an equipment grounding lead, field wiring terminal, or screw for permanent connection to protective earth ground:

a) All heating systems, except as indicated under 12.1.2; and

NOTE: Reference; NEC NFPA 70, Section 424.45(F), 424.99(B)(6).

b) All metal enclosures; and

c) All dead metal parts that are likely to become energized in the event of a fault, and that exposed to the user or service person, either inside or outside enclosure.

12.1.2 Grounding requirements do not apply to the following heating systems. However, if grounding is provided it shall comply with the requirements in this section.

a) The low voltage circuit of a low voltage heating system; and

NOTE: Reference; NEC NFPA 70, Section 424.103(B).

b) Heating system intended to be installed under a concrete subfloor; and

c) Heating system intended to be installed inside or above a ceiling; and

d) Heating panel system that is installed under a wood subfloor.

12.1.3 A equipment grounding lead shall not be smaller than the gauge of the supply wires provided with the system and in no case be less than 18 AWG (0.823 mm^2).

12.1.4 A grounding lead, if insulated, shall be provided with insulation having an outer surface that is green with or without one or more yellow stripes.

12.1.5 An equipment grounding terminal shall be of a size suitable to secure the equipment grounding conductor.

12.1.6 A grounding terminal shall not be located on a removable part, unless the removal of the part during user maintenance does not interrupt the bonding continuity.

12.1.7 A grounding screw shall be minimum M4 (No. 8) size and engage at least two full threads and shall be used in conjunction with upturned lugs, a cupped washer, or an equivalent method that is capable of retaining a minimum 12 AWG conductor under the head of the screw. A sheet metal screw shall not be used to connect equipment grounding conductors to enclosures.

12.1.8 An equipment grounding field-wiring terminal or screw shall be identified by:

a) Use of a wire-binding screw with a green-colored head that is slotted or hexagonal, or both; or

b) Use of a threaded stud with a green-colored hexagonal nut; or

c) Use of a green-colored pressure-terminal connector; or

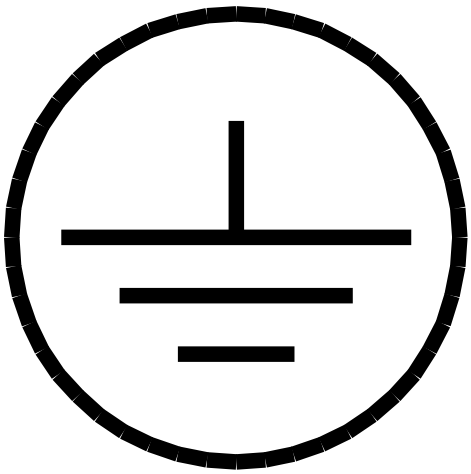
d) Marked with "G," "GR," "GND," "Ground," "Grounding," or the like; or

e) Marked with a grounding marking on a wiring diagram provided on the product; or

f) The grounding symbol illustrated in Figure 12.1 on or adjacent to the terminal or on a wiring diagram provided on the product.

Figure 12.1

Grounding symbol



12.2 Grounding Component

12.2.1 A grounding component as required by this section shall be a covering, sheath, or braid that is to be bonded to protective earth ground.

12.2.2 A grounding component shall be corrosion resistant material or protected by an outer insulation. Ferrous materials shall be zinc or cadmium plated, enameled, or provided with equivalent protection against corrosion. Copper, aluminum, alloys of copper and aluminum, stainless steel, and similar materials having inherent resistance to atmospheric corrosion are not required to be provided with additional protection.

12.2.3 The suitability of the grounding component shall be determined by one of the following methods:

a) The DC resistance of the grounding component per unit length shall be equal to or less than that of the lowest resistance heating conductor per unit length. In no case shall the resistance be higher than that of 18 AWG (0.81 mm^2) pure copper wire per ASTM B193 and ASTM B258 (20.95 mΩ/m at 20° C). Compliance is demonstrated by conducting the Grounding Component DC Resistance Test, Section 31; or

b) The grounding component shall meet the Grounding Component Ampacity Test, Section 32.

12.2.4 A grounding component made with carbon based materials shall additionally be subjected to all of the following tests:

a) Grounding Component Stabilized Resistance Test, Section 33; and

b) Resistance – Stabilized Conditioning Test, 55.2; and

c) Bonding Circuit Ampacity Test, Section 35.

12.3 Grounding component coverage

12.3.1 Heating cables – grounding component coverage

12.3.1.1 A heating cable shall be provided with an integral grounding component covering that is evenly distributed over the heating length and meets one of the following:

a) Provide minimum 70 percent surface area coverage that meets the Standard for Wire and Cable Test Methods, UL 2556; or

b) Meet the Pin Penetration Test, Section 36; or

c) Provide full coverage with no gaps greater than 1 mm (0.039 in).

12.3.2 Non-heating cables – grounding component coverage

12.3.2.1 Non-heating cables are not required to be provided with a grounding component. When provided in order to meet the Exception to 13.4.5, non-heating leads for a heating system shall be provided with grounding that meets 12.1 and a grounding component that meets 12.2 and 12.3.1.

12.3.3 Heating panels – grounding component coverage

12.3.3.1 A heating panel system that is intended to be installed above a subfloor or in a concrete subfloor shall be provided with a grounding component over the entire heating element. The grounding component shall cover all sides of the element that may be damaged after the system is installed. The grounding component shall be an inherent part of the system or be provided and required for installation with the system. Any openings in the grounding component shall:

a) Have no dimensions greater than 1 mm (0.039 in); or

b) Meet the Pin Penetration Test, Section 36.

12.4 Bonding

12.4.1 All non-current carrying conductive parts shall be bonded together and to the electrical supply equipment grounding means in accordance with this section.

12.4.2 A conductor, including a strap, jumper, or similar part, that is used only for bonding shall:

a) Be of copper, copper alloy, aluminum, or other material that has been investigated and found acceptable for use as an electrical conductor; and

b) Be protected from mechanical damage; and

c) Not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is not likely to be omitted after removal and replacement of the fastener; and

d) Have the flexibility needed to withstand mechanical stress due to vibration or flexing during use.

12.4.3 Bonding shall be by a means such as a terminal, clamp, rivet, bolt, screw, welded joint, or a soldered or brazed joint using materials having a softening or melting point higher than 454°C. Terminals complying with the requirements for Electrical Quick-Connect Terminals, UL 310, are acceptable to connect bonding conductors in sizes 18 – 14 AWG under the following conditions:

a) For conductor sizes 18 – 16 AWG, the minimum connector and tab width shall be 2.8 mm (0.110 in); or

b) For conductor size 14 AWG, the minimum connector and tab width shall be 6.4 mm (0.250 in); or

c) Quick-connect tabs shall not be less than 0.8 mm (0.032 in) thick.

12.4.4 A bonding screw shall engage at least two full threads and shall be used in conjunction with upturned lugs, a cupped washer, or an equivalent method that is capable of retaining the intended conductor size under the head of the screw.

12.4.5 If the above requirements cannot be verified, then the bonding provisions shall be tested in accordance with Bonding Circuit Impedance Test, Section 34, or the Bonding Circuit Ampacity Test, Section 35.

13 Power Supply Connections

13.1 General

13.1.1 A heating system shall be constructed so that it may be permanently connected electrically to one of the wiring systems that is acceptable for the appliance in accordance with the National Electrical Code, ANSI/NFPA 70.

13.1.2 It is assumed that a heating system will be connected with conductors having 60° C insulation unless otherwise marked.

13.2 Terminal box

13.2.1 The location of a terminal box or junction box in which power supply connections to a heating system are intended to be made in the field shall be such that these connections may be readily inspected after the product is installed as intended.

13.2.2 A terminal box intended for the connection of a supply raceway shall be so attached to the heating system that it shall not turn with respect to the product.

13.2.3 If inspection indicates that the volume of a terminal box may be insufficient to accommodate the intended wiring, a trial installation is to be made using wires of the size required and conduit and fitting sized for the wire in accordance with the National Electrical Code, ANSI/NFPA 70.

13.3 Wiring terminals and leads

13.3.1 A heating system intended for permanent connection to the power supply shall be provided with wiring terminals or leads for the connection of conductors having an ampacity of not less than 125 percent of the current rating.

13.3.2 A lead that is intended to be spliced in the field to a branch-circuit conductor shall not be smaller than 18 AWG (0.82 mm^2) and the insulation, if rubber or thermoplastic, shall not be less than 1/32 inch (0.79 mm) thick.

13.3.3 A field wiring terminal shall be provided with a pressure terminal connector, firmly bolted or held by a screw.

13.3.4 A wiring terminal shall be prevented from turning or shifting in position.

13.3.5 The free length of a lead inside terminal box shall be 152.4 mm (6 inches) or more when the lead is intended for field connection to an external circuit.

13.3.6 All terminals shall be marked for the intended supply connection or identification of the terminals shall be clearly shown in some other manner, such as on an attached wiring diagram.

13.3.7 Leads shall be identified by color for the intended supply connection. The surface of a lead intended for the connection of a grounded power-supply conductor shall have a white or gray color and shall be readily distinguishable from the other leads.

13.3.8 A lead intended for the connection of the heating system to protective earth ground shall either be bare, or identified in green with or without one or more yellow stripes.

13.4 Non-heating leads

13.4.1 Non-heating leads shall consist of wires or cables of a size and type that are suitably rated for the temperature and voltage. In no case shall the non-heating leads be less than 18 AWG (0.823 mm^2).

13.4.2 A heating system can be supplied with factory installed non-heating leads, can be provided with non-heating leads intended for field installation, or can be provided with specifications for the installer to supply specified non-heating leads.

13.4.3 Leads supplied or installed with a heating cable system shall be minimum 2.1 m (7 ft).

NOTE: Requirement (a) Reference; NFPA 70, (NEC) Section 424.34.

13.4.4 Non-heating leads that are intended to be installed concealed by or extended through a wall, below a subfloor, or inside a ceiling shall be installed in accordance with Chapter 3 of NFPA 70, National Electrical Code (NEC), and shall be one of the following types:

a) Nonmetallic sheathed type NMC-B cable complying with the Standard for Nonmetallic-Sheathed Cables, UL 719; or

b) Underground feeder type UF cable, complying with the Standard for Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables, UL 493; or

c) Mineral insulated type MI cable complying with the Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581; or

d) Other cable found acceptable for the application with respect to use, exposure, and physical properties in accordance with the National Electrical Code, NFPA 70.

NOTE: Reference; NEC NFPA 70, Section 424.43.

Exception: Leads need not meet 13.4.4(a) – (d) when installed as described in 13.4.5 and be of the type indicated in 13.4.6.

13.4.5 Non-heating leads that are not of the types described under 13.4.4 shall be installed protected from physical damage by one or more of the following methods:

a) Installed in an approved raceway in accordance with Chapter 3 of the National Electrical Code, NFPA 70; or

b) Installed covered with a combustion resistant material, such as thinset, mortar, concrete, or the like; or

c) Enclosed in a metal enclosure that meets Enclosures, Section 8.

Exception: Non-heating leads that are intended to be installed above a subfloor or under a ceiling and where risk of physical damage is unlikely based on the heating system construction and/or installation need not meet (a), (b), or (c) when the system is grounded in accordance with 12.1 and provided with a grounding component over the entire length of the non-heating cable in accordance with 12.2 and 12.3.1.

13.4.6 Non-heating leads meeting the Exception to 13.4.4 shall comply with one of the following types:

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) Other types specified in Chapter 3 of the National Electrical Code, NFPA 70.

13.4.7 A lead intended for the connection of the heating system to protective earth ground shall either be bare, or identified in green with or without one or more yellow stripes.

14 Heating Cable Elements

14.1 A heating cable element shall consist of wires or cables of a size and type that are suitably rated for the temperature, ampacity, voltage, and conditions of service to which the element will likely be subjected to. A heating cable element shall also meet the construction and performance requirements in this Standard.

14.2 Insulated conductors of heating cable systems shall comply with the Standard for Appliance Wiring Material, UL 758.

14.3 A flat strip type heating element shall comply with the Standard For Safety For Electric Heating Appliances, UL 499.

15 Laminate Elements

15.1 A laminate heating element shall be acceptable for the particular application with respect to temperature, ampacity, voltage, and conditions of service to which the element will likely be subjected to. A laminate heating element shall also meet the construction and performance requirements in this Standard.

15.2 Material properties of a laminate heating element shall be evaluated in accordance with Table 6.1 of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The requirements that apply shall be based on construction of the laminate and location of use. Similar material properties requirements that are contained in this Standard supersede UL 746C.

15.3 A laminate heating element that is not intended to be embedded in a combustion resistant material, such as thinset, mortar, concrete, or the like shall comply with the Laminate bond strength test, 55.5.

16 Splice Connectors

16.1 Splice connectors including insulation piercing type shall be suitable for use with regards to wire sizes, number of wires, crimp methods, use temperatures, conductor material, and insulation. Such connectors may be evaluated as part of the end-product.

16.2 Splice connectors including insulation piercing type complying with one of the following standards are considered acceptable to fulfill the requirement of this Standard:

a) Wire Connectors, UL 486A-486B; or

b) Splicing Wire Connectors, UL 486C; or

c) Sealed Wire Connector Systems, UL 486D; or

d) Equipment Wiring Terminals for Use With Aluminum and Copper Conductors, UL 486E; or

e) Insulated Multi-Pole Splicing Wire Connectors, UL 2459.

Exception No. 1: Splice connectors that are additionally soldered, welded, or brazed need not meet 16.1 – 16.3. The methods and materials used shall be investigated for the suitability of the connector material and heating element materials involved.

Exception No. 2: Splice connectors including insulation piercing type not meeting the standards described under 16.2 and connectors used outside of the rated wire sizes, crimp methods, use temperatures, or conductor material are considered suitable if they comply with the Connection Temperature Cycling Test, Section 43. When multiple wire sizes or material types are involved, this test is to be conducted on production samples selected from the variables that will represent the most adverse test and operating conditions.

16.3 Connectors used to connect to aluminum shall be suitably rated for the material.

16.4 When a tool is required for the field installation of a splice connector the tool shall be identified in the system's installation instructions by manufacturer's name and model number or an equivalent description. The tool shall be provided with the heating system or made available by the manufacturer unless the tool is commonly available for purchase.

16.5 A splice connector used for grounding or bonding shall comply with 16.1 to 16.3 and the Bonding Circuit Ampacity Test, Section 35.

17 Current Carrying Parts

17.1 A current carrying part shall be silver, copper, copper alloy, nickel alloy, aluminum, stainless steel, or other oxidation resistant metal or alloy acceptable for the application. Carbon based materials shall be subjected to the construction and performance requirements in this standard.

18 Electrical Connections

18.1 An electrical connection shall be mechanically secure and shall provide good electrical contact. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection can result in a risk of fire or of risk electric shock.

Exception: A soldered electrical connection that is fully encapsulated need not be mechanically secured before soldering if the manufacturer has a documented controlled process that will ensure that all of the following are met:

a) The process ensures the parts to be soldered are held together by an apparatus during soldering; and

b) Does not have potential to damage adjacent or supporting insulation materials; and

c) Does not result in loose conductor strands; and

d) Complies with the maximum connection resistance if specified.

18.2 Dissimilar metals and alloys used for an electrical connection shall be galvanically compatible in order to prevent corrosion. Wire connectors used to connect to aluminum shall be rated for the material.

19 Strain Relief

19.1 A Strain relief means shall be provided to restrict mechanical stress to any electrical connection that can be subjected to strain during the installation or use of the heating system. The strain relief means shall meet the Strain Relief Test, Section 44.

20 Electrical Insulation

20.1 The electrical properties of electrical insulation shall be evaluated in accordance with Section 6 and Table 6.1 of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Requirements shall be applied based on type of material and location of use. Similar material properties requirements that are contained in this Standard supersede UL 746C.

Exception No. 1: The electrical properties of tape, sleeving, or tubing can be evaluated under 7.7.

Exception No. 2: The electrical properties of a molded part are to be evaluated under the requirements of this Standard as an integral component.

20.2 The mechanical properties of electrical insulation shall be evaluated under the requirements of this Standard based on type of material and location of use. This includes tape, sleeving, tubing, and molded parts.

21 Electrical Spacings

21.1 The creepage and clearance spacings of a heating system shall be in accordance with Table 21.1 and Table 21.2.

Table 21.1
Minimum acceptable spacings at field wiring terminals[a,b]

Parts Involved	Potential involved, volts	Through air		Over surface	
		mm	(in)	mm	(in)
Between live parts of opposite polarity; and between a live part and a noncurrent carrying metal part, which may be grounded	0 – 250	6.4	(1/4)	9.5	(3/8)
	251 – 600	9.5	(3/8)	12.7	(1/2)

[a] The spacings do not apply to connecting straps or busses extending away from wiring terminals. Such spacings are to be judged under Table 21.2.

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

Table 21.2
Minimum acceptable spacings through air or over surface at points other than field-wiring terminals[a]

Parts involved	Potential involved, volts	mm	(in)
Between uninsulated live parts of opposite polarity; and between a rigidly mounted uninsulated live part and a noncurrent carrying metal part that either is exposed for persons to contact or may be grounded.	0 – 250	1.6	(1/16)
	251 – 600	6.4[b]	(1/4)[b]

[a] If an uninsulated live part is not rigidly supported, or if a movable noncurrent carrying metal part is in proximity to an uninsulated live part, the construction shall be such that at least the minimum acceptable spacing of 1.6 mm (1/16 in) is maintained under all operating conditions and under all normal conditions of handling.

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

22 Securement Means

22.1 A heating system shall be provided with instructions for securement to the building structure.

22.2 Mechanical fasteners and any necessary hardware or material required for securement shall be available from or provided by the manufacturer unless they are commonly available and specified in the installation instructions.

22.3 A heating system that is intended to be installed inside a concrete subfloor shall not be secured to a conductive surface and shall be secured in place by nonmetallic hardware while concrete is applied.

NOTE: Reference; NEC NFPA 70, Section 424.44(B).

23 Accessories

23.1 A heating system having provision for the use of an accessory included with the heating system or referenced by the heating system instruction manual or markings, shall comply with the requirements in this Standard, with and without the accessory installed.

23.2 An electrical accessory shall comply with the requirements applicable to that accessory as contained in the specific standard for the accessory, with consideration given to the particular end use heating system with which it is intended for use.

23.3 An accessory is to be trial installed in accordance with the Installation Test, Section 26 to determine that the installation is feasible, the instructions are detailed and correct, and the use of the accessory does not introduce a risk of fire or risk of electric shock or injury to persons.

PERFORMANCE – ALL SYSTEMS

24 General

24.1 This performance section applies to all heating systems that are covered under this Standard. These requirements are to be combined with the relevant performance requirements in Part 2 of this Standard. When a heating system represents more than one system type or installation method, tests from multiple sections in Part 2 shall be considered. Annex A provides a guide to test requirements.

24.2 Unless otherwise specified, the heating system shall be installed and operated in accordance with the manufacturer's installation instructions.

24.3 Unless otherwise specified, the heating system shall be tested in the as received condition and in a still air ambient temperature of 23 ±5°C.

24.4 When specified, test measurements shall be taken at 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.

24.5 Whenever cheesecloth is mentioned, the cloth is to be bleached, 914 mm (36 in) wide, running 20-30 m/Kg (14-15 yards per pound mass) and having what is known to the trade as a "count" of 32 by 28 in, that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 threads in the other direction).

25 Test Voltage Determination

25.1 For all testing, unless otherwise noted, the heating system shall be energized at a test voltage as described under this section.

25.2 The input voltage and power of a system are to be measured at temperature stabilization with the system installed as described in Normal Temperature Test, Section 28.

25.3 The test voltage is based on Table 25.1, if the measured wattage and watt density at the test voltage specified are equal to or greater than the marked rated wattage and rated watt density. If this is not met, then the test voltage is determined by increasing voltage until both rated wattage and rated watt density ratings are achieved.

Table 25.1
Test voltages

Marked rated voltage, volts, ac	Test voltage, volts ac
110 – 120	120
208	208
220 – 240	240
277	277
440 – 480	480
Value not within one of the above ranges	Rated voltage

26 Installation Test

26.1 The heating system including non-heating leads, heating element, integral components, assembly kits, and accessories shall be subjected to this test. A sample size representing a completed system shall be used. The system shall be installed using the applicable test fixture and installed as described in Normal Temperature Test, Section 28. The installation of the system using the manufacturer's installation instructions shall not present a risk of fire, risk of electric shock, injury to persons or physical damage to the system.

27 Power Input Test

27.1 The assembled heating system including the non-heating leads, heating elements, and integral components shall be subjected to this test. A sample size representing a completed system shall be used. The input power and current are to be measured on the system which is energized at the voltage indicated in Table 25.1. The system is to be installed in accordance with the manufacturer's installation instructions and the measurements shall be taken at temperature stabilization. The power input and current of a system shall not be more than 105 percent of the system's marked ratings.

28 Normal Temperature Test

28.1 General

28.1.1 The heating system is to be installed in accordance with the manufacturer's installation instructions and operated at the voltage or wattage as determined by the Test Voltage Determination Test, Section 25. Temperatures are to be measured and recorded on the system and surrounding locations at temperature stabilization and shall not exceed the limits specified in Table 28.2.

28.2 Test samples

28.2.1 One or more heating system samples are to be subjected to this test. When a series has models that differ in ratings, sizes, or features, a model(s) that represents the most adverse design with respect to operating temperatures can be tested to represent other models in the series.

28.2.2 A heating system is to be tested at the maximum rated watt density and at maximum rated current. If the maximum watt density is not representative of the maximum rated current, a separate test on a different sample shall also be conducted at maximum rated current. An additional load may be added to the system to simulate a maximum rated current. The additional load is to be connected so that the total load current (system plus added load) flows through the non-heating conductors and splice connectors of the system.

28.3 Test fixtures

28.3.1 See 28.1 and Annex B for the construction details of the test ceiling or test floor that shall be used when conducting this test. The test fixture is to be selected based on the installation instructions for the heating system. When a system is intended for more than one installation application, representative testing may be considered based on testing in the most adverse manner(s) with respect to temperature.

28.3.2 When a heating system is intended for installation above a concrete subfloor and above a wood floor, the above wood floor test fixture, Annex B, Figure B.1 can be used to represent the concrete subfloor. When a heating system is only intended for installation above a concrete subfloor the concrete floor test fixture, Annex B, Figure B.3 can be used with the system installed based on the installation instructions.

28.3.3 Test floor and test ceiling fixtures are to be placed in the corner of a two sided, right angle wall alcove made with wood. The walls shall consist of nominal 2 by 4 in (38 by 89 mm) softwood lumber located on nominal 16 in (406 mm) centers and covered with 3/8 in (9.5 mm) thick softwood plywood sides painted flat black. The wall sections shall extend minimum 2 ft (609 mm) from the outermost edges of the test fixture. See Table 28.1 and Annex B for further details.

Table 28.1
Test floor and ceiling fixtures

Test fixture	Figure
Above wood subfloor heating systems	Figure B.1
Under wood subfloor heating systems	Figure B.2
Inside concrete subfloor heating systems	Figure B.3
Under concrete subfloor heating systems	Figure B.4
Inside ceiling heating systems	Figure B.5
Inside ceiling and under wood subfloor heating systems	Figure B.6
Under ceiling heating systems	Figure B.7

28.4 Temperature measurements

28.4.1 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.205 mm^2) and not smaller than 30 AWG (0.0507 mm^2).

28.4.2 Temperatures on gypsum board and user contacted surfaces are to be measured by means of fine wire thermocouples brazed to 1 ±0.5 mm (0.039 ±0.02 in) thick circular or square copper plates having a nominal area of 200 ±5.0 mm^2 (0.31 ±0.008 in^2).

28.5 Test procedure

28.5.1 A heating system shall be operated continuously until temperature stabilization has been reached. The maximum temperature recorded on the system and on surrounding locations shall not exceed the limits specified in Table 28.2.

28.5.2 A heating system shall be tested without any temperature regulating device controlling the temperature, and without any field-installed sensor wire(s) connected. If these devices are provided with the product or offered as accessories, additional testing shall be considered with one or more devices installed, if the inclusion of these devices might result in a more severe test condition.

28.5.3 All values in Table 28.2 are based on an assumed ambient (room) temperature of 25°C. The test may be conducted at any ambient temperature within the range of 10 to 40°C.

28.5.4 If the test is conducted at an ambient other than 25°C, an observed temperature is to be corrected by addition (if the ambient temperature is lower than 25°C) or subtraction (if the ambient temperature is higher than 25°C) of the difference between 25°C and the ambient temperature. If a corrected temperature exceeds the limit specified in Table 28.2, at the request of the manufacturer, the test may be repeated at a temperature closer to the rated operating ambient, or closer to 25°C if no rating ambient is specified.

Table 28.2
Maximum allowable temperatures of heating systems

Item	Location	Maximum temperature, °C
1	Any point within a terminal box or wiring compartment of a heating system in which field-installed conductors are to be connected (including such conductors themselves)	60[a]
2	Non-heating leads	b
3	Combustible building members/materials	90
4	On a heating system surface, intended to be installed in contact with combustible building members/materials	90
5	Electrical insulation	b
6	Electrical components	b
7	Polymeric enclosures or components	b
8	Sealing compound	b
9	Floor surface where user can contact	43
10	Any location on gypsum board used for ceiling construction	60

a = Unless the heating system is marked in accordance with 48.4.

b = Based on material rating/limit

29 Dielectric Voltage Withstand Test

29.1 The assembled heating system including non-heating leads, heating elements, and integral components shall be subjected to this test. A sample size representing a completed system shall be used. The system shall be tested in accordance with Table 29.1 while at its maximum operating temperature. Test A is to be done on all products and Test B is additionally conducted on the specified systems. Tests A and B can be conducted simultaneously. There shall be no dielectric breakdown.

Table 29.1
Dielectric voltage withstand test

Test	Heating system type	Test location	Test potential, V rms
Test A	All systems	Between live parts and grounding component covering. If the grounding component does not completely cover locations such as a splice connection, the potential is also applied to metal foil wrapped tightly around and in contact with the specific location under test.	1000 V plus twice the voltage rating of the heating system; Duration = 60 seconds
Test B	Inside concrete systems Under concrete systems Carpet heating systems Wet location installations	Between live parts and water. Sample is to be immersed in 23 ±5°C tap water for 5 minutes. The test potential is to be applied between the live parts of the system and water.	

29.2 The test equipment shall have a 500 VA or larger capacity transformer, the output voltage of which can be regulated and is essentially sinusoidal. The increase in the applied potential is to be at a substantially uniform rate and is to be as rapid as is consistent with its value being correctly indicated by a voltmeter.

30 Insulation Resistance Test

30.1 The assembled heating system including non-heating leads, heating element, and integral components shall be subjected to this test. A sample size representing a completed system shall be used. The system shall be tested in accordance with Table 30.1. Test A is to be done on all products and Test B is additionally conducted on the specified systems. Tests A and B can be conducted simultaneously. The system shall have an insulation resistance that is not less than 50 M ohms.

Table 30.1
Insulation resistance test

Test	Heating system type	Test location	Test potential, V dc
Test A	All systems	Between live parts and grounding component covering. If the grounding component does not completely cover locations such as a splice connection, the potential is also applied to metal foil wrapped tightly around and in contact with the specific location under test.	500 Duration = 60 seconds.
Test B	Inside concrete systems Under Concrete systems Carpet heating systems Wet location installations	Between live parts and water. Sample is to be immersed in 23 ±5°C tap water for 5 minutes. The test potential is to be applied between the live parts of the system and water.	

30.2 The insulation resistance is to be measured by one of the following:

a) A megohmmeter that has an open circuit output of 500 V; or

b) A voltmeter having an internal resistance of at least 30,000 ohms and using a 250 V DC circuit; or

c) Equivalent equipment.

31 Grounding Component DC Resistance Test

31.1 When required by 12.2.3(a), a grounding component of a heating system shall be subjected to this test. The sample shall be minimum 3 m (9.8 ft) for a heating cable element and any representative sample size of a heating panel. The size shall be sufficient length or size to provide an accurate reading within the meter's capability.

31.2 The DC resistance of the grounding component and each conductor of a heating element shall be measured using a four-wire resistance method. The measurements are to be taken with the samples acclimated to a room temperature of 23 ±5°C.

31.3 The DC resistance of the grounding component is to be measured using a four-wire resistance method with the sample acclimated to a temperature of 23 ±5°C. The resistance is then compared to 18 AWG (0.81 mm^2) copper wire per ASTM B193 (20.95 mOhm/m at 20°C).

31.4 The results shall show that the resistance of the grounding component is equal to or less than the resistance of:

a) The lowest resistance of any of the conductors of a heating element; and

b) The resistance of 18 AWG (0.81 mm^2) copper wire per ASTM B193 (20.95 mOhm/m at 20°C).

32 Grounding Component Ampacity Test

32.1 When required by 12.2.3(b), the grounding component of a heating system shall be subjected to this test. The sample shall be minimum 3 m (9.8 ft) for a heating cable element and any representative sample size of a heating panel can be used.

32.2 The sample under test shall be tested in accordance with the Grounded conductive layer – Other Than Low Impedance test, Clause 4.2.14.2.2 of IEEE 515.1.

32.3 As a result of the test, the grounding component of a system shall comply with the following:

a) No charring or flaming of the cheesecloth; and

b) The insulation shall not have visible damage that presents a risk of fire, electric shock, or injury to persons.

33 Grounding Component Stabilized Resistance Test

33.1 When required by 12.2.4(a), carbon based grounding component of a heating system shall be subjected to this test. The sample(s) shall be minimum 1 m (3.28 ft) long or sufficient length or size to provide an accurate reading within the meter's capability.

33.2 The DC resistance of the grounding component is to be measured using a four-wire resistance method at 100 ±5° C and again at 23 ±5° C. The sample shall be allowed to stabilize at the two temperatures before the resistance measurements are made.

33.3 The resistance measurement at 100 ±5°C shall be compared with that at 23 ±5°C to confirm that the resistance of the carbon based grounding component does not increase as the temperature decreases and does not have a negative temperature coefficient of resistance.

34 Bonding Circuit Impedance Test

34.1 When required by 12.4.5 or 74.5.1, the bonding circuit of an assembled heating system including the non-heating leads, heating element, and integral components shall be subjected to this test. The sample shall be minimum 3 m (9.8 ft) for a heating cable element and any representative sample size for a heating panel element.

34.2 The resistance is to be measured at room temperature between the point of connection of the branch circuit equipment grounding conductor and any non-current carrying metal parts at the furthest locations from the point of connection to the branch circuit. The test apparatus shall be an ohmmeter or similar indicating instrument capable of measuring 0.10 ohms.

34.3 If the resistance measured exceeds 0.10 ohms, then the Bonding Circuit Ampacity Test, Section 35 is to be conducted.

35 Bonding Circuit Ampacity Test

35.1 When required by 12.2.4(c), 12.4.5, 16.5, 74.5.1, or the Bonding Circuit Impedance Test, Section 34, the bonding connection shall be subjected to this test. A sample size representing a completed system shall be used.

35.2 The bonding connection under test is to be connected to an isolated low voltage secondary winding of a step down transformer and operated for a time as specified in Table 35.1, and at a current that equals twice the branch-circuit overcurrent-device rating as specified by the manufacturer but not less than 40 amperes. The current passed through the bonding connection and the potential drop across the bonding connection is to be measured at the end of the test period while the current is still flowing.

35.3 All of the following compliance criteria shall be met:

a) The voltage drop for the bonding connection shall not exceed 4 V; and

b) There shall be no melting of any conductor or metal; and

c) There shall be no burning that could create a fire hazard.

Table 35.1
Duration of current-flow, bonding component ampacity test

Branch overcurrent-device rating, amperes	Test current, amperes	Minimum duration of current flow, minutes
30 or less	Two times branch overcurrent-device rating but not less than 40	2
31 to 60	Two times branch overcurrent-device rating	4
61 to 100	Two times branch overcurrent-device rating	6

36 Pin Penetration Test

36.1 When required by 12.3.1.1(b) or 12.3.3.1(b), three samples of the grounding component assembled as intended in the end use shall be subjected to this test.

36.2 The heating system is to be connected to a Listed Class A, ground-fault circuit-interrupter (GFCI). The system shall be tested as positioned in normal use without any embedment or floor coverings and operating at a voltage as determined by the Test Voltage Determination Test, Section 25. Outer jackets and other protective coverings can be removed from the test sample. A 1 ±0.02 mm (0.039 ±0.0008 in) diameter stainless steel test pin is to be pressed vertically at the force needed to penetrate completely through the system at a right angle to the heating product. The pin and test sample shall not move/drift more than 0.02 mm (0.0008 in) during the test.

36.3 The grounding component of the heating system shall provide sufficient coverage in order for the GFCI to open when the stainless steel test pin contacts live parts.

37 Elevated Temperature Test

37.1 An assembled heating system including non-heating leads, heating element, and integral components shall be subjected to this test. A sample size representing a completed system shall be used.

37.2 Compliance shall be demonstrated by meeting one of the following test methods as applicable:

a) All heating systems except those covered under (b): Elevated Temperature Test, per Clause 22.102 of IEC 60335-2-96; or

b) A heating system intended to be installed under carpet: Elevated Temperature Test, per Clause 22.102 of IEC 60335-2-106.

37.3 The heating system shall be conditioned at a temperature of 80 ±2°C, or 45 ±2°C plus the maximum temperature rise obtained during the Normal Temperature Test, Section 28, whichever is higher, for 336 hours.

37.4 After the test, there shall be no accessibility to uninsulated live parts using the probe illustrated in Figure 9.1 The sample is allowed to acclimate to room temperature (23 ±5° C) and then shall meet the Dielectric Voltage Withstand Test, Section 29, Test A.

38 Cutting Test

38.1 All assembled heating system parts including non-heating leads, heating elements, and integral components shall be subjected to this test. The sample is not energized during this test. A sample size representing a completed system shall be used. The sample under test shall be placed on a flat steel surface and a steel cutting jig with a 0.25 ±0.01 mm (0.01 ±0.0004 in) radius edge is to be applied for one minute at a right angle to the sample with a force of 445 N (100 lbf). One cut is done on each applicable part. Electrical continuity is to be continuously monitored between live parts and metal cutting jig. There shall not be any continuity throughout the test.

39 Crush Test

39.1 All assembled heating system parts including non-heating leads, heating elements, and integral components shall be subjected to this test. The sample is not energized during this test. A sample size representing a completed system shall be used. The sample under test shall be placed on a flat steel surface and a 6 mm (0.24 in) diameter steel rod with hemispherical ends and a total length of 25 mm (1 in) is to be applied for one minute at a right angle to the sample with a force of 800 N (180 lbf). One crush is done on each applicable part. During the crush, the sample is subjected to the Dielectric Voltage Withstand Test, Section 29, between live parts and grounding component. For a part without a grounding component, the potential is applied between live parts and the part wrapped in metal foil. There shall be no dielectric breakdown.

40 Impact Test

40.1 All assembled heating system parts including non-heating leads, heating elements, and integral components shall be subjected to this test. The sample is not energized during this test. A sample size representing a completed system shall be used. The sample is to be conditioned a minimum of 4 hours at the manufacturer's specified minimum installation temperature. Immediately following the conditioning, the sample is placed on a flat steel surface and impacted at a force of 6.8 J (5 ft-lb) by a 0.535 kg (1.18 lb), 50.8 mm (2 in) diameter steel sphere, dropped at a height of 1.3 m (51 in). The sample is allowed to acclimate to room temperature (23 ±5° C) and then shall meet the Dielectric Voltage Withstand Test, Section 29.

41 Cold Bend Test

41.1 All assembled heating system parts including non-heating leads, heating elements, and integral components shall be subjected to this test. The sample is not energized during this test. This test is not conducted on laminate elements; see Cold bend test – Laminate elements, 55.3. A sample size representing a completed system shall be used.

Exception: Sections of the heating system including integral components need not be tested if they are rigid, or not likely to be bent, or not intended to be bent as indicated in the manufacturer's installation instructions.

41.2 The sample is to be conditioned a minimum of 4 hours at the manufacturer's specified minimum installation temperature. After the conditioning and while still cold, the sample is placed between two bending mandrels with a radius equivalent to the manufacturer's specified minimum bending radius (tightest bend). The sample is bent degrees back and forth over the mandrels for three full cycles. The sample is allowed to acclimate to room temperature (23 ±5°C) and then shall meet the Dielectric Voltage Withstand Test, Section 29.

42 Scratch Test – Underlayment

42.1 An underlayment or other layer that is to be installed with the heating system based on the manufacturer's installation instructions and relied on to protect electrical parts from physical damage shall be subjected to this test. Two samples of the underlayment at any size shall be tested.

42.2 The samples shall be tested and comply with the Scratch Test per Clause 21.104 of IEC 60335-2-96.

42.3 There shall be no penetration through the material under test.

43 Connection Temperature Cycling Test

43.1 When required by 16.2, Exception No. 2, a splice connector including insulation piercing type shall be subjected to this test. When multiple wire sizes, material types, or installation variables (e.g. crimp force) are involved, this test is to be conducted on samples selected from the variables that will represent most adverse testing and operating conditions.

43.2 The connector shall meet one of the following tests as applicable:

a) All heating systems except as covered under (b): Electrical Connections Test per Clause 18.101 of IEC 60335-2-96; or

b) A heating system intended to be installed under carpet: Electrical Connections Test per Clause 18.101 of IEC 60335-2-106.

43.3 After the test, the voltage drop of the connection shall not exceed 22.5 mV or 1.5 times the first value measured, whichever is lower; and there shall be no evidence of damage to the connector and connection.

44 Strain Relief Test

44.1 When required by Strain Relief, Section 19, leads that maybe subjected to strain during the installation or use of a heating system are to be subjected to this test. A sample size representing a completed system shall be used.

44.2 The test procedure is to be performed as described under the Strain Relief Test per Clause 22.101 of IEC 60335-2-96.

44.3 After the test, the leads, connections, and heating elements are to be examined and there shall be no evidence of damage or strain to the electrical connections. The samples shall meet the Dielectric Voltage Withstand Test, Section 29.

45 Permanence of Cord Tag Test

45.1 General

45.1.1 When required by 48.2.2 (b) or (c), a cord tag shall meet the requirements in this section.

45.2 Test samples and conditions

45.2.1 For each type of the following conditions, three as received lengths of non-heating leads with cord tags applied are to be tested. Nine samples total are needed. If tags are applied by an adhesive, tests are to be conducted no sooner than 24 hours after application of the tag.

a) Three lengths of non-heating leads each with a cord tag are to be tested as received.

b) Three lengths of non-heating leads each with a cord tag are to be tested at the end of 30 minutes of conditioning at a room temperature of 23 ±5° C and 50 ±5 percent relative humidity, following conditioning in an air-circulating oven at 60 ±1°C for 240 hours.

c) Three lengths of non-heating leads each with a cord tag are to be tested within 1 minute after exposure for 72 hours to a relative humidity of 85 ±5 percent at 32 ±2°C.

45.3 Test method

45.3.1 Each sample described under 45.2 shall be subjected to the following tests conditions.

a) With the non-heating leads held in a vertical plane, a force of 13.3 N (3 lbf) shall be applied for 1 minute to the upper most corner of the tag at the spot farthest from the non-heating lead, within 6.4 mm (1/4 in) of the vertical edge of the tag. The force is to be applied vertically downward in a direction parallel to the major axis of the non-heating lead.

b) Each sample is to be scraped ten times across printed areas and edges, with a force of approximately 8.9 N (2 lbf), using the edge of a 2 mm (5/64 in) thick steel blade held at a right angle to the test surface.

45.3.2 As a result of the test the cord tag shall meet the following:

a) The tag shall resist tearing more than 1.6 mm (1/16 in) at any point; and

b) The tag shall not separate from the non-heating lead; and

c) There shall be no permanent shrinkage, deformation, cracking, or any other condition that will render the marking on the tag illegible; and

d) Overlamination shall remain in place and not be torn or otherwise damaged. The printing shall remain legible.

MANUFACTURING AND PRODUCTION LINE TESTS – ALL SYSTEMS

46 General

46.1 Each heating system shall withstand without dielectric breakdown, as a routine production-line test, the application of a potential at a frequency within the range of 40 to 70 hertz:

a) Between the primary wiring, including connected components, and accessible dead metal parts that are likely to become energized; and

b) Between live parts and the grounding component, when one is provided; and

c) Between primary wiring and accessible low-voltage (42.4 volts peak or less) metal parts, including terminals.

46.2 The production-line test shall be in accordance with either Condition A or Condition B of Table 46.1.

Table 46.1
Production-line conditions

Product and voltage rating	Condition A		Condition B	
	Potential, volts	Time, seconds	Potential, volts	Time, seconds
Heating cable and cable on carrier 0 – 250 volts	1000	60	1200	1
Heating cable and cable on carrier 251 – 480 volts	1000 +2V[a]	60	1200 +2.4V[a]	1
Heating panels 0 – 600 volts	1000 +2V[a]	60	1200 +2.4V[a]	1
[a] Maximum marked voltage.				

46.3 The heating system may be in a heated or unheated condition for the test.

46.4 The test shall be conducted when the heating system is fully assembled. It is not intended that the heating product be unwired, modified, or disassembled for the test.

Exception No. 1: A part such as a snap cover that would interfere with conducting the test need not be in place if it would not impact the results of the test.

Exception No. 2: The test may be performed before final assembly if the test represents that for the completed heating system.

46.5 The test equipment shall include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visible indicator of dielectric breakdown, and either a manual reset device to restore the equipment after dielectric breakdown or an automatic reject feature activated by a dielectric breakdown.

46.6 If the output of the test equipment transformer is less than 500 volt-amperes, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

46.7 If the output of the test equipment transformer is 500 volt-amperes or larger, the test potential may be indicated by a voltmeter in the primary circuit or in a tertiary winding circuit, by a selector switch marked to indicate the test potential, or in the case of equipment having a single test-potential output, by a marking in a readily visible location to indicate the test potential. When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manual-reset switch has been reset following a dielectric breakdown.

46.8 Test equipment other than that described in 46.5 to 46.7 may be used if found to accomplish the intended factory control.

RATINGS – ALL HEATING SYSTEMS

47 General

47.1 A factory assembled heating system shall be rated in:

a) Volts; and

b) AC or DC, as applicable; and

c) Total wattage or current.

47.2 A field assembled heating system shall be rated in:

a) Volts; and

b) AC or DC, as applicable; and

c) Maximum rated watts per unit length or watts per unit area, as applicable; and

d) Maximum current.

MARKINGS – ALL SYSTEMS

48 General

48.1 General

48.1.1 A heating system shall be permanently marked as described under this section.

48.1.2 Unless otherwise noted, all required markings shall be in letters not less than 1.6 mm (1/16 in) high.

48.2 Nameplate marking

48.2.1 A nameplate marking shall be permanently affixed to the heating system in a location where readily visible or accessible after installation and shall include the markings as described under 48.2.3. One or more nameplates can be used to complete the markings.

NOTE: Reference; NEC NFPA 70, Section 424.28, 424.92.

48.2.2 A nameplate marking shall be made with a non-conductive material, be of a size that facilitates legibility of the required markings, and all exposed surfaces shall have a clear plastic overlay, or the equivalent, to protect the markings. The marking shall be one or more of the following forms:

a) A printed adhesive attached label shall comply with the applicable requirements of use in accordance with the Standard for Marking and Labeling Systems, UL 969.

b) A flat tag made of substantial material (cardboard, cloth, plastic, or the equivalent) to provide mechanical strength and to prevent easy removal. The tag shall have a hole to permit securement to the non-heating lead by a plastic strap or equivalent means. The strap shall not be removable without cutting. The construction shall meet the Permanence of Cord Tag Test, Section 45.

c) A flag-type cord tag with an adhesive back. The tag is to be wrapped tightly once around and adhered to the non-heating leads. The ends of the tag are to adhere to each other and project as a flag. The required markings are to be positioned on the projecting flag portion of the tag. The construction shall meet the Permanence of Cord Tag Test, Section 45.

48.2.3 The following markings are required:

a) The manufacturer's name, trade name, trademark or other descriptive marking by which the organization responsible for the heating system may be identified; and

b) The heating systems part or model number; and

c) The electrical ratings in accordance with Ratings, General, Section 47; and

d) As applicable, the letters "V AC" after the voltage, or the symbol "~", or the letters "V DC" or the symbol ⎓" , or both. See Ratings, General, Section 47; and

e) The following or equivalent statement, as applicable: "FLOOR HEATING SYSTEM," "CEILING HEATING SYSTEM," "RADIANT HEATING SYSTEM."

f) The following or equivalent: "Connect to a Class A Ground-Fault Circuit-Interrupter (GFCI)". (For heating systems described under 6.5); and

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

g) The following or equivalent: "SEE INSTALLATION INSTRUCTIONS" in capital letters not less than 2.4 mm (3/32 in) high; and

h) For a heating system where the final dimensions are to be determined during installation, the maximum allowable heating system length or area; and

i) For a heating system where the final dimensions are to be determined during installation, a location for the installer to mark the maximum length or area of heating system installed; and

j) A heating system intended for use in wet locations and that complies with Wet Location Installations, Sections 68 and 69, shall be marked: "SUITABLE FOR WET LOCATIONS"; and

k) If a manufacturer produces a heating system at more than one factory, each finished system shall have a distinctive marking, which may be in code, to identify it as the product of a particular factory; and

l) The date or other dating period of manufacturer not exceeding any three consecutive months.

Exception: The date of manufacture may be abbreviated; or may be in a nationally accepted conventional code or in a code chosen by the manufacturer, provided that the code:

a) Does not repeat in less than 10 years for a household heating system and less than 20 years for a commercial system; and

b) Does not require reference to the production records of the manufacturer to determine when the system was manufactured.

48.3 Warning labels

48.3.1 A heating system shall be provided with an adhesive type label(s) and instructions (see 49.9) for the installer on how to complete and affix the label to the electrical panelboard supplying the system on a location that is visible after installation. The markings shall be in letters not less than 1.6 mm (1/16 in) high except that the signal word "WARNING" shall be in letters not less than 2.4 mm (3/32 in) high. The label shall contain the following items as applicable:

a) A blank location on the label for the installer to mark where the heating system is installed (e.g., master bathroom, kitchen, living room); and

b) A blank location for the installer to mark the circuit identification (e.g. Circuit 3, Breaker 2); and

c) Floor heating systems, including modular flooring heating panels systems shall include the following or equivalent statements:

"FLOOR HEATING SYSTEM"

"WARNING – RISK OF ELECTRIC SHOCK – ELECTRIC WIRING CONTAINED BELOW THE FLOOR. DO NOT PENETRATE FLOOR WITH NAILS, SCREWS, OR SIMILAR ITEMS"

"WARNING – RISK OF FIRE. UNLESS SPECIFIED, DO NOT INSTALL OBJECTS ON HEATED FLOOR THAT MAY TRAP RADIANT HEAT. SEE INSTALLATION INSTRUCTIONS"

d) For ceiling heating systems, the following or equivalent statement:

"CEILING HEATING SYSTEM"

"WARNING – RISK OF ELECTRIC SHOCK – ELECTRIC WIRING CONTAINED IN CEILING. DO NOT PENETRATE CEILING WITH NAILS, SCREWS OR SIMILAR ITEMS"

"WARNING – RISK OF FIRE. DO NOT INSTALL MATERIAL ON HEATED CEILING THAT MAY TRAP RADIANT HEAT. SEE INSTALLATION INSTRUCTIONS"

48.3.2 A heating system that is accessible after installation (e.g., attic spaces; under subfloor crawl spaces) shall be provided with an adhesive type label with the following statement. Instructions shall be provided that direct the installer to affix the label to a visible location near the point of access to the heating system, or on the heating system itself if visible after installation. The marking shall be in letters not less than 1.6 mm (1/16 in) high except that the signal word "CAUTION" shall be in letters not less than 2.4 mm (3/32 in) high:

"CAUTION – ELECTRIC HEATING SYSTEMS INSTALLED IN THIS AREA. AVOID ACTIONS WHICH MAY RESULT IN DAMAGE TO THE SYSTEM"

48.4 Supply wire marking

48.4.1 If any location within a supply connection terminal box or wiring compartment, including the surface of conductors, attains a temperature higher than 60° C during the Normal Temperature Test, Section 28, the heating system shall be marked with the following at or near the point where the supply connections are to be made and shall be clearly visible during installation and examination of the supply-wiring connections:

"For supply connections, use wires suitable for at least __°C (__°F)" or equivalent. The temperature value on the marking shall be in accordance with Table 48.1.

Table 48.1
Temperature for marking

Temperature attained in terminal box or compartment during test	Temperature marking
61 to 75°C	75°C
76 to 90°C	90°C

NOTE: Reference; NEC NFPA 70, Section 424.11.

48.5 Assembly kits and Accessories

48.5.1 Each assembly kit and accessory that is provided by the manufacturer and required for installation of the heating system (connectors, insulating covers, crimping tools, insulating tape, etc.), shall be marked on the kit or the kits smallest unit packaging with the following:

a) The kit manufacturer's name, trade name, or trademark or other descriptive marking by which the kit manufacturer may be identified;

b) The assembly kit part or model number.

c) The statement "TO COMPLETE INSTALLATION, ONLY FOR USE WITH (Manufacturer's name) MODEL (part or model number) _____ (name of heating system)", or equivalent.

INSTALLATION AND OPERATING INSTRUCTIONS – ALL HEATING SYSTEMS

49 General

49.1 General

49.1.1 A heating system shall be provided with legible installation and operating instructions that include safety instructions, system identification, system specification and limitations, ratings, installation details, and instructions for operation, labeling, and inspection as detailed in 49.2 to 49.9. The document shall start with the Safety Instructions, 49.2.

49.1.2 The installation and operating instructions required by this section shall be provided in printed form with each heating system.

49.1.3 The installation instructions shall incorporate illustrations or photos of the assembly of the system and installation procedure, as necessary to provide enough detail so that the heating system can be installed in a consistent manner by each installer.

49.2 Safety instructions

49.2.1 The safety instructions section shall include items in 49.2.2 that warn the user of risk of fire, risk of electric shock, risk of injury to persons, and state the precautions that should be taken to reduce the likelihood of any such risk. Other important items are not prohibited from being inserted as considered appropriate by the manufacturer. This section shall be a permanent part of the manual, in a location with clearly displayed boundaries unique to this section and shall precede all other instructions.

49.2.2 The safety instructions shall include the following items verbatim or equivalent as applicable. Additional statements related to safety may be added to this list.

IMPORTANT SAFETY INSTRUCTIONS PERTAINING TO A RISK OF FIRE, ELECTRIC SHOCK, AND INJURY TO PERSONS

READ AND FOLLOW ALL SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS

This heating system shall be INSTALLED ONLY by qualified personnel who are familiar with the construction and operation of the system and the risks involved.

The installation of this heating system SHALL BE in accordance with this document and regulations of the authority having jurisdiction including the National Electrical Code (NEC), NFPA 70.

DO NOT USE OR INSTALL this heating system for other than its intended use.

ONLY USE materials and accessories as specified in this document.

ENSURE clearances are provided between this heating system and any cabinets nearby the heating system as specified in this document.

This heating system is NOT to be installed under, through, or inside walls.

Inspect and REMOVE damaged or defective heating systems before covering or concealing.

DO NOT penetrate the heated system with nails, screws or similar devices.

ONLY cover this heating system with materials as specified in this document. DO NOT install any other materials on the heated surface due to risk of trapping radiant heat.

DO NOT install in decks near swimming pools, hot tubs and similar installations.

SHALL BE connected to a circuit having Class A Ground-Fault Circuit-Interrupter (GFCI) protection. (For heating systems described under 6.5).

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

DO NOT let adjacent heating cables contact or crossover each other. (For heating cable systems that meet the Exception to 51.1.4).

SAVE THESE INSTRUCTIONS

49.3 Heating system identification

49.3.1 The heating system identification section of the installation instructions shall include:

a) The manufacturer's name, trade name, or trademark or other descriptive marking; and

b) The part or model number; and

c) A description of intended system use and installation location; and

d) The part or model number for all assembly kits that are required or may optionally be used with the system.

49.4 System specifications and limitations

49.4.1 The installation instructions shall include a section on system specifications and limitations that includes the following:

a) Minimum allowable distance between adjacent cables, mats or panels (for heating cables the distance should be identified as "on-center spacing"); and

b) Minimum allowable distance to the wall; and

c) Minimum allowable distance to combustible materials, if applicable; and

NOTE: Reference; NEC NFPA 70, Section 424.13.

d) Minimum allowable installation temperature; and

e) Minimum startup temperature for self-regulating elements; and

f) Minimum allowable bend radius, if applicable; and

g) Maximum (and minimum if applicable) allowable thermal resistance R value of the floor covering, in units of BTU/(h·°F·ft^2), if applicable; and

h) Maximum allowable thermal resistance R value of building insulation that can be located under and/or over the heating system, in units of BTU/(h·°F·ft^2), if applicable. The R value and location of the insulation shall be specified; and

i) Specifications of underlayment material and location used, if applicable; and

j) Maximum permeability of barrier to be placed over or under the system, in units of perm, if applicable. The perm value and location of insulation shall be specified; and

k) Maximum allowable branch circuit overcurrent protection.

49.5 Rating section

49.5.1 The installation instructions shall include the following system ratings in a single location of the document:

a) Electrical ratings as described under Ratings, General, Section 47; and

b) For a heating system of dimensions determined during field installation, the maximum allowed system length or area and how to determine the total wattage or current of the system. The instructions shall describe that the total wattage or current; and total length or area of the heating system shall be permanently written (using indelible ink) on the marking label described under 48.2.3(h) during installation; and

c) For a heating cable system, the maximum watt density and information on how it is determined; and

d) For a heating system where multiple systems are intended to be connected together, the maximum number of systems and the maximum total wattage or current allowed.

49.6 Installation section

49.6.1 The installation instructions shall include the following details, as applicable.

a) Floor covering – The allowed floor covering materials and the maximum R value ($ft^2 \cdot °F \cdot h/Btu$). Details shall be provided on how the R value can be determined. For example, a list may be provided with allowable floor coverings including examples of various floor covering materials and the corresponding R values for each material, or where to find such information, as applicable; and

b) Vapor barrier – Material specifications and perm value, as applicable; and

c) Materials – Details on installer supplied materials (thinset, adhesive, insulation, underlayment, vapor barrier, etc.), including building trade specifications, minimum and maximum thicknesses, and any limitations, as applicable; and

d) Components – Details on installer supplied components (GFCI, junction box, fittings, conduit, wire, insulating tape, etc.), including required specifications and ratings, required certifications, and any limitations as applicable; and

e) Assembly kits – Information including part or model number for any assembly kit required for use with the heating system (may be shipped separate from the heating system) required for on-site installation; and

f) GFCI – As required based on the installation location, a statement requiring that the heating system is to be connected to a Ground-Fault Circuit-Interrupter (GFCI) for protection of personnel (Class A); and

g) Tools – Details of any specific tool required and instructions for usage. The tool shall be provided with the heating system or details shall be provided on how to obtain the tool; and

h) Securement – Details on how to secure the heating system in place; and

NOTE: Reference; NEC NFPA 70, Section 424.45(D), 424.99(B)(3).

i) Routing of Leads – Details regarding how to route non-heating leads to the mains power; and

j) Grounding – Details regarding how to connect the grounding component to protective earth ground.

49.6.2 The installation instructions for ceiling installed heating systems shall not describe attaching the heating system to an electrically conductive surface.

NOTE: Reference; NEC NFPA 70, Section 424.41(F)(H).

49.6.3 For a heating cable system that employs a series heating element, the installation instructions shall state that the length of heating cable shall not be altered.

NOTE: Reference; NEC NFPA 70, Section 424.40.

49.6.4 For a heating cable system that employs parallel heating elements, when the length is permitted to be altered in the field, the installation instructions shall specify the splices and methods identified in the manufacturer's installation instructions to be used.

NOTE: Reference; NEC NFPA 70, Section 424.40.

49.6.5 For a floor heating system, the installation instructions shall not specify that the heating system can be installed in closets.

NOTE: Reference; NEC NFPA 70, Section 424.38(B)(1).

49.6.6 For an inside concrete subfloor heating system, the installation instructions shall describe that the heating cables shall be secured in place by nonmetallic hardware while concrete is applied.

NOTE: Reference; NEC NFPA 70, Section 424.44(B).

49.6.7 For an inside concrete subfloor heating system, the installation instructions shall state that the elements shall not be installed where they bridge expansion joints, unless provisions for expansion and contraction of the heating system are provided by the manufacturer.

NOTE: Reference; NEC NFPA 70, Section 424.45(B), 424.98(B), 424.99(B)(1).

49.6.8 For an under or inside concrete subfloor heating system, the installation instructions shall indicate that the non-heating leads shall be protected where they leave the floor by approved conduit, fittings, and/or bushings.

NOTE: Reference; NEC NFPA 70, Section 424.44(C)(D), 424.98(D)(E).

49.6.9 For a ceiling heating system, the installation instructions shall state that the heating elements shall be spaced minimum 200 mm (8 in) from outlet boxes and junction boxes that are to be used for mounting surface luminaires and minimum 50 mm (2 in) from recessed luminaires and their trims, ventilating openings, and other such openings in room surfaces. The instructions shall state that the heating system shall not be covered by any surface-mounted equipment or fixtures.

NOTE: Reference; NEC NFPA 70, Section 424.39, 424.93(A)(3).

49.6.10 For a heating system intended for installation inside a ceiling, the installation instructions shall state that all branch circuit wiring shall be spaced minimum 50 mm (2 in) from the system.

NOTE: Reference; NEC NFPA 70, Section 424.36

49.6.11 For ceiling heating systems that are intended to be installed in closets, the installation instructions shall specify that the system can only be installed in portions of the ceiling that are unobstructed to the floor by shelves or other permanent luminaires.

NOTE: Reference; NEC NFPA 70, Section 424.38 (B)(C).

49.7 Operation

49.7.1 The operating instructions shall provide details on proper operation of the heating system, as applicable.

49.8 Labeling

49.8.1 The installation instructions shall provide details where to install the nameplate label and warning labels as described under 48.2 and 48.3, respectively.

NOTE: Reference; NEC NFPA 70, Section 424.47.

49.9 Inspection

49.9.1 The installation instructions shall provide details on how to properly inspect the heating system before it is covered or concealed. This shall include details on how to inspect the system for damage and remove or replace damaged cables. This should also include details on how to conduct a resistance test, continuity test, and/or insulation resistance test.

NOTE: Reference; NEC NFPA 70, Section 424.46.

49.10 Assembly kits

49.10.1 Each assembly kit required for installation of the heating system (connectors, insulating covers, crimping tools, insulating tape, etc.), shall be described in the installation instructions for the heating system or in a separate document provided with the assembly kit. When provided in a separate document, the separate document shall reference the system installation instructions.

49.10.2 The assembly kit instructions shall incorporate illustrations or photos of the assembly of the system and installation procedure, as necessary to provide enough detail so that the kit can be assembled in a consistent manner by each installer.

49.10.3 Assembly kit instructions shall include the following as applicable:

a) The manufacturer's name, trade name, or trademark or other descriptive marking; and

b) The catalog or model number of the kit; and

c) The statement "ONLY FOR USE WITH (Manufacturer's name) MODEL (part or model number) _____ (name of heating system)", or equivalent.

d) Details describing the intended use and installation location; and

e) Safety instructions in accordance with 49.2, as applicable; and

f) System specification and limitations in accordance with 49.4, as applicable; and

g) Ratings in accordance with 49.5, as applicable; and

h) Installation details in accordance with 49.6, as applicable.

49.11 Accessories

49.11.1 Accessories provided with the heating system or specified for use with the heating system shall meet 49.10 as applicable.

PART 2 – SPECIFIC HEATING SYSTEM DESIGNS AND INSTALLATION LOCATIONS

FLOOR HEATING SYSTEMS

50 General

50.1 In addition to the applicable requirements in Part 1 and Part 2 sections of this Standard, a floor heating system shall additionally comply with the requirements in this section. This section covers systems installed on:

a) Wood subfloors – Installed above (on top) or under (adjacent to rafters or joists); and

b) Concrete subfloors – Installed above (on top), inside (embedded), or under (in earth or sand bed).

50.2 This section also covers separate floor and ceiling heating systems that are intended to be installed together in a ceiling rafter/floor joist space, such as between the floor of one room and the ceiling of the room below. The ceiling heating system shall additionally meet Sections 52 and 53.

51 Performance

51.1 Normal temperature test – floor systems

51.1.1 See Normal Temperature Test, Section 28 for additional requirements.

51.1.2 When a heating system is intended for installation above a wood or concrete subfloor, the above wood subfloor test fixture Figure B.1 of Annex B, can be used to represent the concrete subfloor.

51.1.3 A floor heating system shall be installed based on the manufacturer's installation instructions in the most adverse method with respect to operating temperatures. This includes the materials specified for the installation such as thinset, adhesive, vapor barrier, underlayment and insulation.

51.1.4 For a cable floor heating system, the test assembly shall include at least one point of cable crossover. The temperature at this location shall determine the effects of improper separation during installation.

Exception: One point of cable crossover is not required for a heating system that is provided with an installation aid such as a carrier, scrim, guides, strapping, or equivalent, and the installation instructions shall include the statement not allowing the cable to crossover as described under 49.2.2. Tape is not considered a suitable installation aid.

51.1.5 To simulate a floor covering, polystyrene foam insulation is to be used and the thermal resistance of the simulated floor covering shall be based on the minimum and maximum R value ($ft^2 \cdot °F \cdot h/Btu$) in accordance with the manufacturers' installation instructions and as described under 49.4.1 (f). Different test methods shall be conducted to simulate different thermal resistance properties of different floor coverings in respect to obtaining maximum touch surface temperatures and maximum operating temperatures. If an R value provided in the installation instructions is other than a whole number, the R value used for test is to be the next highest R-0.5 value increment (i.e. If R value in instructions indicates R-1.2, then R-1.5 is to be used for test; if R-2.6 is given, R-3 is to be used for test).

51.1.6 Any building materials that are specified in the manufacturer's installation instructions for the installation shall be selected based on the most unfavorable installation material with regard to obtaining maximum touch surface temperatures and maximum operating temperatures.

51.1.7 For wood subfloor heating systems, as a minimum the Normal Temperature Test, Section 28 and 51.1 shall be conducted with a simulated floor covering thermal insulation with the following ratings:

a) Minimum R value – The thermal resistance of the simulated floor covering shall be based on the minimum R value ($ft^2 \cdot °F \cdot h/Btu$) in accordance with the installation instructions or R-0.5, whichever is lower; and

b) Maximum R value – The thermal resistance of the simulated floor covering shall be based on the maximum R value ($ft^2 \cdot °F \cdot h/Btu$) in accordance with the installation instructions or R-1, whichever is higher.

51.1.8 For concrete subfloor heating systems, as a minimum the Normal Temperature Test, Section 28 and 51.1 shall be conducted with a simulated floor covering thermal insulation with the following ratings:

a) Minimum R value – Tested without any simulated floor covering; and

b) Maximum R value – The thermal resistance of the simulated floor covering shall be based on the maximum R value ($ft^2 \cdot °F \cdot h/Btu$) in accordance with the installation instructions or R-1, whichever is higher.

51.1.9 If specified, the heating system is to be installed with additional insulation, underlayment, vapor barrier, or other material in accordance with the system installation instructions. The materials used for the testing shall have a perm value as described in the installation instructions. The position of materials shall be as detailed in the manufacturer's installation instructions for the system as required by 49.4.

51.1.10 For an under subfloor heating system, if an air gap between the heating system and the bottom of the wood subfloor is required by the manufacturer's installation instructions, then the insulation of test fixture Figure B.2 of Annex B is to be positioned accordingly.

51.2 Abnormal operation test – floor systems

51.2.1 A floor heating system (wood and concrete) shall be subjected to this test. The same sample(s) and installation methods used for the Normal Temperature Test, Sections 28 and 51.1 are to be used for this test.

51.2.2 The test fixture is modified by adding a 2.0 by 3.0 ft (0.61 by 0.91 m) piece of polystyrene foam insulation having a thermal resistance of R-5 ($ft^2 \cdot °F \cdot h/Btu$) above the floor covering layer and positioned in the most adverse method with respect to operating temperatures. For systems intended to be installed above a wood subfloor, temperatures are to be measured on the surrounding combustible building materials in the joist-bays. The test is conducted until thermal equilibrium is reached.

51.2.3 Immediately at the end of the test and while still in a heated condition, the sample shall meet the Dielectric Voltage Withstand Test, Section 29. In addition, the heating system intended for wood floors shall meet the following:

a) The temperatures of combustible building materials in the joist-bay shall not exceed 90°C.

b) The heating system shall not show any evidence of cracking, deformation or delamination based on visual inspection.

CEILING HEATING SYSTEMS

52 General

52.1 In addition to the applicable requirements in Part 1 and Part 2 sections of this Standard, a heating system intended to be installed inside (embedded), above (attic or between floors of a building adjacent to ceiling rafters or joists), or under (room side) shall additionally comply with this section.

52.2 This section also applies to floor and ceiling heating systems that are intended to be installed together in common space, such as between the floor of one room and the ceiling of the room below. The floor heating portion of the system shall additionally meet Sections 50 and 51.

53 Performance

53.1 Normal temperature test – ceiling systems

53.1.1 See Normal Temperature Test, Section 28 for additional requirements.

53.1.2 A ceiling system shall be installed based on the manufacturer's installation instructions in the most adverse method with respect to operating temperatures. This includes the materials specified for the installation, such as drywall compound, adhesive, and other materials. The system is to be installed based in the applicable test fixture as described in Annex B.

53.1.3 The heating systems are to be covered from below with ceiling facing materials as specified by the manufacturer installation instructions of the system under test. Where more than one type of ceiling facing material is specified, the combination of materials having the maximum overall thermal resistance is to be used.

53.1.4 If the manufacturer's installation instructions permit installation of heating system inside, above, or under a sloped ceiling, an additional test ceiling with a worst case pitch (rise to run; in) in accordance with the manufacturer's installation instructions.

Exception: An additional test with a sloped ceiling is not required if during the Normal Temperature Test of a horizontal ceiling installation, the maximum temperatures of Table 28.2 are not exceeded and the maximum temperature of building members/materials (Item 3 of Table 28.2) does not exceed 85°C.

53.2 Abnormal operation test – ceiling systems

53.2.1 An inside or above ceiling system shall be subjected to this test. The same sample and basic installation used for the Normal Temperature Test, Section 28 and 53.1 is used for this test.

53.2.2 The test fixture is to be modified by adding one additional layer of 3/4 in (19.1 mm) thick softwood plywood secured to the underside of the test ceiling. The heating systems are to be then operated in accordance with the test procedure of the Normal temperature test, 53.1, until temperature stabilization is reached.

53.2.3 After the test, temperatures of ceiling surface materials and the combustible building materials in the joist-bay shall not exceed 90° C and the heating system shall not show any evidence of cracking, deformation or delamination based on visual inspection. Immediately at the end of the test and while still in a heated condition, the sample shall meet the Dielectric Voltage Withstand Test, Section 29.

LAMINATE ELEMENTS

54 General

54.1 In addition to the applicable requirements in Part 1 and Part 2 sections of this Standard, a heating panel system employing laminate elements shall additionally comply with the requirements in this section.

55 Performance

55.1 Non-heating conductor (busbar) securement test

55.1.1 This test is conducted on a flexible laminate element. This test does not apply to a laminate element that is only intended to be embedded in a combustion resistant material, such as thinset, mortar, concrete, or the like. Two samples, minimum 1 m (3.28 ft) long are to be subjected to this test.

55.1.2 The electrical connection between a non-heating conductor (busbar) and carbon element resistance material shall be reliable, and compliance shall be demonstrated by meeting one of the following tests as applicable:

a) A laminate element intended to be installed non-embedded: Electrode Securement Test per Clause 18.102 of IEC 60335-2-96; or

b) A laminate element intended to be installed non-embedded and under carpet: Electrode Securement Test per Clause 18.102 of IEC 60335-2-106.

55.1.3 After the tests, the measured voltage drop across the electrical connection between a non-heating conductor (busbar) and carbon element resistance material of the element shall meet 18.102 of IEC 60335-2-96 or of IEC 60335-2-106 and the samples shall not show any damage or pitting.

55.2 Resistance – stabilized conditioning test

55.2.1 This test is conducted on a carbon based laminate element. This test is also to be conducted on grounding components constructed of carbon based materials as required by 12.4.2. The sample under test shall be minimum 1 m (3.28 ft) long.

55.2.2 The laminate element shall comply with one of the following tests as applicable:

a) All laminate elements except covered by (b): Stabilized Conditioning Test per Clause 18.103 of IEC 60335-2-96; or

b) A laminate element intended to be installed under carpet: Stabilized Conditioning Test per Clause 18.103 of IEC 60335-2-106.

55.2.3 The final resistance of the element shall not decrease more than 5 percent below the value measured after the initial period of 2 hours.

55.3 Cold bend test – laminate elements

55.3.1 A laminate element shall be subjected to this test. The sample under test shall be minimum 61 cm (2.0 ft) long. This test is not applicable to locations and parts of a sample that cannot be bent or are contained in a rigid enclosure.

55.3.2 The laminate element shall be tested and comply with one of the following tests as applicable:

a) All heating systems except as covered by (b): Cold Bend Test, per Clause 21.101 of IEC 60335-2-96; or

b) A heating system intended to be installed under carpet: Cold Bend Test, per Clause 21.101 of IEC 60335-2-106.

55.3.3 After the test the samples shall not show any evidence of cracking, deformation, or delamination. The sample is allowed to acclimate to room temperature (23 ±5° C) and then shall meet the Dielectric Voltage Withstand Test, Section 29.

55.4 Scratch test – laminate elements

55.4.1 A laminate element shall be subjected to this test. Two samples, each minimum 61 cm (2 ft) long shall be tested.

55.4.2 Each laminate element shall be tested and comply with one of the following tests as applicable:

a) All laminate element except as covered by (a): Scratch Test, per Clause 21.102 of IEC 60335-2-96; or

b) A laminate element intended to be installed under carpet: Scratch Test, per Clause 21.102 of IEC 60335-2-106.

55.4.3 After the test, each element shall meet the Dielectric Voltage Withstand Test, Section 29, Test A.

55.5 Laminate bond strength test

55.5.1 A laminate element shall be subjected to this test. This test does not apply to elements that are embedded in a combustion resistant material, such as thinset, mortar, concrete, or the like. Two sets of three samples having dimensions approximately 15 by 150 mm (0.6 by 6 in) are to be cut from a heating element. The samples for each set are taken from the different edges of the element.

55.5.2 The test procedure is to be performed as follows, as applicable. The conditioning temperature is based on the maximum temperature measured on the element during the Normal Temperature Test, Section 28.

a) All laminate element except as covered by (a): Bond Strength Test per Clause 22.103 of IEC 60335-2-96; or

b) A laminate element intended to be installed under carpet: Bond Strength Test per Clause 22.103 of IEC 60335-2-106.

55.5.3 The bond strength of each laminate shall be at least 1.5 N (0.34 lbf), and the average bond strength of the element shall not be less than 80 percent of the average of the unconditioned samples.

55.6 Insulation bond strength test

55.6.1 A laminate element shall be subjected to this test. This test does not apply to elements that are embedded in a combustion resistant material, such as thinset, mortar, concrete, or the like. Two samples, minimum 1 m (3.28 ft) long are to be subjected to this test.

55.6.2 The insulation covering the electrical connections and/or edges of the laminate element shall comply with one of the following tests as applicable:

a) All laminate elements intended to be installed non-embedded except covered by (b): Insulation Bond Strength Test per Clause 22.102 of IEC 60335-2-96; or

b) A laminate element intended to be installed under carpet: Insulation Bond Strength Test per Clause 22.102 of IEC 60335-2-106.

55.6.3 After the test, the element shall meet the Dielectric Voltage Withstand Test, Section 29 Test A.

55.7 Non-heating conductor (busbar) overload test

55.7.1 This test is conducted on a laminate element that is intended for feed-through (i. e., series) connection to other elements of the same type. The sample under test shall be minimum 3 m (9.8 ft) long. One sample is to be tested.

55.7.2 The sample under test is to be connected to a voltage as determined by the Test Voltage Determination Test, Section 25. A single layer of cheesecloth is to be placed above and below the heating surface and the non-heating conductors (busbars). An adjustable resistive load is to be added to the element, at the buss conductors opposite the supply connections. The load is to be adjusted so that the total circuit current is 110 percent of the current rating of the branch circuit overcurrent protective device (minimum 20 A) to which the system is intended to be connected. The load is to be adjusted to maintain the 110 percent value until a stable condition is observed and temperature stabilization is reached.

55.7.3 After the test, the element shall be examined and there shall be no evidence of arcing or fire as indicated by severe discoloration, burning or charring of the cheesecloth.

SYSTEMS WITH A RIGID ENCLOSURE

56 General

56.1 In addition to the applicable requirements in Part 1 and Part 2 sections of this Standard, a system with a rigid enclosure shall additionally comply with the requirements in this section.

57 Performance

57.1 Drop test – rigid enclosure

57.1.1 An assembled rigid heating system including non-heating leads, heating element, and integral components shall be subjected to this test. A sample size representing a completed system shall be used.

57.1.2 The heating system is to be conditioned for 4 hours at -15 ±2° C or the minimum installation temperature marked in the manufacturer's installation instructions, whichever is lower. The heating system is to be removed from this ambient and immediately raised over a concrete test floor and dropped so as to strike the floor in the orientation most likely to result in damage to the heating system. The drop is from a height of 0.91 m (3 ft) for floor heating system or 2 m (6 ft-7 in) for ceiling installed systems.

57.1.3 The heating system shall not develop openings or cracks that expose live parts that can be contacted by the probe as shown in Figure 9.1. The sample is allowed to acclimate to room temperature (23 ±5°C) and then shall meet the Dielectric Voltage Withstand Test, Section 29.

MODULAR FLOORING SYSTEMS

58 General

58.1 In addition to the applicable requirements in Part 1 and Part 2 sections of this Standard, a modular flooring heating system shall comply with the requirements in this section.

59 Construction

59.1 Connector securement means

59.1.1 Connectors used to interconnect modular panels shall be mechanically secured together by the design of the connector or by the design of the modular flooring heating panel, so that there will be no stress or movement of the electrical connections after installation.

59.2 Panel securement means

59.2.1 A modular flooring heating system shall be provided with means to mechanically secure individual panels together.

60 Performance

60.1 General

60.1.1 A modular flooring heating system need not meet the tests noted in Table 60.1.

Table 60.1
Test list

Test	Section
Cold Bend Test	41

60.2 Normal temperature test – modular flooring systems

60.2.1 See Normal Temperature Test, Section 28 for additional requirements.

60.2.2 A modular flooring heating system shall be installed based on the manufacturer's installation instructions in the most adverse method with respect to operating temperatures. This includes the materials specified for the installation, such as thinset, adhesive, vapor barrier, underlayment, and insulation. The system shall be installed on the subfloor in accordance with Annex B, Figure B.1. A simulated floor covering is to be applied in accordance with 51.1.5 if applicable.

60.3 Drop test – modular flooring systems

60.3.1 A modular heating panel assembly shall meet the Drop Test described under 57.1 with a drop height of 0.91 m (3 ft).

60.4 Moisture resistance test – modular flooring systems

60.4.1 A modular heating panel assembly shall be subjected to this test. Any representative sample size can be used.

60.4.2 The modular heating panel assembly shall be designed with a protection of water ingress rating of IPX1 per Clause 6.2 of IEC 60335-2-96 and tested in accordance with Clause 14.2.1 of IEC 60529.

60.4.3 Immediately after the conditioning the modular heating panel assembly shall not have any water ingress per 14.3 of IEC 60529. The sample shall meet the Dielectric Voltage Withstand Test, Section 29.

RIGID AND SEMI-RIGID FLOORING SYSTEMS

61 General

61.1 In addition to the applicable requirements in Part 1 and Part 2 sections of this Standard, a heating system that is in direct contact with rigid and semi-rigid flooring shall comply with the requirements in this section.

62 Construction

62.1 All electrical components shall be protected from physical damage by an enclosure meeting Enclosures, Section 8, by the flooring panel, or by method/materials of installation.

63 Performance

63.1 Normal temperature test – systems in contact with rigid and semi-rigid flooring

63.1.1 See Normal Temperature Test, Section 28 for additional requirements.

63.1.2 A heating system that is in direct contact with rigid and semi-rigid flooring shall be installed based on the manufacturer's installation instructions in the most adverse method with respect to operating

temperatures. This includes the materials specified for the installation, such as thinset, adhesive, vapor barrier, underlayment and insulation. The system shall be installed on the subfloor in accordance with Annex B, Figure B.1. If the manufacturer's installation instructions allow the use of an area rug over the heating system, then a simulated floor covering is to be applied in accordance with 51.1.5.

63.2 Moisture resistance test – systems in contact with rigid and semi-rigid flooring systems

63.2.1 A system in contact with rigid and semi-rigid flooring shall comply with Moisture resistance test, 60.4, without the floor covering installed.

INSIDE CONCRETE SYSTEMS

64 General

64.1 In addition to the applicable requirements in Part 1 of and Part 2 sections of this Standard, a heating system intended to be installed inside a concrete subfloor shall additionally comply with the requirements in this section.

65 Performance

65.1 Concrete slab cracking test

65.1.1 An inside concrete system including non-heating leads, heating elements, and integral components that is intended to be installed in a concrete slab shall be subjected to this test. The system shall be installed in accordance with Annex B, Figure B.3, except that the size of the slab shall be minimum 2 by 2 ft. The non-heating leads, heating element, and integral components shall be positioned across the location where the crack will be formed.

Exception: Mineral insulated (MI) cable is exempt from this test.

65.1.2 One end of the concrete slab is to be raised and a crack is to be created in the concrete by hitting the slab on the control joint with a sledge hammer. The concrete sections are to be separated farther by means of a pry bar until the gap between the slabs is 12.7 ±6.35 mm (1/2 ±0.25 in) wide. Salt water solution consisting of 1 gram of sodium chloride (NaCl) per liter of distilled water is to be poured continuously in the crack and is to submerge the space heating cable and integral components. The water solution is poured continuously in the crack while applying a dielectric voltage test potential of 1000 V plus twice the maximum rated voltage of the heating system between the live parts and a copper probe made of 1.52 mm (6 in) of 12 AWG uninsulated solid copper alloy wire which is inserted through the crack in the concrete slab. The probe is to be inserted into the water solution and placed within 12.7 ±6.35 mm (1/2 ±0.25 in) from the system but not in contact.

65.1.3 The test equipment is to be the same as described in Dielectric Voltage Withstand Test, Section 29. The system shall withstand the dielectric voltage test potential for one minute without dielectric breakdown.

CARPET HEATING SYSTEMS

66 General

66.1 In addition to the applicable requirements in Part 1 and Part 2 sections of this Standard, a heating system intended to be installed directly under carpet without embedment shall additionally comply with the requirements in this section.

67 Performance

67.1 Normal temperature test – carpet heating systems

67.1.1 See Normal Temperature Test, Section 28 for additional requirements.

67.1.2 An under carpet heating system shall be installed based on the manufacturer's installation instructions in the most adverse method with respect to operating temperatures. This includes the materials specified for the installation, such as thinset, adhesive, vapor barrier, underlayment, padding, and insulation. The system shall be installed on the subfloor in accordance with Annex B, B1. A simulated floor covering is to be applied over the heating product in accordance with 51.1.5.

67.2 Moisture resistance test – carpet heating systems

67.2.1 A carpet heating system shall be subjected to this test. Any representative sample size can be testing.

67.2.2 The system shall be designed with a protection of water ingress rating of IPX7 per Clause 6.2 of IEC 60335-2-96 and shall be tested in accordance with Clause 14.2.1 of IEC 60529.

67.2.3 After the test, the system shall not have any water ingress per 14.3 of IEC 60529. The system shall also meet the Dielectric Voltage Withstand Test, Section 29.

67.3 Crush test – carpet heating systems

67.3.1 A carpet heating system including the heating element, integral components, and non-heating leads shall be subjected to this test. A sample size representing a completed system shall be used.

67.3.2 The test procedure is to be performed as described per the Crush Test in Clause 21.103 of IEC 60335-2-106.

67.3.3 After the test, there shall be no visible damage to the heating system to such an extent that compliance with this Standard is impaired. The system shall also meet the Dielectric Voltage Withstand Test, Section 29.

67.4 Crush test (chair)

67.4.1 A carpet heating system including the heating element, integral components, and non-heating leads shall be subjected to this test. The sample under test shall be minimum 61 cm (2 ft) long. Underlayment is used if required by the manufacturer’s installation instructions.

67.4.2 The test procedure is to be performed as described per the Crush Test (Chair) in Clause 21.104 of IEC 60335-2-106.

67.4.3 After the test, there shall be no visible damage to the system to such an extent that compliance with this standard is impaired. The system shall also meet the Dielectric Voltage Withstand Test, Section 29.

67.5 Flexing test (carpet heating cable)

67.5.1 A carpet heating system employing a heating cable shall be subjected to this test. A sample size representing a completed system shall be used.

67.5.2 The test procedure is to be performed as described per the Flexing Test of Clause 21.105 of IEC 60335-2-106.

67.5.3 After the test, there shall be no visible damage to the system to such an extent that compliance with this Standard is impaired. The insulation resistance shall be measured in accordance with the Insulation Resistance Test, Section 30. The resistance shall be minimum 1.0 M ohms.

67.6 Severe conditions test

67.6.1 An assembled carpet heating system including the heating element, integral components, and non-heating leads shall be subjected to this test. The same sample and installation used for the Normal Temperature Test, Section 28 is used for this test.

67.6.2 The system shall be operated for minimum 7 hours at 106 percent of the test voltage as determined by the Test Voltage Determination Test, Section 25. A single layer of cheesecloth is to be draped over the entire heating system (under the carpet) and the equipment is to be operated as described.

67.6.3 There shall be no fire and no visible damage to the system to such an extent that compliance with this standard. The system shall also meet the Dielectric Voltage Withstand Test, Section 29.

67.7 Spark emission test (laminate heating elements)

67.7.1 A carpet heating system with a laminate heating element shall be subjected to this test. Six samples of the enclosure (without the heating element) having dimensions of 100 by 200 mm (3.9 by 7.9 in) shall be used.

67.7.2 The enclosure of the laminate heating element shall meet the Spark Emission Test per Clause 30.101 and 30.101.1 of IEC 60335-2-106.

67.7.3 After the test, the resistance of ignition values are calculated and shall meet 30.101.1 of IEC 60335-2-106.

WET LOCATION INSTALLATIONS

68 General

68.1 In addition to the applicable requirements in Part 1 and Part 2 of this Standard, a heating system intended to be installed in a wet location shall meet the requirements of this section.

69 Performance

69.1 Long-term insulation resistance test – non-heating leads and heating elements

69.1.1 Non-heating leads and all heating elements shall be subjected to this test. The test shall be performed on two samples, each 17 m (56 ft) in length for heating cables and non-heating leads, or minimum 91 cm (3 ft) for laminate heating elements. Integral components and carriers are not subjected to this test.

Exception No. 1: Non-heating leads need not be subjected to this test if they are not intended for wet location use and are restricted from wet locations in the installation instructions.

Exception No. 2: Non-heating leads and heating cable elements that comply with wet location requirements per the Standard for Thermoset-Insulated Wires and Cables, UL 44, or the Standard for Thermoplastic-Insulated Wires and Cables, UL 83, or the Standard for Appliance Wiring Materials, UL 758, need not be subjected to this test.

69.1.2 The samples shall be tested in accordance with Long-term insulation resistance (Method 1), in the Standard for Safety for Wire and Cable Test Methods, UL 2556. The test is to be conducted by submerging 15 m (50 ft) of the 17 m (56 ft) cables or 30 cm (1 ft) of the 61 cm (2 ft) samples of the laminate heating elements in 75 ±2°C tap water for a period of minimum 12 weeks and no longer than 24 weeks.

69.1.3 An AC voltage equal to the voltage rating of the heating system shall be applied between carrying parts and the grounding component covering at all times, other than while measuring the insulation resistance. For non-heating leads and elements that are not provided with a grounding component, the voltage is to be applied between current carrying parts and the water.

69.1.4 While in the water bath, the insulation resistance is to be measured once a week between current carrying parts and the grounding component. For non-heating leads and elements that are not provided with a grounding component, the insulation resistance is to be measured between current carrying parts and the water.

69.1.5 The insulation resistance shall be in accordance with the following:

a) Greater than 20 G ohms at all times; or

b) Greater than 10 M ohms at all times, and the maximum decrease in insulation resistance shall not be more than 4 percent between weeks using a linear regression over a 12 week period. The test may be continued up to 24 weeks, if needed, to establish compliance.

69.2 Long-term Insulation resistance test – integral components

69.2.1 The integral components of a heating system assembled to non-heating leads and heating elements shall be subjected to this test. Any representative sample size can be used.

Exception: Integral components that are not intended be installed in a wet location and are restricted from wet locations in the installation instructions need not be subjected to this.

69.2.2 The sample under test shall be placed in a 23 ±5°C water bath for a minimum of 12 weeks and no longer than 24 weeks. While in the water bath, the insulation resistance is to be measured every seven days between current carrying parts and the water. The insulation resistance shall be in accordance with the following:

a) Greater than 1 G ohms at all times; or

b) Greater than 10 M ohms at all times, and the maximum decrease in insulation resistance shall not be more than 4 percent between weeks using a linear regression over a 12 week period. The test may be continued up to 24 weeks, if needed, to establish compliance.

69.3 Water resistance test

69.3.1 The heating system including non-heating leads, heating elements, and integral components shall be subjected to this test. The test shall be performed on one sample, minimum 3 m (9.8 ft) in length for heating cables and non-heating leads; and minimum 30.5 cm (1 ft) for laminate heating elements.

Exception: Integral components and non-heating leads of a system need not be subjected to this test if they are not intended for wet location use and are restricted from wet location in the installation instructions.

69.3.2 The sample under test shall be tested in accordance the requirements per the Integral Components Resistance to Water Test, Clause 4.2.4 of IEEE 515.1.

69.3.3 Immediately after conditioning, the sample shall meet the Dielectric Voltage Withstand Test, Section 29, Test B.

SELF-REGULATING SYSTEMS

70 General

70.1 In addition to the applicable requirements in Part 1 and Part 2 sections of this Standard, a self-regulating (positive temperature coefficient, PTC) type heating system, shall additionally comply with the requirements in this section.

71 Performance

71.1 Thermal endurance test

71.1.1 A self-regulating type heating system that has PTC characteristics shall be subjected to this test. Three samples are to be tested that are minimum 600 mm (23.6 in) in length for heating cables and any representative size for laminate elements. If the element device has different levels of rated voltage and wattage, then three samples each shall be selected that represent:

a) Lowest rated voltage and the maximum rated output power; and

b) Maximum rated voltage and the minimum rated output power.

71.1.2 The heating system shall comply with the Thermal Endurance Test, Clause 4.2.6 of IEEE 515.1.

71.1.3 After the test the heating element shall maintain an output power within +20 percent or -25 percent of the initial measured output power.

71.2 Verification of startup current test

71.2.1 A self-regulating type heating system that has PTC characteristics shall be subjected to this test. One sample is to be tested that is minimum 1 m (3.28 ft) in length.

71.2.2 The heating system shall comply with the Verification of Startup Current, Clause 4.2.12 of IEEE 515.1.

71.2.3 The startup current shall be measured at 5 ±2°C or the manufacturer's specified minimum rated startup temperature, whichever is lower.

LOW VOLTAGE SYSTEMS

72 General

72.1 In addition to the applicable requirements in Part 1 and Part 2 sections of this Standard, a low voltage heating system shall meet the requirements of this section.

72.2 These requirements cover indoor fixed electric space heating systems in accordance with National Electrical Code, NFPA 70, Article 424, Part X that consist of a low voltage isolating power unit, heating elements, and associated components that are identified and intended for use in dry locations. The output circuits of the power unit that connect to the heating element shall be limited to 25 amperes and operate at or below the risk of electric shock voltage level. The system shall be supplied from a maximum 30 ampere branch circuit.

72.3 A low voltage heating system shall be provided as a complete system in accordance with 4.25.

73 Construction

73.1 Enclosure

73.1.1 The enclosure requirements of Enclosures, Section 8 apply to low voltage heating system and power units.

Exception No. 1: The Enclosures, Section 8 requirements do not apply to low voltage parts of a low voltage heating system installed above a subfloor and that are fully encapsulated in a combustion resistant building material, such as thinset, mortar, concrete, or the like, and connected to a power unit that meets the Exposed current carrying parts test, 74.8.

Exception No. 2: The Enclosures, Section 8 requirements do not apply to low voltage parts of a low voltage heating system installed under a ceiling (i.e. occupied space) made of gypsum board, are located at least 2.2 m (7 ft) above the floor, and connected to a power unit that meets Exposed current carrying parts test, 74.8.

73.2 Power unit

73.2.1 The maximum output rating of a power unit shall not exceed the risk of electric shock voltage and 25 A per circuit, under any conditions of load.

73.2.2 The low voltage secondary circuit shall be isolated from the primary circuit and shall not be grounded.

73.2.3 The primary and secondary windings of a transformer type power unit shall be isolated, and shall comply with one of the following standards or set of standards, as applicable:

a) Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2; or

b) Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3; or

c) Transformer and Motor Transformers for Use in Audio-, Radio- and Television-Type Appliances, UL 1411; or

d) Low Voltage Landscape Lighting Systems, UL 1838; or

e) Power Units Other Than Class 2, UL 1012; or

f) Class 2 Power Units, UL 1310; or

g) Low Voltage Lighting Systems, UL 2108.

73.2.4 An electronic power supply of a power unit shall comply with the electrical construction and performance requirements of one of the following standards:

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

b) Standard for Class 2 Power Units, UL 1310;

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

73.3 Power unit overload and thermal protection

73.3.1 Each output of the power unit shall be provided with overcurrent protection and be limited to a maximum of 25 A under all loading conditions.

73.3.2 An overcurrent protective device shall comply with 7.6.

73.3.3 If provided, a thermal protective device shall comply with the appropriate standard.

73.3.4 If provided, a non-resettable thermal protective device shall be located within an enclosure and shall not be accessible to the end user.

73.4 Power supply connection

73.4.1 Line voltage and low voltage non-heating conductors intended to be concealed or extended through a wall, floor, or ceiling shall be of the type permitted by Chapter 3 of the National Electrical Code (NEC), NFPA 70. Instructions referring to wiring intended to be concealed or extended through a wall, floor, or ceiling shall indicate that such wiring shall be installed in accordance with Chapter 3 of the NEC.

73.4.2 A power unit shall be provided with a permanent means of connection based on one of the following:

a) Provision for mounting over a standard outlet box; or

b) Provision for connection to conduit; or

c) Other means in accordance with the National Electrical Code, NFPA 70.

73.4.3 The means for connection to the power unit shall consist of pigtail leads, terminal block, pressure terminal connector, flexible cord without attachment plug, or equivalent means.

73.4.4 All connections shall be mechanically secured.

73.5 Exposed current carrying parts

73.5.1 A current carrying part (i.e. conductors, bus bars, heating elements, connectors) of a low voltage heating system can be exposed and installed without electrical insulation when all of the following are met.

a) The part is located in an occupied space and is at least 2.2 m (7 ft) above a floor or installed above a subfloor and fully encapsulated in a combustion resistant building material, such as thinset, mortar, concrete, or the like; and

b) The part is connected to a power unit that is provided with integral protection against inadvertent shorting and overloading by meeting the Exposed Current Carrying Parts Test, 74.8.