UL 539

STANDARD FOR SAFETY

Single and Multiple Station Heat Alarms

UL Standard for Safety for Single and Multiple Station Heat Alarms, UL 539

Eighth Edition, Dated June 23, 2022

Summary of Topics

This revision of ANSI/UL 539 dated January 14, 2025 includes alignment of Maximum Ambient Temperature of Heat Alarms with NFPA 72: Table 7.1 and 7.2A.

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated November 1, 2024.

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Commitment for Amendments

This Standard is issued jointly by ULSE Inc. (ULSE) and ULC Standards. Amendments to this Standard will be made only after processing according to the Standards writing procedures by ULSE and ULC Standards.

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

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The most recent designation of ANSI/UL 539 as an American National Standard (ANSI) occurred on January 14, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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Preface

This is the common ULSE and ULC Standard for Single and Multiple Station Heat Alarms. It is the First edition of CAN/ULC 589, and the Eighth edition of ANSI/UL 539.

This common Standard was prepared by ULSE Inc., ULC Standards, and the Joint ULSE/ULC Task Group. The efforts and support of the Joint Task Group are gratefully acknowledged.

This Standard was formally approved by the ULC Standards Committee on Fire Alarm And Life Safety Equipment And Systems and ULSE Technical Committee on Smoke Detectors and Alarms.

Only metric SI units of measurement are used in this Standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

Annexes A and C, are identified as normative, forms mandatory parts of this Standard.

Annexes B and D, identified as informative, is for informational purposes only.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of Harmonization

This Standard is published as an identical standard between ULSE and ULC Standards. An identical standard is a standard that is the same in technical content except for conflicts in Codes and Governmental Regulations. Presentation shall be word for word except for editorial changes.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard shall be based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision shall be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

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INTRODUCTION

1 Scope

1.1 These requirements cover heat-actuated, single and multiple station heat alarms intended for indoor installation in accordance with:

a) In Canada:

1) The National Building Code of Canada,

2) The National Fire Code of Canada,

b) In the United States:

3) The National Fire Alarm and Signaling Code, NFPA 72

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.2 A component is not required to comply with a specific requirement that:

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

b) Is superseded by a requirement in this standard.

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

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

3 Units of Measurement

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

4 Referenced Publications

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

4.2 The following publications are referenced in this Standard:

ASTM International

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM MNL 12, *Manual on the Use of Thermocouples in Temperature Measurement*

Binational

CSA C22.2 No. 153/UL 310, *Electrical Quick-Connect Terminals*

CSA Group

CSA 22.1, *Canadian Electrical Code, Part I, Safety Standard for Electrical Installations*

CSA C22.2 No. 0.17, *Evaluation of Properties of Polymeric Materials*

CSA C22.2 No. 65, *Standard for Wire Connectors*

CSA C22.2 No. 158, *Terminal Blocks*

Department of Defense

MIL-STD-1916, *DoD Preferred Methods for Acceptance of Product*
(MIL STD 105, *Sampling Procedures and Tables for Inspection by Attributes)*

MIL-HDBK 217F, *Reliability Prediction of Electronic Equipment*
(MIL-HDBK 217B, *Reliability Prediction of Electronic Equipment)*

MIL-STD 750E, *Test Methods for Semiconductor Devices*

MIL-STD 883H, *Test Methods Standard Microcircuits*
(MIL-STD 883K, *Test Methods Standard Microcircuits)*
(MIL-STD 883D, *Test Methods Standard Microcircuits)*
(MIL-STD 883B, *Test Methods Standard Microcircuits)*

IEC

IEC 61000-4-5, *Electromagnetic Compatibility (EMC) Part 4-5: Testing and Measurements Techniques – Surge Immunity Test*

NFPA

NFPA 70, *National Electrical Code*

NFPA 72, *National Fire Alarm and Signaling Code*

NRCC

National Building Code of Canada

National Fire Code of Canada

UL Standards

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 486A-486B, *Wire Connectors*

UL 486E, *Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors*

UL 746E, *Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards*

UL 1059, *Terminal Blocks*

5 Glossary

5.1 For the purpose of this standard the following definitions apply.

5.2 ALARM SIGNAL – An audible signal that lasts at least two complete cycles of the temporal pattern to indicate an emergency fire condition.

5.3 COMPONENT, LIMITED LIFE – A component that is expected to fail and be periodically replaced and whose failure is supervised when failure of the component affects the intended operation, heat sensitivity, or both. Typical examples of such components include incandescent lamps, electronic tube heaters, functional heating elements, and batteries. See also Component Failure, 28.4.

5.4 COMPONENT, RELIABLE – A component that is not expected to fail or be periodically replaced and is not supervised. A reliable component shall have a predicted failure rate of 2.5 or less failures per million hours and determined for a "Ground Fixed" (GF) environment by MIL-HDBK 217F, or equivalent.

5.5 HEAT ALARM, SINGLE STATION – A self-contained fire alarm device comprising of a heat sensor, an alarm sounding device, and a stored energy source (wound spring or battery) incorporated in one integral package.

5.6 LOW BATTERY TROUBLE POINT – Any combination of battery voltage and series resistance that results in an audible trouble signal from a battery-operated alarm.

5.7 MANUFACTURER'S PUBLISHED INSTRUCTIONS – Published installation and operating documentation provided for each product or component. The documentation includes directions and necessary information for the intended installation, maintenance, and operation of the product or component.

5.8 MECHANICALLY-OPERATED-TYPE – A heat alarm having a temperature sensitive bimetal or eutectic element and a spring-wound-type mechanism with clapper mounted within a bell housing. The snap action of the bimetal or melting of the eutectic element releases the spring mechanism resulting in a bell-type sound.

5.9 RISK OF ELECTRIC SHOCK – A risk of electric shock is determined to exist at any part, when:

a) The potential between the part and earth ground or any other accessible part is more than 42.4 volt peak and

b) The continuous current flow through a 1500 ohm resistor connected across the potential exceeds 0.5 milliampere.

5.10 RISK OF FIRE – A risk of fire is determined to exist at any point in a circuit where:

a) The open circuit voltage is more than 42.4 volt peak, and the energy available to the circuit under any condition of load, including short circuit, results in a current of 8 amperes or more after 1 min of operation or

b) A power of more than 15 watts is deliverable into an external resistor connected between the two points.

5.11 TROUBLE SIGNAL – A visible or audible signal intended to indicate a fault or trouble condition.

5.12 UNCONDITIONED AREA – Enclosed spaces without continuous climate controls where an individual spends time. (Examples include attached garages, crawl spaces and attics associated with a family living unit, cottages and cabins with combustible fuel appliances and/or fireplaces, barns, etc.)

5.13 VOLTAGE CLASSIFICATION – Unless otherwise indicated, all voltage and current values specified in this standard are rms:

a) Extra-Low-Voltage Circuit – A circuit that has an AC voltage of not more than 30 volts alternating current (AC) (42.4 volts peak) and maximum power of 100 volt-amperes, such as supplied by a Class 2 transformer; or a circuit of not more than 30 volts direct current (DC) supplied by a primary battery; or a circuit supplied by a combination of a transformer and fixed impedance, that as a unit, complies with all the performance requirements of a Class 2 transformer. A circuit that is derived from a supply circuit of more than 30 volts by connecting resistance or impedance, or both, in series with the supply circuit to limit the voltage and current, is not identified as an extra-low-voltage circuit.

b) Hazardous-Voltage Circuit – A circuit having characteristics in excess of those of an extra-low-voltage circuit.

6 Manufacturer's Published Instructions

6.1 A copy of the installation and operating instructions and related schematic wiring diagrams and installation drawings shall be used as a reference in the examination and test of the heat alarm. For this purpose, a printed edition is not required.

6.2 The manufacturer's published instructions shall include directions and information deemed by the manufacturer to be required for proper and safe installation, testing, maintenance, operation, and use of the heat alarm.

7 Temperature Classification

7.1 Single and multiple station heat alarms are classified as to their temperature of operation. See Table 7.1.

Table 7.1
Temperature Classifications

Temperature classification	Rating range °C	(°F)
Low	46 – 57	(115 – 134)
Ordinary	57 – 79	(135 – 174)
Intermediate	79 – 107	(175 – 225)

7.2 The maximum rating of a heat alarm shall not exceed 107 °C (225 °F).

7.2A The maximum installation temperature of a heat alarm shall be a minimum of 11.1 °C (20 °F) below its operating temperature rating.

8 Alarm Reliability Prediction (Electrically-operated)

8.1 The maximum failure rate for heat alarm units shall be 4.0 failures per million hours as calculated by a full part stress analysis prediction as described in of MIL-HDBK 217F or 3.5 failures per million hours as calculated by a simplified parts count reliability prediction as described in MIL-HDBK 217F, or equivalent. A "Ground Fixed" (GF) environment is to be used for all calculations. When actual equivalent data is available from the manufacturer, it shall be used in lieu of the projected data for the purpose of determining reliability.

8.2 Any component whose failure results in energization of an audible trouble signal, energization of a separate visual indication (orange or yellow), de-energization of a power-on light, or:

a) Does not affect the normal operation or

b) Is evaluated by specific performance tests included in this standard

does not require inclusion in the failure rate calculation. Examples include the audible signal appliance, thermostat, test switch, and battery contacts.

8.3 An integral or remote accessory, such as an integral transmitter or remote sounding appliance, is not required to be included in the reliability prediction except for those components whose failure affects the normal operation of the heat alarm.

8.4 A custom integrated circuit used in a heat alarm shall have a predicted failure rate of not greater than 2.5 failures per million hours. The failure rate is to be determined through evaluation of data in a 3000-hour burn-in test, or equivalent.

9 Batteries

9.1 General

9.1.1 When a battery or set of batteries is used as the main source of power of a single or multiple station heat alarm, it shall comply to the requirements of the Battery Tests, Section 66.

9.1.2 Batteries included as part of an alarm shall be so located and mounted that terminals of cells are prevented from coming in contact with uninsulated live parts, terminals or adjacent cells, or metal parts of the enclosure as a result of shifting.

9.1.3 A battery compartment intended for use with rechargeable batteries which emit gases during charging shall be provided with vent holes.

9.1.4 Ready access shall be available to the battery compartment to facilitate battery replacement, without damage to the alarm components or disassembly of any part of the alarm, except for a cover or the equivalent.

9.1.5 Connections of external wiring to a battery-operated single or multiple-station heat alarm, or to a portable accessory, shall not be subjected to stress or motion during battery replacement, servicing, or both. Removal of the alarm or accessory from the mounting support to replace a battery or to service the unit shall occur only when the connected wiring is not subjected to flexing or stress.

9.2 Battery connections

9.2.1 Lead or terminal connections to batteries shall be identified with the proper polarity, (plus or minus signs), and provided with strain relief. It is not prohibited for the polarity to be indicated on the unit adjacent to the battery terminals or leads.

9.2.2 Connections to battery terminals shall be either by a lead terminating in a positive snap action type of clip, or a fixed butt type connection which applies a minimum of 6.6 N (1.5 lb) force to each battery contact, or equivalent. The connection shall consist of an unplated or plated metal which is resistant to the corrosive action of the electrolyte.

9.2.3 Each lead of a clip-lead assembly used as part of a battery operated alarm shall be a minimum of 22 AWG (0.32 mm^2) stranded wire with a minimum 0.4 mm (1/64 in) insulation.

9.3 Battery removal/deactivation indicator

9.3.1 Removal of a battery from a battery-operated (or AC with battery back-up) heat alarm shall result in a readily apparent and prominent indication. The indication shall consist of at least one of the following:

a) A warning flag that is exposed with the battery removed and the cover closed;

b) A hinged cover that is resistant to being closed with the battery removed;

c) A swing-out or pull-out battery compartment that is resistant to being closed unless it has a battery in place;

d) An audible or audible and tactile trouble signal on an AC powered smoke alarm with battery back-up;

e) An arrangement to render the unit resistant to reinstallation; or

f) A local audible, local audible and tactile, or local visual indication at the control panel.

9.3.2 When a warning flag, or equivalent, is employed to comply with the requirement of 9.3.1, it shall be marked as required in 73.2, Marking.

CONSTRUCTION

10 Mounting

10.1 A heat alarm shall be provided with a means for mounting either to a ceiling or wall.

10.2 The means for mounting shall not result in any distortion of the heat alarm that alters its operating characteristics.

MECHANICALLY OPERATED HEAT ALARMS

(Note: These requirements apply specifically to mechanically-operated alarms only)

11 Calibration

11.1 Any means for calibration or adjustment shall be guarded or sealed to reduce the risk of manipulation by hand or ordinary tools. A thermal responsive element adjustment, if provided as part of a unit, shall not be adjustable after shipment from the factory.

11.2 A calibration means is considered to be not accessible or apparent when it is not showing, not exposed to manipulation by conventional tools, or not readily displaced. The complete concealment of conventional tool-engaging means in a screw, such as a slot and a recessed head, by the use of solder or brazing material is considered to prevent manipulation if the calibration means cannot be changed by gripping with conventional tools and engagement or manipulation is prevented.

12 Materials

12.1 Diaphragms and spring parts shall be made of nonferrous material, such as phosphor bronze, nickel, silver, or of ferrous materials. If ferrous materials are used, they shall be hermetically sealed or plated to protect against corrosion.

12.2 A heat sensing element, provided that it is used as the operating member of a heat alarm, shall be protected against conditions it is likely to be exposed to when in service, as represented by the tests described in Sections 25 – 71 of this standard.

12.3 All exposed parts whose required performance can be impaired by corrosion shall be protected by enameling, galvanizing, sherardizing, plating, or other means determined to be equivalent.

13 Operating Mechanisms

13.1 The moving parts of a heat alarm shall have sufficient play at bearing surfaces to protect against binding.

13.2 A gear train driving spring shall be securely anchored at each end. The spring winding means shall be provided with a positive stop to limit the winding or shall withstand the maximum force likely to be applied without impairing the operation of the mechanism.

14 Mechanical Assembly

14.1 Any servicing or restoration operations intended to be made by the user shall be simple and capable of being accomplished with ordinary hand tools.

14.2 A heat alarm shall be so constructed that parts will not become displaced during or after installation.

14.3 An obstruction means, such as a wire mesh screen, shall be provided to protect against the entry of foreign bodies or materials into sounding devices that could prevent their operation. The maximum size of the openings shall be 3.2 mm (1/8 in). The obstruction means is to be attached securely in place. See the Vibration Test, Section 38.

15 Power Supervisory Feature

15.1 A means shall be provided on a unit to automatically indicate that operating power is not available. The indication may be in the form of a flag, target, sight glass, change in mounting position of the heat alarm, or other means determined to be equivalent.

ELECTRICALLY OPERATED HEAT ALARMS

16 Remote Accessories

16.1 Unless specifically indicated otherwise, the construction requirements specified for an alarm shall apply also for any remote accessories with which it is to be used.

17 Supplementary Signaling Features

17.1 A supplementary signaling feature, such as a transmitter for remote signaling, included integral with a single or multiple station heat alarm, is to be compatible with the device(s) with which it is intended to be used, and the remote signaling device(s) shall be intended for fire alarm application.

18 Servicing and Maintenance Protection

18.1 General

18.1.1 An uninsulated live part of a high-voltage circuit and hazardous moving parts within the enclosure shall be located, guarded, or enclosed to reduce the risk of accidental contact by persons performing service functions with the equipment energized.

18.1.2 Manual switching devices may be located or oriented with respect to uninsulated live parts or hazardous moving parts so that manipulation of the mechanism can be accomplished in the normal direction of access if uninsulated live parts or hazardous moving parts are not located in front (in the direction of access) of the mechanism, or not located within 150 mm (5.9 in) of any side or behind the mechanism, unless guarded.

18.1.3 In determining compliance with 18.1.2 only uninsulated live parts in circuits above 30 Vrms shall be considered.

18.1.4 An electrical component that requires examination, replacement, adjustment, servicing, or maintenance with the alarm energized shall be located and mounted with respect to other components and grounded metal so that it is accessible for such service without subjecting the user to an electric shock from adjacent uninsulated high-voltage live parts or unintended contact to adjacent hazardous moving parts.

18.1.5 Other arrangements of location of components and/or guarding shall be also acceptable where electrical components are accessible for service as indicated by 16.1, Remote accessories.

18.1.6 The following shall not be considered uninsulated live parts:

a) Coils of controllers, relays, and solenoids, and transformer windings, when the coils and windings are provided with insulating overwraps;

b) Enclosed motor windings;

c) Terminals and splices with suitable insulation and

d) Insulated wire.

18.2 Sharp edges

18.2.1 An edge or corner of an enclosure, opening, frame, guard, knob, handle, or other similar projection of a heat alarm shall be smooth and rounded so as not to result in a cut-type injury when contacted during use or user maintenance.

19 Enclosure

19.1 General

19.1.1 The enclosure of a heat alarm shall be constructed to resist the abuses encountered in service. The degree of resistance to abuse inherent in the alarm shall preclude total or partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other defects that, alone or in combination, present a risk of fire, electric shock, or injury to persons.

19.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two shall be evaluated in determining compliance with the requirement of 19.1.1.

19.1.3 All electrical parts of a heat alarm, including a separate power supply, except for plug-in blades, shall be enclosed to provide protection against contact with uninsulated live parts. A separate enclosure for field-wiring terminals to be enclosed by a back box is not required.

19.1.4 The enclosure of a heat alarm shall be provided with means for mounting in the intended manner. Any fittings, such as brackets or hangers, required for mounting means shall be accessible without disassembling any operating part of the alarm. The removal of a completely assembled panel or cover to mount the alarm is not identified as disassembly of an operating part.

19.1.5 When the heat alarm is intended for permanent connection, the enclosure shall either have provision for the connection of metal-clad cable, conduit, or nonmetallic sheathed cable, or have provision for mounting on an outlet box.

19.2 Cast metal enclosures

19.2.1 The thickness of cast metal for an enclosure shall be as indicated in Table 19.1, Cast metal enclosures. Cast metal having a thickness 0.8 mm (1/32 in) less than that indicated in Table 19.1 shall be used only when the surface under consideration shall be curved, ribbed, or otherwise reinforced, or when the shape of the surface, size of the surface, or both, are such that equivalent mechanical strength is determined to be provided.

Table 19.1
Cast-metal Enclosures

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

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

19.2.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is used, there shall be not less than 3.5 nor more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing can be properly attached.

19.2.3 If threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall not be less than 3.5 full threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

19.3 Sheet metal enclosures

19.3.1 The thickness of sheet metal used for the enclosure of an alarm shall not be less than that indicated in Table 19.2, Sheet metal enclosures. If sheet metal of two gauge size lesser thickness is used, the surface under consideration shall be curved, ribbed, or otherwise reinforced, or the shape of the surface, size of the surface, or both shall be such that equivalent mechanical strength is determined to be provided.

Table 19.2
Sheet Metal Enclosures

Maximum dimensions of enclosure				Minimum thickness of sheet metal								
				Steel						Brass or aluminum		
Length or width		Area		Zinc-coated			Uncoated					
mm	(in)	cm^2	(in^2)	mm	(in)	GSG	mm	(in)	MSG	mm	(in)	AWG
305	(12)	581	(90)	0.86	(0.034)	20	0.81	(0.032)	20	1.14	(0.045)	16
610	(24)	2322	(360)	1.14	(0.045)	18	1.07	(0.042)	18	1.47	(0.058)	14
1219	(48)	7742	(1200)	1.42	(0.056)	16	1.35	(0.053)	16	1.91	(0.075)	12
1524	(60)	9678	(1500)	1.78	(0.070)	14	1.70	(0.067)	14	2.41	(0.095)	10
Over 1524	(Over 60)	(Over 9678)	(Over 1500)	2.46	(0.097)	12	2.36	(0.093)	12	3.10	(0.122)	8

19.3.2 At any point where conduit or metal-clad cable is to be attached, sheet metal shall have a thickness of not less than 0.81 mm (0.032 in) when of uncoated steel, not less than 0.86 mm (0.034 in) when of galvanized steel, and not less than 1.14 mm (0.045 in) when of nonferrous metal.

19.3.3 A ferrous plate or plug closure for an unused conduit opening or other hole in the enclosure shall have a thickness not less than 0.69 mm (0.027 in) or 0.81 mm (0.032 in) nonferrous metal for a hole having a 34.9 mm (1-3/8 in) diameter maximum dimension.

19.3.4 A closure for a hole larger than 34.9 mm (1-3/8 in) diameter shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted. See 23.1.1, Mounting of components.

19.3.5 A knockout in a sheet metal enclosure shall be secured and shall be capable of being removed without undue deformation of the enclosure.

19.3.6 A knockout shall be provided with a surrounding surface for seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout used during installation does not result in spacings between uninsulated live parts and the bushing of less than those indicated in Spacings, Section 24.

19.4 Nonmetallic enclosures

19.4.1 An enclosure or parts of an enclosure of nonmetallic material shall have the mechanical strength and durability and be formed so that operating parts are protected against damage. The mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 19.2, Sheet metal enclosures or Table 19.3, Thickness of glass covers. See also the Tests of Thermoplastic Materials, Section 60.

19.4.2 The continuity of any grounding system intended for an alarm connection shall not rely on the dimensional integrity of the nonmetallic material.

19.4.3 Polymeric materials used for an enclosure shall comply with the following requirements:

a) Enclosures containing parts including a risk of fire – minimum flammability rating of 5VA or V-0 and compliance with the Flame Test 127 mm (5 in) as described in 60.3.1 – 60.3.6.

b) Enclosures containing power limited circuits with a voltage not exceeding 30 volts AC, 42.4 volts-peak, or 60 volts DC – minimum flammability rating of:

1) V-2, or

2) HB and successful completion with the Flame test – 19-mm (3/4-in), as described in 60.2.1 – 60.2.6;

c) Enclosures containing circuits with a voltage not exceeding 30 volts AC, 42.4 volts-peak, or 60 volts DC – minimum flammability rating of HB and compliance with the Flame Test 19 mm (3/4 in), as described in 60.2.1 – 60.2.6.

d) Enclosures containing circuits powered by batteries with energy limited to 15 watts – minimum flammability rating of HB.

19.4.4 For 19.4.3, Flammability ratings are defined in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

19.5 Ventilating openings

19.5.1 Ventilating openings in an enclosure including holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening will permit passage of a rod having a diameter of 3.6 mm (9/64 in) for circuits greater than 30 V rms (42.4 V peak). An enclosure for a fuse(s) or other overload protective device provided with ventilating openings shall afford adequate protection against the emission of flame or molten metal. Openings provided for the cleaning of internal parts shall be arranged to prevent damage to functional internal components during such cleaning operations. For units equipped with a cover, the requirements of this paragraph apply with the cover open for circuits greater than 30 V rms (42.4 V peak).

19.5.2 Except as noted in 19.5.3, perforated sheet metal used for expanded metal mesh shall not be less than 1.0 mm (0.039 in) in average thickness, 1.2 mm (0.047 in) when zinc coated.

19.5.3 When the indentation of the guard enclosure does not alter the clearance between uninsulated live parts and grounded metal so as to reduce spacings below the minimum values required, 0.5 mm (0.02 in) expanded metal mesh or perforated sheet metal 0.61 mm (0.024 in) when zinc coated can be used under the following conditions:

a) The exposed mesh on any one side or surface of the product has an area of not more than 465 cm^2 (72 in^2) and has no dimension greater than 305 mm (12 in) or

b) The width of an opening so protected is not greater than 88.9 mm (3.5 in).

19.5.4 The wires forming a screen protecting high-voltage current-carrying parts shall not be smaller than 16 AWG (1.3 mm^2) and the screen openings shall not be greater than 3.2 cm^2 (1/2 in^2) in area.

19.6 Covers

19.6.1 An enclosure cover, other than the type usually employed over the sensing chamber, shall be hinged, sliding, pivoted, or similarly attached when:

a) It provides ready access to fuses or any other overcurrent protective device, the intended protective functioning of which requires renewal or

b) It is required that the cover be opened periodically in connection with the intended operation of the alarm.

For the purpose of this requirement, intended operation is determined to be operation of a switch for testing, or for silencing an audible signal device or operation of any other component of a heat alarm that requires such action in connection with its intended performance.

Exception: This requirement does not apply to the battery replacement aspect of a heat alarm employing a battery as the main or standby supply.

19.6.2 A cover that is intended to be removed only for periodic cleaning of the sensing chamber shall be secured by any one of the following or equivalent means: positive snap catch, plug-in or twist action, snap tab with one screw, or two or more screws.

19.6.3 When a heat alarm cover is not intended to be removed for cleaning, maintenance, or both, and the alarm is intended to be returned to the factory for servicing, the cover shall be secured so that it is not readily removed. Exposed screw slots or nuts, other than a tamper-proof type, shall be sealed or covered. See 19.6.3 (bb) for supplementary marking.

Exception: These requirements do not apply when the heat alarm cover is intended to be removed for cleaning, maintenance, or both, even though the alarm is intended to be returned to the manufacturer for servicing.

19.6.4 A hinged cover is not required where the only fuse(s) enclosed is intended to provide protection to portions of internal circuits, such as employed on a separate printed-wiring board or circuit subassembly, to prevent circuit damage resulting from a fault. The use of such a fuse(s) shall occur only when the word "CAUTION" « MISE EN GARDE » and the following or equivalent marking is located on the cover of an alarm employing high-voltage circuits: "Circuit Fuse(s) Inside – Disconnect Power Prior To Servicing" « Fusible(s) à L'intérieur – Déconnecter avant de procéder à L'entretien ».

19.6.5 A hinged cover shall be provided with a latch, screw, or catch to hold it closed. An unhinged cover shall be securely held in place by screws or the equivalent.

19.7 Glass panels

19.7.1 Glass covering an enclosure opening shall be held securely in place so that it is not capable of being displaced in service and shall provide mechanical protection of the enclosed parts. The thickness of a glass cover shall not be less than that indicated in Table 19.3, Thickness of Glass Covers.

19.7.2 A transparent material other than glass employed as a cover over an opening in an enclosure shall:

a) Be mechanically equivalent to that of glass,

b) Not become a fire hazard or distort and

c) Not become less transparent at the temperature to which it is subjected under normal or abnormal service conditions.

Table 19.3
Thickness of Glass Covers

Maximum size of opening				Minimum thickness	
Length or width		Area			
mm	(in)	cm^2	(in^2)	mm	(in)
102	(4)	103	(16)	1.6	(1/16)
305	(12)	929	(144)	3.2	(1/8)
Over 305	(Over 12)	Over 929	(Over 144)	See footnote a	See footnote a

[a] 3.2 mm (1/8 in) or more, based upon the size, shape, and mounting of the glass panel. A glass panel for an opening having an area greater than 929 cm^2 (144 in^2), or having any dimension greater than 305 mm (12 in), shall be supported by a continuous groove not less than 4.8 mm (3/16 in) deep along all four edges of the panel.

19.7.3 A lens, light filter, or similar part of a heat alarm shall be constructed of a material whose transparency is not diminished by the conditions to which it is exposed in service, as represented by the Performance Tests of this standard. See Sections 25 – 71.

19.8 Corrosion protection

19.8.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means.

19.8.2 The requirement of 19.8.1 applies to all sheet steel or cast iron enclosures, and to all springs and other parts upon which mechanical operation depends. It does not apply to minor parts, such as washers, screws, bolts, and other parts, when the failure of such unprotected parts does not result in a risk of fire or electric shock or injury to persons or impair the operation of the alarm.

19.8.3 Bearing surfaces shall be of materials that prevent binding due to corrosion.

19.8.4 Metal shall not be used in combinations such as to result in galvanic action which adversely affects cabinets or enclosures.

19.8.5 Hinges and other attachments shall be resistant to corrosion.

19.8.6 It is not prohibited for nonferrous cabinets and enclosures to be used without special corrosion protection.

20 Power Supply (Electrically Operated Heat Alarms)

20.1 Primary power supply

20.1.1 The primary power supply of a single station heat alarm shall be either a commercial light and power source or an integral battery or batteries. Connection to the utility supply (commercial light and power source), when used, shall be in the form of permanent wiring to terminals or leads in a separate wiring compartment having provision for the connection of conduit, metal-clad or nonmetallic sheathed cable, by means of a power-supply cord and attachment-plug cap, or by means of a separate power supply.

20.1.2 When a separate power supply is provided, it shall have limited output energy consisting of an open circuit voltage not in excess of 30 volts rms, 42.4 volts peak or direct current (DC), and its output capacity shall be limited to a maximum of 100 volt-amperes. The energy may be limited by an energy-limiting device having an output rating of 100 VA or less or by a transformer plus additional circuitry having characteristics equivalent to those of a 100 VA transformer.

20.2 Secondary power supply

20.2.1 A secondary power supply, such as a battery, shall be provided and have the capacity to supply the maximum intended power to the heat alarm for no less than 7 days in the standby condition and thereafter be able to operate the heat alarm for an alarm signal for at least 4 min continuously. This capacity shall be measured using a fully charged battery or other applicable rechargeable energy storage media, or a fresh non-rechargeable battery, as appropriate. Refer to 28.3, Battery powered (primary or secondary) alarms. Alarms consisting of battery primary power shall not be subjected to this requirement.

20.2.2 When a battery is used for the secondary power supply, it shall be either a rechargeable or non-rechargeable type. For a rechargeable type battery, the maximum charging current, as well as the maximum trickle charging current available, shall not exceed the battery manufacturer's specifications. For a non-rechargeable type battery, data on battery life, including discharge curves, shall be provided for the investigation to evaluate battery shelf aging and performance characteristics.

20.2.3 If a battery or set of batteries is employed as the main source of power of a heat alarm, it shall meet the requirements of the Battery Tests, Section 66.

20.2.4 When a non-rechargeable or rechargeable type battery is used as a secondary power supply, the marking on the unit shall include specified periodic battery replacement instructions.

20.2.5 The discharge condition of a non-rechargeable or rechargeable type battery shall be monitored where a trouble indication, as described in 28.3.1, Battery powered (primary or secondary) units, is obtained. The monitoring shall take place whether the alarm is operating on the primary supply or on the standby supply.

20.3 Supplementary signaling circuits

20.3.1 For a cord-connected or battery operated single station alarm employing a supplementary signaling circuit which is energized from a separate source of supply, the source of energy shall not exceed the energy limits defined in Section 67, Power Supply Tests.

20.3.2 For an alarm intended to be connected to a fixed wiring system and employing a separately energized signaling circuit, the source of energy shall not exceed the limits in Section 67, Power Supply Tests, unless the connections are made as a Class 1 wiring system as defined:

a) In Canada, C22.1-18 Canadian Electrical Code, Part I, Safety Standard for Electrical Installations;

b) In the United States, the National Electrical Code, NFPA 70.

21 Field Wiring

21.1 Permanent connection

21.1.1 General

21.1.1.1 A single station or multiple station heat alarm intended for permanent connection shall be provided with wiring terminals or leads for the connection of conductors of at least the size required by the following corresponding to the rating of the unit:

a) In Canada, C22.1-18 Canadian Electrical Code, Part I, Safety Standard for Electrical Installations;

b) In the United States, the National Electrical Code, NFPA 70.

21.2 Field-wiring compartment

21.2.1 The field-wiring compartment area is to be sized for completing all field-wiring connections as specified by the installation wiring diagram. There shall be space within the compartment to permit the use of a standard conduit bushing on conduit connected to the compartment when a bushing is required for installation.

21.2.2 Protection for internal components and wire insulation from sharp edges shall be provided by insulating barriers or metal barriers having smooth rounded edges, or by protection that has been determined to be the equivalent.

21.3 Field-wiring terminals (general)

21.3.1 A field-wiring terminal to which field-wiring connections are made shall comply with the requirements in 21.3.2 – 21.3.5 and CSA C22.2 No. 153/UL 310, Electrical Quick-Connect Terminals (for field wiring), and:

a) In Canada only:

1) CSA C22.2 No. 65, Standard for Wire Connectors;

2) CSA C22.2 No. 158, Terminal Blocks, rated for field-wiring applications and also suitable for the voltage, current, wire range, and wire type of the intended application; or

3) UL 486E, Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

b) In the United States only:

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

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

3) The Standard for Terminal Blocks, UL 1059, rated for field-wiring applications and also suitable for the voltage, current, wire range, and wire type of the intended application.

21.3.2 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 10 AWG (5.3 mm^2) and larger wires. When the connectors or lugs are secured to a plate, the plate thickness shall not be less than 1.3 mm (0.050 in) thick. Securing screws of plated steel have been determined to meet the requirements.

21.3.3 A wire- binding screw used at a wiring terminal shall not be smaller than 4.2 mm (No. 8) diameter. Plated screws are not prohibited.

Exception: A 3.5 mm (No. 6) diameter screw is appropriate for use for the connection of a 14 AWG (2.1 mm^2) and a 2.8 mm (No. 4) diameter screw is appropriate for use for the connection of a 19 AWG (0.65 mm^2) or smaller conductor.

21.3.4 Terminal plates tapped for wire-binding screws shall:

a) Have not less than two full threads in the metal (the terminal plate metal may be extruded to provide the two full threads) and shall have upturned lugs, clamps, or the equivalent, to hold the wires in position. Other constructions may be used if they provide equivalent thread security of the wire-binding screw.

b) Be of a nonferrous metal not less than 1.3 mm (0.050 in) thick when used with a 4.2 mm (No. 8) diameter or larger screw, and not less than 0.76 mm (0.030 in) thick when used with a 3.5 mm (No. 6) diameter or smaller screw.

21.3.5 When two or more conductors are intended to be connected by wrapping under the same screw, a nonferrous intervening metal washer shall be used for each additional conductor. A separator washer is not required when two conductors are separated and intended to be secured under a common clamping plate. When the wires protrude above terminal barriers, the nonferrous separator shall include means, such as upturned tabs or sides, to retain the wire.

21.4 Special field-wiring terminals (qualified application)

21.4.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in 21.4.2 are met:

a) Quick-Connect Terminals – Nonferrous, quick-connect (push-type) terminals consisting of male posts permanently secured to the device and provided with compatible, female connectors for connection to field wiring. These require a special tool for crimping of field wires. Mating terminals shall be shipped with the control unit with instructions for their installation;

b) Push-In Terminals – Nonferrous, push-in terminals (screwless) of the type used on some switches and receptacles. Solid conductors are pushed into slots containing spring-type contacts. The leads are removable by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals are not to be used with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used; and

c) Other Terminals – Other terminal connections are not prohibited when determined to be equivalent to (a) and (b) and are limited to the same restrictions.

21.4.2 Any of the terminal configurations listed in 21.4.1 are appropriate for connection of field wiring provided all of the following indicated conditions are met:

a) When a special tool is required for connection, it shall be provided and its use indicated on the installation wiring diagram by name of the manufacturer and the model number or equivalent;

b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size to be used shall not be less than 26 AWG (0.13 mm^2) for a jacketed, multi-conductor cable or 18 AWG (0.82 mm^2) for a single conductor wire;

c) The wire size to be used shall be rated for the current-carrying capacity of the circuit application; and

d) The special field-wiring terminal assembly shall comply with the strain relief test as outlined in Section 65.3, Strain Relief Test (special field-wiring terminals).

21.5 Field-wiring leads

21.5.1 Power supply leads provided for field connection shall not be less than 152 mm (6 in) long; shall be provided with strain relief; and shall not be smaller than 18 AWG (0.82 mm^2). The insulation, when of rubber or thermoplastic, shall not be less than 0.8 mm (1/32 in) thick. Wire shall be of stranded copper.

21.5.2 Leads provided for field connection to power limited fire protective signaling circuits, such as employed for multiple station interconnection or for connection to remote signaling devices, shall not be smaller than 16 AWG (1.3 mm^2) for a single conductor, 19 AWG (0.65 mm^2) for two or more conductors, and 22 AWG (0.32 mm^2) for four or more conductors of a multi-conductor cable. The conductor shall be solid, bunch tinned stranded, or stranded copper. Stranded copper wire, consisting of not more than seven strands, shall be used only for 18 AWG (0.82 mm^2) and larger conductors.

21.6 Grounding terminals and leads

21.6.1 An equipment-grounding terminal or lead shall be provided for a heat alarm intended for connection to an energy source greater than 30 volts rms by means other than a metal enclosed wiring system.

21.6.2 The grounding means shall be reliably connected to all exposed dead metal parts which are liable to become energized and all dead metal parts within the enclosure which are exposed to contact during servicing and maintenance.

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

21.6.4 A field wiring terminal intended for connection of an equipment grounding conductor shall be plainly identified, such as being marked "G", "GR", "Ground", "Grounding", or the equivalent, or by a suitable marking on a wiring diagram provided on the heat alarm. The field wiring terminal shall be so located that it is unlikely to be removed during normal servicing of the heat alarm.

21.6.5 A field wiring terminal for the connection of an identified supply conductor shall be identified by means of a metallic plated coating substantially white in color and shall be readily distinguishable from the other terminals, or proper identification of the terminal for the connection of the identified supply conductor shall be clearly shown in some other manner, such as on an attached wiring diagram.

21.6.6 A field wiring lead provided for connection of an identified supply conductor shall be finished to show a white or gray color and shall be readily distinguishable from other leads and no other leads, other than identified supply conductors, shall be so identified.

21.6.7 A terminal or lead identified for the connection of the identified supply conductor shall not be electrically connected to a single-pole manual switching device which has an off position or to a single-pole over-current (not thermal) protective device.

21.6.8 The grounding means for a cord-connected heat alarm shall consist of a separate ground lead integral with the supply cord and terminating in the grounding pin of a parallel blade attachment plug.

21.6.9 An equipment grounding terminal or lead is not required for a heat alarm provided with an overall nonmetallic enclosure and cover that:

a) Is not intended to be internally serviced;

b) Does not employ internal dead-metal parts which may be energized under a fault condition and which can be contacted during servicing.

21.7 Power supply cord

21.7.1 A cord-connected single station heat alarm shall be provided with not less than 1.83 m (6 ft) nor more than 6.10 m (20 ft) of flexible cord and a two or three prong attachment plug of the type and rating for connection to the supply circuit.

21.7.2 The flexible cord shall be of Type SP-1, SPT-1, SP-2, SPT-2, SV, SVT, SJ, SJT, SPE, SVE, or equivalent, minimum 18 AWG (0.82 mm^2). It shall be rated for use at the voltage and ampacity rating of the heat alarm, in accordance with:

a) In Canada, C22.1-18, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations);

b) In the United States, the National Electrical Code, NFPA 70.

21.7.3 Means shall be provided to prevent the flexible cord from being pushed into the enclosure through the cord-entry hole when it is possible for such displacement to:

a) Subject the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is rated,

b) Reduce spacings below the minimum required values or

c) Result in damage in internal components.

21.7.4 Where a flexible cord passes through an opening in a wall, barrier, or enclosing case, the edges of the hole shall be smooth and rounded, without burrs, fins, or sharp edges which may damage the cord jacket. The cord as connected to the heat alarm shall comply with Strain Relief Test, Section 65.

21.8 Equipment grounding

21.8.1 General

21.8.1.1 An equipment grounding terminal or lead, or equivalent, is required for a hazardous-voltage alarm provided with an overall nonmetallic enclosure and cover that:

a) Is intended to be serviced internally and

b) Employs internal dead metal parts that become energized under a fault condition.

21.8.1.2 An equipment grounding terminal or lead is not required for:

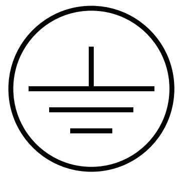
a) An extra-low-voltage alarm;

b) A hazardous-voltage alarm provided with an overall nonmetallic enclosure and cover, and that is not intended to be internally serviced or

c) A hazardous-voltage alarm provided with an overall nonmetallic enclosure and cover, where internal dead metal parts are not capable of either being energized under a fault condition nor being contacted during servicing.

21.8.2 Permanently connected units

21.8.2.1 The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green, with or without one or more yellow stripes. No other leads visible to the installer, other than grounding conductors, shall be so identified. A field-wiring terminal intended for connection of an equipment-grounding conductor shall be plainly identified, such as being marked "G," "GR," "Ground," "Grounding," or the equivalent, or with this symbol:



or by a marking on a wiring diagram provided on the alarm. The field-wiring terminal shall be located so that it shall not be removed during servicing of the alarm.

21.8.3 Cord connected units

21.8.3.1 The grounding means for a cord-connected alarm, having an overall nonmetallic enclosure and cover, that is intended to be serviced internally shall consist of a separate grounding lead integral with the supply cord and terminating in the grounding pin of a parallel blade attachment-plug cap.

21.9 Remote power supply

21.9.1 For an alarm that is intended to be connected to a separate remote power supply such as a transformer, the supply cord is not required to be factory wired to the alarm, or to the transformer terminals or leads, when the installation instructions provided with the unit are explicit regarding the method of connection. The minimum size conductors between the alarm and remote power supply shall not be less than 18 AWG (0.82 mm^2) and shall not be longer than 6.1 m (20 ft). The interconnecting wiring is to be provided with the alarm and the transformer by the manufacturer.

21.9.2 Where longer runs of interconnecting wiring are used in an installation, such as in a multiple station configuration, or where several alarms are supplied by a common power supply, the wiring is not required to be provided by the manufacturer. However, the installation wiring diagram or instructions shall be marked to specify that the wiring to be used shall be in accordance with:

a) In Canada: The installation of electrical equipment shall be in accordance with CEC C22.1.

b) In the United States: The provisions of Articles 210 and 300.3 (B) of the National Electrical Code, NFPA 70.

In addition, the resistance of the interconnecting wiring shall be a maximum of 10 ohms, unless otherwise specified by the manufacturer.

22 Internal Wiring

22.1 General

22.1.1 The internal wiring of an alarm shall consist of conductors having insulation rated for the potential involved and the temperatures to which it is subjected, and shall have the mechanical strength and current-carrying capacity for the service. The wiring shall be routed away from moving parts and sharp projections and held in place with clamps, string, ties, or equivalent, unless of rigidity that retains a shaped form.

22.1.2 Leads, or a cable assembly, connected to parts mounted on a hinged cover shall be of a length to permit the full opening of the cover without applying stress to the leads or their connections. The leads shall be secured or equivalently arranged to prevent abrasion of insulation and jamming between parts of the enclosure. Wire shall be stranded copper.

22.1.3 When the use of a short length of insulated conductor is not possible, such as for a short coil lead, electrical insulating tubing shall be used. The tubing shall not be subjected to sharp bends, tension, compression, or repeated flexing, and shall not contact sharp edges, projections, or corners. The wall thickness of the tubing shall comply with the requirements for such tubing, except that the wall thickness at any point for polyvinyl chloride tubing of 9.5 mm (3/8 in) diameter or less, shall not be less than 0.43 mm (0.017 in). For insulating tubing of other types the wall thickness shall not be less than that required to at least equal the mechanical strength, dielectric properties, and heat and moisture resistance characteristics of polyvinyl chloride tubing having a wall thickness of 0.43 mm (0.017 in).

22.1.4 Internal wiring of circuits that operate at different potentials shall be reliably separated by barriers or shall be segregated, unless the conductors of the circuits of lower voltage are provided with insulation equivalent to that required for the highest voltage involved. Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means that ensures permanent separation. See 22.4, Barriers.

22.1.5 Stranded conductors clamped under wire-binding screws, or similar parts, shall have the individual strands soldered together or be equivalently arranged, to provide secure connections.

22.2 Wireways

22.2.1 Wireways shall be smooth and free from sharp edges, burrs, fins, moving parts, and the like which may cause abrasion of the conductor insulation.

22.3 Splices

22.3.1 All splices and connections shall be mechanically secured and bonded electrically. Tack soldering of components is permitted where the construction precludes mechanical security only when 5 samples resist a pull-force of 8.9 N (2 lbf) applied for 3 s and the connection is subjected to 100 % inspection and testing with the same pull force by the manufacturer.

22.3.2 A splice shall be provided with insulation determined to be equivalent to that of the wires involved when permanence of electrical spacings between the splice and uninsulated metal parts is not provided.

22.3.3 Splices shall be located, enclosed, and supported so that flexing, movement, or vibration does not damage the insulation or affect the integrity of the splice.

22.4 Barriers

22.4.1 A metal barrier shall have a thickness at least equal to that required by Table 19.2, Sheet metal enclosures, as determined by the size of the barrier. A barrier of insulating material shall not be less than 0.71 mm (0.028 in) thick and shall be thicker when its deformation is readily accomplished so as to defeat its purpose. Any clearance between the edge of a barrier and a compartment wall shall not exceed 1.6 mm (1/16 in).

22.5 Bonding for grounding

22.5.1 An exposed non-current-carrying metal part of a heat alarm operating at more than 30 volts rms that is liable to become energized, shall be reliably bonded to the point of connection of the field-equipment grounding terminal or lead, if provided or required, and to the metal surrounding the knockout, hole, or bushing provided for field power- supply connections. This requirement also applies to a heat alarm equipped with auxiliary function contacts rated at more than 30 volts rms.

22.5.2 Except as indicated in 22.5.3, uninsulated metal parts of electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors, and other electrical components shall be bonded for grounding when it is possible that they be contacted by the user or by a service person in servicing or operating the equipment.

22.5.3 Metal parts as described below are not required to comply with the requirement specified in 22.5.2:

a) Adhesive attached metal foil markings, screws, and handles that are located on the outside of the smoke alarm enclosure and isolated from electrical components or wiring by grounded metal parts so that they do not become energized.

b) Isolated metal parts, such as small assembly screws, that are positively separated from wiring and uninsulated live parts.

c) Panels and covers that do not enclose uninsulated live parts when wiring is positively separated from the panel or cover so that it does not become energized.

d) Panels and covers that are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 0.8 mm (1/32 in) thick and secured in place.

22.5.4 A bonding conductor shall be of material determined capable for use as an electrical conductor. When of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The conductor shall not be smaller than the maximum size wire employed in the circuit wiring of the component or part. A separate bonding conductor or strap shall be installed in such a manner that it is protected from mechanical damage.

22.5.5 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, brazing, or welding or soldering of a mechanically secured component. The bonding connection shall penetrate nonconductive coatings such as paint. Bonding around a resilient mount shall not rely on the clamping action of rubber or similar material.

NOTE 1: A bolted or screwed connection that incorporates a star washer under the screw head is considered acceptable for penetrating non-conductive coatings.

NOTE 2: Where the bonding means depend upon screw threads, two or more screws or two full threads of a single screw engaging metal are considered acceptable. Metal-to-metal hinge-bearing members for doors or covers may be considered as a means for bonding the door or cover for grounding providing that a multiple bearing, pin-type hinge is employed.

22.5.6 Splices shall not be employed in conductors used to bond electrical enclosures or components.

23 Electrical Components

23.1 General

23.1.1 Mounting of components

23.1.1.1 A switch, lampholder, attachment-plug receptacle, plug connector, or similar electrical component, and uninsulated live parts shall be mounted securely and shall be prevented from turning.

Exception No. 1: It is not required that a switch be prevented from turning when all four of the following conditions are met:

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

b) The switch mounting means is constructed so that it is not loosened by the switch operation.

c) The spacings are not reduced below the minimum required values when the switch rotates.

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

Exception No. 2: It is not required that a lampholder of the type in which the lamp is not capable of being replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel be prevented from turning when rotation does not reduce spacings below the minimum values required. See Spacings, Section 24.

23.1.1.2 Uninsulated live parts shall be secured to the base or mounting surface so that they are prevented from turning or shifting in position, where such motion results in the possibility of a reduction of spacings. Friction between surfaces shall not be relied upon as a means to prevent shifting or turning of live parts. A properly applied lock washer is accepted.

23.1.1.3 Uninsulated live parts, for example, field-wiring terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they are prevented from turning or shifting in position when such motion results in reduction of spacings below the minimum values required. This shall be accomplished by two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by an equivalent method.

23.1.2 Operating components

23.1.2.1 Operating components and assemblies, such as switches, relays, and similar devices, shall be protected by individual dust covers or dust tight cabinets, against the possibility of impaired operation due to dust or other material.

23.1.2.2 Adjusting screws and similar adjustable parts shall be prevented from loosening under the conditions of actual use. The use of a properly applied lock washer to prevent loosening is accepted.

23.1.3 Current-carrying parts

23.1.3.1 A current-carrying part shall be of metal such as silver, copper or copper alloy, or equivalent material.

23.1.3.2 Bearings, hinges, and other similar parts are not to be used for carrying current between fixed and moving parts.

23.1.4 Electrical insulating material

23.1.4.1 Material for the mounting of current-carrying parts shall be porcelain, phenolic composition, cold-molded composition, or equivalent material.

23.1.4.2 When vulcanized fiber is used for insulating bushings, washers, separators, and barriers it shall not be as the sole support for uninsulated current-carrying parts of other than extra-low-voltage circuits.

23.1.4.3 Polymeric materials shall not be used for the sole support of uninsulated live parts unless found to be equivalent to the materials indicated in 23.1.4.1.

23.1.4.4 The thickness of a flat sheet of insulating material, such as phenolic composition employed for panel-mounting of parts, shall not be less than 1.6 mm (1/16 in) thick. Material less than 1.6 mm (1/16 in) thick shall not be employed unless the panel is supported or reinforced to provide equivalent rigidity.

23.1.4.5 A terminal block mounted on a metal surface capable of being grounded shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base unless the parts are staked, upset, sealed, or equivalently prevented from loosening so as to prevent the parts and the ends of replaceable terminal screws from coming in contact with the supporting surface or reducing spacings below the minimum values required.

23.1.4.6 A countersunk sealed part shall be covered with a waterproof insulating compound which shall not melt at a temperature 15 °C (27 °F) higher than the maximum normal operating temperature of the assembly, and not less than 65 °C (149 °F) in any case. The depth or thickness of the sealing compound shall not be less than 3.2 mm (1/8 in).

23.2 Bushings

23.2.1 When a lead or wire harness passes through an opening in a wall, barrier, or enclosing case, there shall be a metal or insulating type bushing, or the equivalent, which shall be substantial, secured in place, and have a smooth rounded surface against which the wire rests.

23.2.2 When the opening is in a phenolic composition or other nonconducting material, or in metal of thickness greater than 1.07 mm (0.042 in), a smooth surface having rounded edges is determined to be the equivalent of a bushing.

23.2.3 Ceramic materials and some molded compositions are capable of being used for insulating bushings, separate bushings of wood and hot-molded shellac shall not be used.

23.2.4 Fiber shall be employed only where:

a) It is not subjected to a temperature higher than 90°C (194 °F) under normal operating conditions;

b) The bushing is not less than 1.6 mm (1/16 in) thick, with a minus tolerance of 0.4 mm (1/64 in) for manufacturing variations and

c) It is not affected adversely by normal ambient humidity conditions.

23.2.5 When a soft-rubber bushing or similar material that deteriorates with age is employed in a hole in metal, the hole shall be free from sharp edges, burrs, or similar projections, which cut into the bushing and wire insulation.

23.2.6 When an insulating metal grommet is used in lieu of an insulating bushing, the insulating material used shall not be less than 0.8 mm (1/32 in) thick and shall fill completely the space between the grommet and the metal in which it is mounted.

23.3 Lampholders and lamps

23.3.1 A single station heat alarm intended to be connected to a commercial alternating current (AC) power source shall be provided with a "power-on" lamp to indicate energization of the unit. When pulsed, the lamp shall pulse at least once per minute.

23.3.2 A “power-on” lamp shall be white or green, an alarm indicating lamp shall be red, and a trouble lamp shall be amber or yellow.

Exception: Different colors are not prohibited if marked to identify their function.

23.3.3 A lampholder and lamp shall be rated for the circuit in which they are employed.

23.3.4 A lampholder in a hazardous-voltage circuit shall be wired so that the screw shell is connected to an identified (grounded circuit) conductor.

23.3.5 A lampholder shall be installed so that uninsulated hazardous-voltage live parts are not exposed to contact by persons removing or replacing lamps in service.

23.3.6 A lamp or equivalent means, such as a distinctive audible signal indication, shall be provided on an alarm intended for multiple-station interconnection to identify the unit from which the alarm was initiated.

23.4 Protective devices

23.4.1 Fuseholders, fuses, and circuit breakers shall be rated for the application.

23.5 Printed-wiring boards

23.5.1 Printed-wiring boards shall be suitable for the application. The securing of components to the board shall be made in the intended manner and the spacings between circuits shall comply with the requirements for Spacings, Section 24. The board shall be reliably mounted so that deflection of the board during installation or servicing shall not result in damage to the board or in developing a risk of fire or electric shock.

23.5.2 All printed-wiring boards shall have a minimum flammability rating of V-2, rated for direct support of current-carrying parts, and be suitable for the soldering process used.

Exception: On printed-wiring boards having a flammability classification of V-0 in accordance with CSA C22.2 No. 0.17, Evaluation of Polymeric Materials (in Canada), the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94 (in the United States) spacings (other than spacings to dead metal traces, between primary and secondary circuits, and at field wiring terminals) shall not be specified between traces of different potential connected in the same circuit when:

a) The spacings are adequate to comply with the requirements in 69, Evaluation of reduced spacings on printed-wiring boards; or

b) An analysis of the circuit indicates that no more than 12.5 mA of current is available between short-circuited traces having reduced spacings.

23.6 Switches

23.6.1 A switch shall have a current and voltage rating not less than that of the circuit which it controls.

23.6.2 When a reset switch is provided, it shall be of a self-restoring type.

23.6.3 An alarm silencing switch or equivalent means shall be provided on a single or multiple station heat alarm only when its "off normal" position is supervised.

23.7 Transformers and coils

23.7.1 A transformer shall be of the two-coil or insulated type.

Exception: An autotransformer shall only be employed in an alarm intended for permanent connection only, when the terminal or lead connected to the autotransformer winding which is common to both input and output circuits is identified, and the output circuits are located within the enclosure containing the autotransformer. See 21.8.1.1 and 21.8.1.2.

23.7.2 The insulation of coil windings of relays, transformers and similar components shall be such as to resist the absorption of moisture.

23.7.3 Film-coated or equivalently insulated wire is not required to be given additional treatment to prevent moisture absorption.

23.8 Dropping resistors

23.8.1 A carbon composition resistor shall not be used as a dropping resistor in the hazardous-voltage circuit of an alarm.

24 Spacings

24.1 General

24.1.1 A product shall provide maintained spacings between uninsulated live parts and the enclosure or dead-metal parts, and between uninsulated live parts of opposite polarity. The spacings shall not be less than those indicated in Table 24.1.

Exception: On printed-wiring boards having a flammability classification of V-0 in accordance with CSA C22.2 No. 0.17, Evaluation of Polymeric Materials (in Canada), the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94 (in the United States) spacings (other than spacings to dead metal traces, between primary and secondary circuits, and at field wiring terminals) are not specified between traces of different potential connected in the same circuit when:

a) The spacings are adequate to comply with the requirements in Section 67, Evaluation of Reduced Spacings on Printed-Wiring Boards; or

b) An analysis of the circuit indicates that no more than 12.5 mA of current is available between short-circuited traces having reduced spacings.

24.1.2 The spacings between an uninsulated live part and items (a) – (c) below shall not be less than those indicated in Table 24.1, Minimum spacings:

a) A wall or cover of a metal enclosure;

b) A fitting for conduit or metal-clad cable and

c) Any dead metal part.

24.1.3 The "Through-Air" and "Over-Surface" spacings of Table 24.1 measured at an individual component part are to be judged on the basis of the volt-amperes used and controlled by the individual component. However, the spacings from one component to another, and from any component to the enclosure or to other uninsulated dead metal parts, excluding the component mounting surface, shall be evaluated on the basis of the maximum voltage and total volt-amperes rating of all components in the enclosure.

Table 24.1
Minimum Spacings

Point of application	Voltage range	Minimum spacings[a,b] Through air, mm	(in)	Over surface, mm	(in)
To walls of enclosure					
Cast metal enclosures	0 – 300	6.4	(1/4)	6.4	(1/4)
Sheet metal enclosures	0 – 300	12.7	(1/2)	12.7	(1/2)
Installation wiring terminals					
With barriers	0 – 30	3.2	(1/8)	4.8	(3/16)
	31 – 150	3.2	(1/8)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)
Without barriers	0 – 30	4.8	(3/16)	4.8	(3/16)
	31 – 150	6.4	(1/4)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)
Rigidly clamped assemblies[c]					
100 volt-amperes maximum[d,e]	0 – 30	0.8	(1/32)	0.8	(1/32)
Over 100 volt-amperes[e]	0 – 30	1.2	(3/64)	1.3	(3/64)
	31 – 150	1.6	(1/16)	1.6	(1/16)
	151 – 300	2.4	(3/32)	2.4	(3/32)
Other parts	0 – 30	1.6	(1/16)	3.2	(1/8)
	31 – 150	3.2	(1/8)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)

[a] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material employed where spacings are otherwise insufficient, shall not be less than 0.71 mm (0.028 in) thick; except that a liner or barrier not less than 0.33 mm (0.013 in) thick shall be used only in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it is not affected adversely by arcing. Insulating material having a thickness less than that specified shall be used only when it complies with the requirements for the particular application.

[b] Measurements are to be made with solid wire of adequate ampacity for the applied load connected to each terminal. In no case is the wire to be smaller than 16 AWG (1.3 mm^2).

[c] Rigidly clamped assemblies include such parts as contact springs on relays or cam switches, printed-wiring boards, and similar assemblies.

[d] Spacings less than those indicated, and not less than 0.4 mm (1/64 in), are appropriate for the connection of integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 0.8 mm (1/32 in).

[e] When spacings between traces on a printed-wiring board are less than the minimum specified, the boards shall be covered with a conformal coating, and the combination shall be evaluated to the requirements in Conformal Coatings of Printed-Wiring Boards, Section 68.

24.1.4 The spacing requirements in Table 24.1 do not apply to the inherent spacings inside motors, except at wiring terminals, nor to the inherent spacings of a component provided as part of the alarm. Such spacings are evaluated on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete device, including clearances to dead metal or enclosures, shall be those indicated in Table 24.1.

24.1.5 The "To Wall of Enclosure" spacings of Table 24.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

24.1.6 Enameled or equivalently insulated wire is an uninsulated live part. Enamel is capable of being used as turn-to-turn insulation in coils.

24.1.7 Spacings on printed-wiring boards which are less than those indicated in Table 24.2 shall comply with the minimum spacings of Table 24.2 and shall be provided with a coating in compliance with Conformal Coatings on Printed-Wiring Boards, Section 68.

Table 24.2
Minimum Over-surface Spacings on Printed-wiring Boards

Voltage, volts[a]	Energy available, volt-amperes	Spacing		Coating program
		mm	(in)	
0 – 30	100 maximum	0.2	(13/64)	66.1
0 – 30	Over 100	0.4	(13/32)	66.1
31 – 300	Over 100	0.8	(13/16)	66.2

NOTE – The minimum spacings are required between live parts of opposite polarity. Spacings between live parts and dead metal shall comply with Table 24.1.

[a] RMS volts for sinusoidal waveform. The equivalent peak voltage is to be used for nonsinusoidal waveforms.

24.2 Determination of Installation Spacings

24.2.1 The sensitivity of a heat alarm is to be expressed in terms of spacing limitations. Spacing limitations refer to the maximum distance permitted between devices mounted on smooth ceilings.

24.2.2 Installation spacing limitations of a heat alarm are to be determined by the Fire Test, Section 32.

24.2.3 Heat alarms used to determine installation spacing limitations shall be units classified for the highest ordinary temperature ratings in accordance with 7.1. The minimum fire test spacing allocation shall be 15.2 m (50 ft). Spacing allocation for the intermediate degree temperature classification is based on tests conducted on the highest ordinary degree rating.

24.2.4 A heat alarm does not comply with these requirements if it fails to qualify for at least a 15.2 m (50 ft) spacing, for example, if it does not operate within 2 min when subjected to the Fire Test, Section 32.

PERFORMANCE

ALL ALARMS

25 General

25.1 Representative samples of units in commercial form shall be subjected to the tests specified in Sections 26 – 71.

25.2 If a heat alarm(s) is required to be mounted in a definite position in order to function as intended it shall be tested in that position.

25.3 If a heat alarm is intended to be connected to tubing to function, it shall be connected to the maximum length of tubing specified by the manufacturer unless the length of tubing would not have a bearing on its operation.

26 Test Voltages

26.1 Unless otherwise specified, the test voltage for each test shall be as indicated in Table 26.1, at rated frequency.

Table 26.1
Test Voltages

Alarm rated voltage, nameplate	Test voltage
110 – 120	120
220 – 240	240
Other	Marked rating

27 Normal Operation Test

27.1 General

27.1.1 An alarm shall operate for all conditions of its intended performance when energized from a source of rated voltage (or mechanical power, as applicable), under all conditions covered both in the installation instructions and in any supplementary information provided by the manufacturer.

27.1.2 The test voltage shall be in accordance with section 26. The alarm is to be in the standby condition and prepared for its intended signaling operation when it is connected to related devices and circuits.

27.1.3 The introduction of heat into the detection chamber, such as from a hair dryer or equivalent, shall result in the operation of the alarm in its intended manner. The alarm signal shall persist for at least 4 min under an abnormal level of heat.

27.1.4 A heat alarm that employs a secondary power supply shall operate for alarm signals with the main power de-energized.

27.1.5 When single station heat alarms are intended for multiple station connection, the operation for alarm of one station shall result in the alarm signal of all connected stations being energized and the station that initiated the alarm signal shall be identified. See Lampholders and Lamps, 23.3. When the interconnection wiring is not supervised for opens, shorts, and grounds, no more than 12 heat alarms, or 18 alarms [12 heat and 6 other (heat, CO, or similar alarms)] shall be specified for interconnection. When the interconnection is supervised, no more than 64 alarms shall be specified for interconnection.

27.1.6 Operation for alarm of a heat alarm with integral transmitter that is energized by an initial pulse(s) shall result in an alarm signal being locked in for at least 4 min at a compatible receiving unit located at the maximum distance specified by the manufacturer, when tested under free-field conditions with no obstructions between the heat alarm transmitter and receiver units. Refer to 72.1 (o) for instructions to be provided. Lock-in of the receiver is not required when the receiving unit audible alarm signal is energized in time sequence and duration with the heat alarm.

27.2 Standardized alarm signal (Electrically-operated only)

27.2.1 An alarm shall produce an audible signal in the form of the "three pulse" temporal pattern shown in Figure 27.1. Each ON phase shall last 0.5 second ±10 %, followed by an OFF phase of 0.5 second ±10 %. After the third of these ON phases, there shall be an OFF phase that lasts 1.5 s ±10 %.

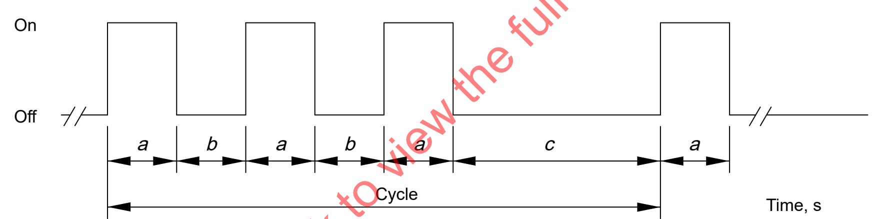
27.2.2 A voice message shall be permitted to be included with the standardized alarm signal in one or both of the formats noted below.

a) A voice message of 1.5 s or less in length shall be permitted to be inserted into any or all of the 1.5 s OFF phases of the temporal pattern.

b) A voice message that exceeds 1.5 s but does not exceed 10 s in length shall be permitted to be inserted following a minimum of 8 cycles of the initial “three pulse” temporal pattern. This voice message shall be followed by not less than 2 cycles of the “three pulse” temporal pattern. The voice message shall then be permitted to be repeatedly inserted provided that each additional use of the voice message follows at least 2 cycles of the “three pulse” temporal pattern.

Figure 27.1

Standardized Alarm Signal Temporal Pattern



Key

Phase a signal is "on" for 0.5 s ± 10 %
Phase b signal is "off" for 0.5 s ± 10 %
Phase c signal is "off" for 1.5 s ± 10 % (c = a + 2b)
Total cycle lasts for: 4 s ± 10 %

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28 Electrical Supervision Test (Electrically-operated Only)

28.1 General

28.1.1 A single station heat alarm shall be electrically supervised so that failure of a limited life component, open in an externally connected alarm circuit, or ground fault on any externally connected wiring which prevents operation for an alarm signal from the alarm shall result in an audible trouble signal.

28.1.2 The wiring extending between alarms wired in a multiple station configuration shall be electrically supervised so that a short or multiple ground fault, which prevents operation for an alarm signal, shall result in an audible trouble signal or result in an alarm signal. An "open" in any of the wiring between alarms is not required to be indicated by a trouble signal when the operation as a single station alarm is not prevented. This requirement does not apply to the interconnected wiring of alarms intended to be connected by a Class 1 wiring method.

28.1.3 When an audible trouble signal is required to indicate a fault condition, it shall be produced at least once every minute for a minimum of seven consecutive days. The trouble signal shall be distinctive from the alarm signal.

28.1.4 To determine that an alarm unit complies with the requirements for electrical supervision, the alarm is to be energized in the standby condition, and the type of fault to be detected is then to be introduced. Each fault is to be applied separately, the results noted and the fault removed. The alarm is then to be restored to the standby condition prior to establishing the next fault.

28.1.5 A fault condition (open, ground, or short), of other than the heat detection circuit of a heat alarm with a non-fire alarm feature shall not prevent alarm signal operation as a heat alarm. For this test the alarm is to be energized from a rated source of supply in the normal standby condition and the fault is to be applied. With the fault applied the alarm is then to be subjected to an abnormal heat condition which shall result in an audible heat alarm.

28.2 AC or remotely powered units

28.2.1 Failure of the main power supply to an alarm other than those powered from a primary battery shall be indicated by de-energization of a "power-on" lamp.

28.2.2 Neither loss nor restoration of power shall result in an alarm signal under either momentary or extended (at least 1/2 hour) power outage conditions. Momentary energization of the alarm circuit (maximum of 1 second), and energization of the trouble circuit (maximum of 2 min), is appropriate. A gradual increase to 110 % of rated voltage or reduction to 0 volts from rated voltage at a rate of not greater than 5 volts per minute shall not result in energization of the alarm signal for more than 1 second, nor energization of the trouble circuit for more than 2 min.

28.2.3 Loss of power to a single unit of a multiple station alarm configuration, while energized in the standby condition, shall not result in a false alarm and shall not prevent the operation of the remaining units for alarm.

28.3 Battery powered (primary or secondary) units

28.3.1 An alarm which uses a battery as the main source of supply shall be capable of producing an alarm signal for at least 4 min at the battery voltage at which an audible trouble signal is obtained followed by 7 days of audible trouble signal indication.

28.3.2 An alarm which uses a battery (or other applicable rechargeable energy storage media) as the secondary source of supply shall be capable of supplying the alarm with a minimum of 7 days of power in the normal standby condition, and producing an alarm signal for at least 4 min at the battery voltage at which an audible trouble signal is obtained followed by 7 days of audible trouble signal indication. Reference the Sound Output Measurement Test – section 42.2 for Canada and section 42.3 for the United States.

28.3.3 To determine compliance with 28.3.1, three samples, powered from primary battery supplies, shall be equipped with batteries which have been depleted to the trouble signal level. The samples are then to be placed in alarm for 4 min. Following the 4 min of alarm the trouble signal shall persist for at least seven consecutive days. It is possible to deplete a fresh battery by applying a 1 % or smaller loading factor based on the ampere hour rating of the battery. For example, a 1000 milliampere-hour rated battery is depleted by applying a 10 milliamperes (1 % load) or less drain continuously until the battery voltage reaches the predetermined test level.

28.3.4 To determine compliance with 28.3.2 for alarms whose secondary supply is a battery or other applicable rechargeable energy storage media, three samples shall be powered from secondary sources of supply (with the primary source of supply disabled) which are fully charged, or in fresh condition (see 20.2) and allowed to remain in the normal standby condition for a minimum of 7 days. The samples shall not emit audible low battery trouble signals before the end of the 7 day period. Three samples shall also be equipped with secondary supplies (with the primary source of supply disabled) which have been depleted to the trouble signal level. The samples are then to be placed in alarm for 4 min. Following the 4 min of alarm, the trouble signal shall persist for at least 7 consecutive days. It is possible to deplete a fresh battery by applying a 1 % or smaller loading factor based on the ampere hour rating of the battery. For example, a 1000 milliampere-hour rated battery is depleted by applying a 10 milliampere (1 % load) or less drain continuously until the battery voltage reaches the predetermined test level.

28.3.5 When a battery operated heat alarm locks in on alarm, it shall automatically transfer from alarm to audible trouble when the battery voltage reaches the trouble signal level. When an alarm does not lock-in on alarm, automatic transfer from alarm to trouble is not required.

28.3.6 To determine compliance with 28.3.5, two samples of a heat alarm that locks-in on alarm shall be equipped with batteries which have been depleted and stabilized at just above the trouble signal level. The samples are then to be placed in alarm and the battery voltage monitored. The samples shall automatically transfer to audible trouble when the battery trouble voltage is reached. The trouble signal shall persist for seven consecutive days. In cases where the battery voltage recovers to a point where the trouble signal is no longer emitted, the unit shall be placed into alarm again until the trouble signal is reinstituted.

28.3.7 A decrease in the battery capacity of a heat alarm, which uses a battery as the main power supply, to a level where at least a 4-min alarm signal is not obtainable shall result in an audible trouble signal. The trouble signal is to be produced at least once each minute for seven consecutive days.

28.4 Component failure

28.4.1 Failure of a limited life electronic component, such as opening or shorting of electrolytic capacitors, shall be indicated by an audible trouble or alarm signal, or a reliable component shall be used. The reliable component shall fall within the reliability prediction described in 8.1.

28.5 External wiring

28.5.1 An open or ground fault in the loop wiring connected from a single station heat alarm to additional remote heat detectors that prevent operation for alarm signals from any of the interconnected alarms, shall not result in an alarm signal and shall result in an audible trouble signal. It is possible for a short or double ground fault in the leads to result in an alarm.

28.5.2 An open, ground fault, or short in any power limited fire protective circuit wiring among multiple station interconnected alarms or any wiring extending to a remote signaling device is not required to be indicated by a trouble signal when the fault does not prevent operation of any of the interconnected units as a single station alarm. It is not prohibited for a ground fault to prevent operation for alarm when the interconnected wiring is to be made in accordance with Class 1 requirements of:

a) In Canada: C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations.

b) In the United States: the National Electrical Code, NFPA 70.

The installation wiring diagram shall indicate the type of connections to be used.

28.5.3 An open, ground fault, or short in the power limited fire protection circuit conductors extending between the output of a separate power supply and an alarm, which prevents operation of the alarm, shall result in de-energization of the heat alarm "power-on" light.

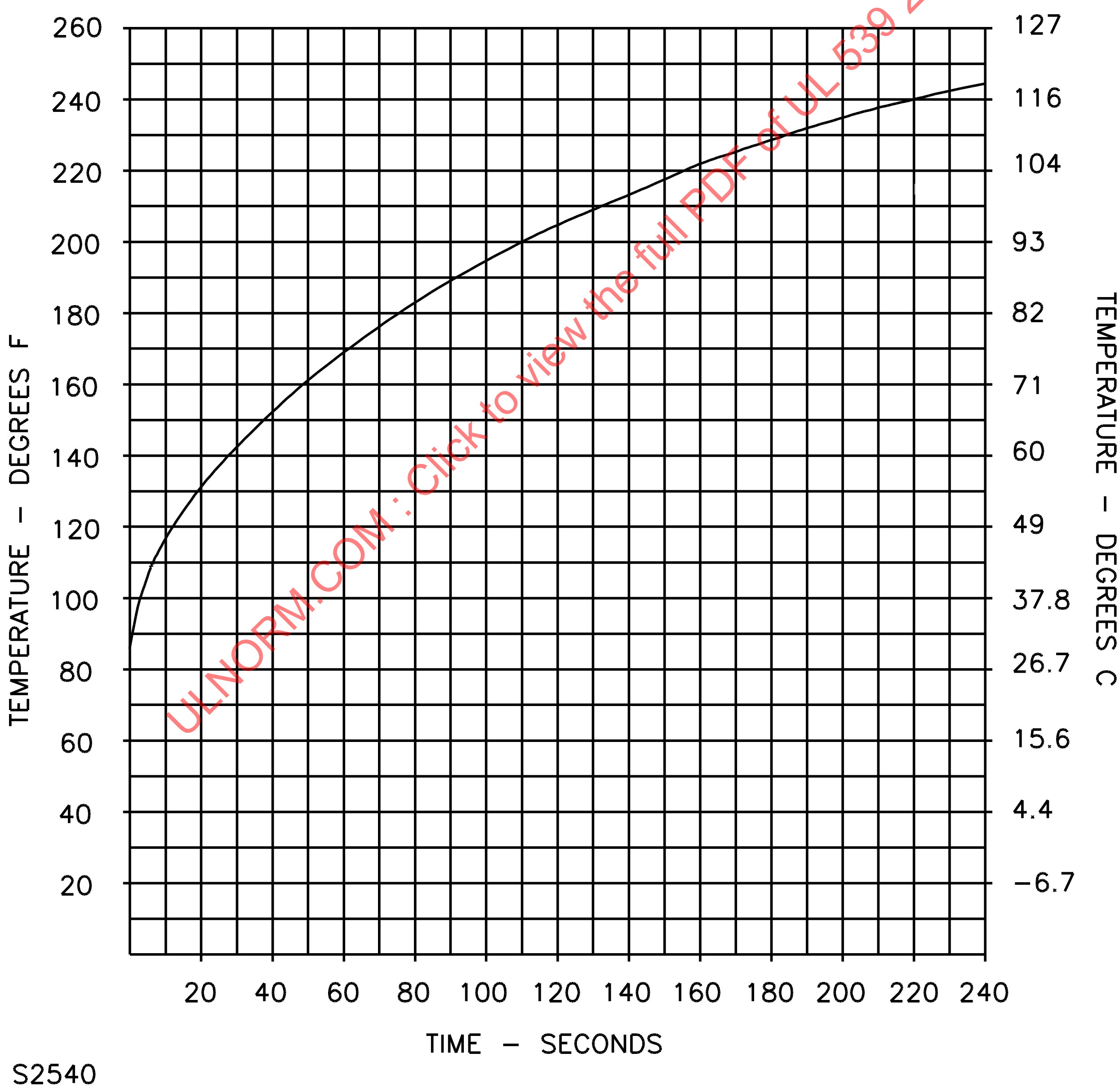
29 Oven Test

29.1 Five heat alarms shall independently produce an alarm signal within 2 min or less when subjected to the time-temperature condition shown in Figure 29.1. If the five heat alarms produce the alarm signal within 2 min as specified, the product shall be eligible for a 4.57 m (15-ft) installation spacing.

29.2 Heat alarm samples shall be uniform in operation when mounted in the same position. They are to be tested in each of the different positions permitted by the design. Operation is considered uniform if the heat alarms operate within the applicable temperature range indicated in the tabulation under the Operating Temperature Test, Section 37. See Table 37.1.

Figure 29.1

Time Temperature Curve – Oven Test



29.3 Performance under this time-temperature condition is to be tested, recorded, and compared to Figure 29.1 to determine the responsiveness of the device, its uniformity, and its qualifications for a 4.57-m (15-ft) spacing. The spacing limitation is to be based upon the performance with the samples located in the least favorable position on the sample-mounting panel.

29.4 To verify uniform performance of a heat alarm, the test is to be repeated four times (totaling 5 samples) using a different sample for each test, but each of the five samples is to be installed on the sample-mounting panel in the same position. Depending upon the construction of the heat alarm, it may be necessary to repeat the oven tests with test samples rotated 90 degrees and 180 degrees from the original test position.

29.5 The testing oven is to be constructed similar to the specifications detailed in Annex B. Annex B contains figures detailing the typical construction of a heat alarm test oven and associated wiring schematic for the test setup. The construction of the oven should enable testing to achieve the profile specified in Figure 29.1.

29.6 The time and temperature build-up during the test is to be monitored and controlled by a data acquisition and control instrument.

29.7 In certain devices, variations in operation are possible with the device installed in different positions with respect to the direction of air flow. In such cases, the sensitivity or spacing designation is to be determined from test data with the device mounted in the least favorable position.

29.8 Preparation for test consists of mounting the heat alarm on the small removable panel (noted in Annex B). Conduit-fitting mountings are to be accommodated on a special panel provided with a 76.2-by-76.2 mm (3-by-3 in) conduit box fitted into the panel. Flush-mounted devices employ a plain panel. The test sample is to remain in the oven at least 5 min prior to the start of each test run.

29.9 The preparation for test is to consist of mounting the device on the small removable screen base of 6.4 mm (1/4 in) hardware cloth formed to a height where the temperature sensing element is midway between the top of the chamber and the guide vane. The sample under test is to be positioned in the air stream so that there is no obstruction between the guide vane and sensing element. A spring-wound device is to be mounted with the sensing element in a horizontal position. The test sample is to remain in the oven at least 5 min prior to starting each test run.

29.10 The heating coils are to be preheated for 10 – 20 s prior to starting the test. The fan controlling the air flow is to be turned on and its speed adjusted to produce the required velocity. The temperatures are to be read every 10 s. The two variable autotransformers are to be adjusted as needed to obtain the desired rate of temperature rise. Normal oven temperatures at the start of the test are to be 29.4 – 32.2 °C (85 – 90 °F). A deviation of ±4.2 °C (±7.5 °F) is permitted from Figure 29.1 during buildup.

29.11 Where applicable, multiple-station interconnect, relay connections, or other wire connections are to be wired in accordance with the installation instructions. Operation of the alarms and their associated connections shall be verified in accordance with the requirements outlined in this standard and the manufacturer's published instructions.

29.12 After installation in the oven, the heat alarm is to be subjected to the time-temperature condition illustrated in Figure 29.1. Oven temperature at the start of the test is to be 29.4 – 32.2 °C (85 – 90 °F).

29.13 After the heat alarm produces the alarm signal, the current applied to the bank of heaters is to be cut off and the oven is to be cooled to room temperature by use of the external cooling fan.

30 Stability Test (Electrically-operated Only)

30.1 Two heat alarms shall be subjected to the test specified in (a) – (c). Different alarms may be employed for each test. During conditions (b) and (c), there shall not be false alarms.

a) Two alarms shall operate for their intended signaling performance after being subjected for 90 days to an ambient temperature of 15 degrees below its maximum installation temperature. Alternatively, the two detectors may be subjected to a shorter time period and higher temperature as determined by the following equation:

$$\frac{4 * D_1}{D_2} = e^{-\frac{\Theta}{K}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)}$$

in which:

D_1 is 90 days,

D_2 is the proposed time period in days,

T_1 is the temperature in Kelvin when testing for 90 days,

T_2 is the temperature in Kelvin when testing for proposed time period in days,

Θ is 0.65 eV and

K is 8.62 x 10^{-5} eV/K.

Two samples are to be placed in a circulating air oven and energized from a source of rated voltage and frequency. Following removal, the energized samples are to be permitted to cool to room temperature for at least 24 h.

b) Fifty cycles of momentary (approximately 1/2 second) interruption of the heat alarm power supply at a rate of not more than 6 cycles per minute.

c) Three plunges from an ambient humidity of 20 ±5 % relative humidity to an ambient of 90 ±5 % relative humidity at 23 ±2 °C (73.4 ±3.6 °F).

30.2 The two heat alarms shall be mounted in a position of intended use, energized from a source of supply in accordance with Test Voltages, Section 26, and subjected to each of the test conditions in 30.1.

30.3 For 30.1 (a), two heat alarms shall be mounted on wooden supports simulating intended installation and shall be connected to indicating lamps or equivalent means to indicate a false alarm.

30.4 For 30.1 (c), the two heat alarms shall be individually plunged from one humidity level to the other (not more than 3 seconds between each plunge) and maintained at each humidity level for not less than 1/2 hour.

30.5 At the conclusion of conditions 30.1 (a) – (c), the heat alarms shall comply with the requirements of the Oven Test, Section 29, the Operating Temperature Test, Section 37, or the Rate-of-Rise Operation Test, Section 33, whichever tests are applicable.

31 Determination of Stability Test for Mechanical Heat Alarms

31.1 A heat alarm using both eutectic solder and copper within the construction of the releasing mechanism where the two dissimilar metals are in contact with each other shall operate for its intended signaling performance after being subjected to the stability test. The releasing mechanism is defined as the components that cause the contacts to operate as the eutectic solder melts.

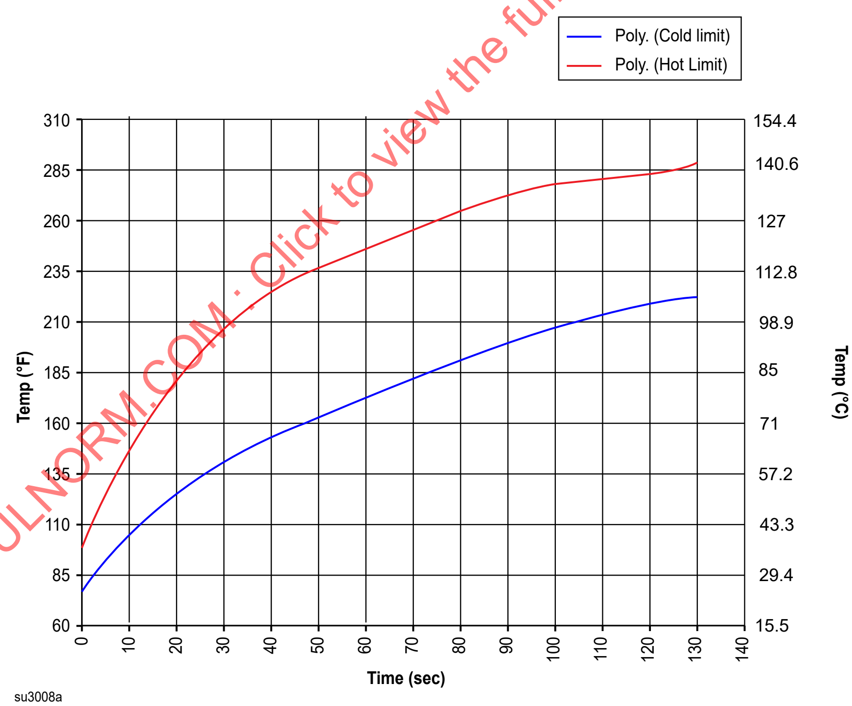
31.2 Ten samples shall be subjected to 30 days at an ambient temperature of 8.3 °C (15 °F) below its operating temperature in an environment with relative humidity of 85 ±5 %. Upon completion of the test, the samples shall remain at room temperature for a period of 24 hours, after which they shall be subjected to the Operating Temperature Test, Section 37, or the Rate-of-Rise Operation Test, Section 33, whichever tests are applicable, to determine the activation temperature.

32 Fire Test

32.1 To qualify for an installation spacing by fire tests, four highest ordinary-degree rated and four highest low-degree rated heat detectors installed in the least favorable position as determined from the Oven Test, Section 29, and at the intended spacing, shall operate within 130s. The temperature profile of the fire is to be monitored by a type J thermocouple located at the 3 m (10 ft) spacing, 178 mm (7 in) below the ceiling, and on the same diagonal as the detectors. The temperature profile shall be within the limits shown in Figure 32.1. At least two trials are to be conducted.

Figure 32.1

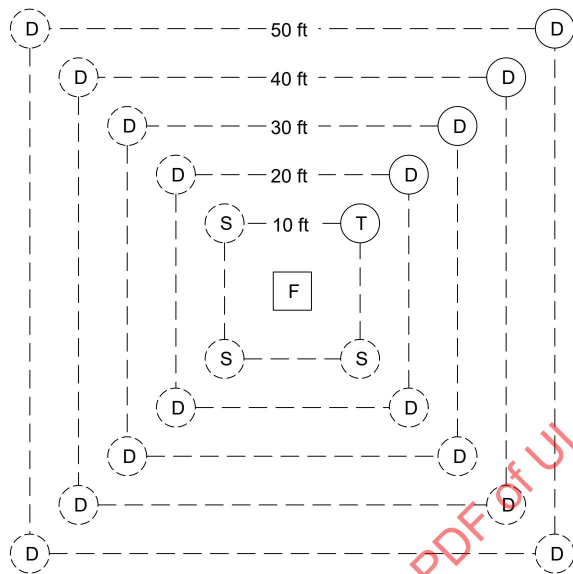
Temperature Profile Fire Test Time Temperature Limits



32.2 Fire tests are to be conducted in a 18.3 by 18.3 m (60 by 60 ft) test room with a smooth ceiling at a height of 4.80 m (15 ft, 9 in). The heat detectors are to be installed at their designated spacings, minimum 15.2 m (50 ft), in line with the sprinkler and fire test pan. See Figure 32.2 for the layout.

Figure 32.2

Fire Test Layout



Legend:

F — Test fire,denatured alcohol, 190 proof. Pan located approximately 0.91 m (3 ft) above floor.

S — Indicates normal sprinkler spacing on 3.05 m (10 ft) schedules.

T — Thermocouple installed during Fire Test at 178 mm (7 in) below ceiling.

D — Indicates normal detector spacing on various spacing schedules.

D — Detectors installed during Fire Test. Employed to determine maximum allowable spacing.

Test Room — 18.3 by 18.3 m (60 by 60 ft), with a 4.80 m (15 ft 9 in) smooth ceiling.

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32.3 The fire tests are to be produced by burning denatured alcohol consisting of 190 proof ethanol to which 5 % methanol has been added as a denaturant in steel pans of a size necessary to produce a temperature rise within the limits shown in Figure 32.1. Since temperature conditions in a test room may vary throughout the year, it is necessary to use different pan sizes in order to obtain the intended temperature-rise condition. This test condition develops a time-temperature curve similar to the 4.57 m (15 ft) spacing curve shown by Figure 32.1.

32.4 The fire tests are to be conducted to compare the operating time of the fire alarm devices when installed at their recommended spacing schedule as compared with the operating time of automatic sprinklers installed on the standard 3.05-by-3.05 m (10-by-10 ft) spacing schedule. Operation of the heat detectors within 130 s will qualify the device for the spacing on which it was installed.

32.5 Units that are intended to be mounted on a side wall are to be mounted in a vertical position so that the distance between the top of the unit and the ceiling is 305 mm (12 in). The distance between the top of the unit and the ceiling may be less than 305 mm (12 in) but not less than 102 mm (4 in) to the top of the alarm if the manufacturer's installation instructions specify a shorter distance. The front of the units shall face the fire source and the surface on which a unit is mounted shall extend 76 mm (3 in) beyond the periphery of the unit.

32.6 If a heat alarm is intended to be mounted on the ceiling, the unit is to be so installed for this test.

32.7 If a heat alarm is intended to be used with an enclosure such as used in mounting, it is to be subjected to the Fire Test using the enclosure representative for installation as intended.

33 Rate-of-Rise Operation Test

33.1 Heat alarms that operate on the rate-of-rise principle shall be calibrated so that the devices will function at the rate of rise for which they are intended, but shall not operate when subjected to a rate of temperature rise of 6.7 °C (12 °F) per minute or less until a temperature of at least 54 °C (130 °F) is reached [starting from a temperature of 29.4 to 32.2 °C (85 to 90 °F)].

33.2 Five samples of rate-of-rise heat detectors are to be tested in the testing oven under various uniform temperature-rise conditions. Typical rates of rise of temperature such as 6.7, 8.3, and 11.1 °C (12, 15, and 20 °F) per min and the intended (rated) temperature rate of rise are to be employed. Each unit is to remain in the oven ambient at least 5 min prior to a test run.

34 High Temperature Exposure Test

34.1 A heat alarm shall not activate when subjected for 30 days to the ambient test temperature indicated in Table 32.1. Following the exposure, the response of the units shall not show a time variation of more than 20 % from the average value obtained in the Oven Test, Section 29, on as-received samples. Electrically operated devices under test shall be energized per Test Voltages, Section 26. There shall not be any change in the sound intensity when tested following the exposure. There shall not be evidence of eutectic flow as a result of this test.

Table 32.1
Ambient Test Temperature

Temperature classification	Rating range,		Test temperature,	
	°C	(°F)	°C	(°F)
Low	46 – 57	(115 – 134)	See note	
Ordinary	57 – 79	(135 – 174)	52	(125)
Intermediate	79 – 107	(175 – 225)	66	(150)
NOTE – 5.6 °C (10 °F) below rating				

34.2 A device capable of repeated operation is to be subjected to the Oven Test, Section 29, before and after exposure to the ambient test temperature. For a device not capable of repeated operation, the response data after exposure is to be compared to the response of identical as-received samples.

34.3 A fire alarm device shall withstand the high temperature exposure without false operation and there shall not be visible deformation or change in the temperature sensitive element or any other part of the unit as a result of the test.

34.4 Five samples of each temperature rating are to be tested for their intended operating temperature after which they are to be placed in a circulating air oven maintained at the test temperature.

34.5 The units are to be removed from the oven after the 30-day period, allowed to remain at room temperature for at least 24 h, examined for deformation of the temperature-sensitive element, and then subjected to the Oven Test, Section 29.

35 Corrosion Tests

35.1 The response of a heat alarm, after being subjected to corrosive atmospheres, shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples. For mechanically-operated heat alarms with an energized power source, no false alarms shall occur during the exposure and there shall not be change in the sound intensity when the units are subjected to the Oven Test.

35.2 The sensitivity of a heat alarm operating on the rate-of-rise principle, after subjected to corrosive atmospheres, shall not show a variation of more than 50 % from the value obtained in the Rate-of-Rise Operation Test, Section 33 on as-received samples. For mechanically-operated heat alarms with an energized power source, no false operation shall occur following the exposure to the corrosive atmospheres or at a temperature rise of 6.7 °C (12 °F) per min or less until a temperature of at least 54 °C (130 °F) is reached [starting from a temperature of 29.4 °C to 32.2 °C (85 °F to 90 °F)].

35.3 Devices capable of repeated operation are to be subjected to the Oven Test, Section 29, before and after exposure to the corrosive atmospheres. Where devices are not capable of repeated operation the response data obtained from the Oven Test is to be compared to the response of identical as-received samples.

35.4 A heat alarm shall operate as intended after being subjected to the corrosive atmosphere tests described in 35.5 – 35.7. The samples are to be placed in the test chambers simulating the intended position of use on a platform approximately 50.8 mm (2 in) above the bottom of the exposure chamber.

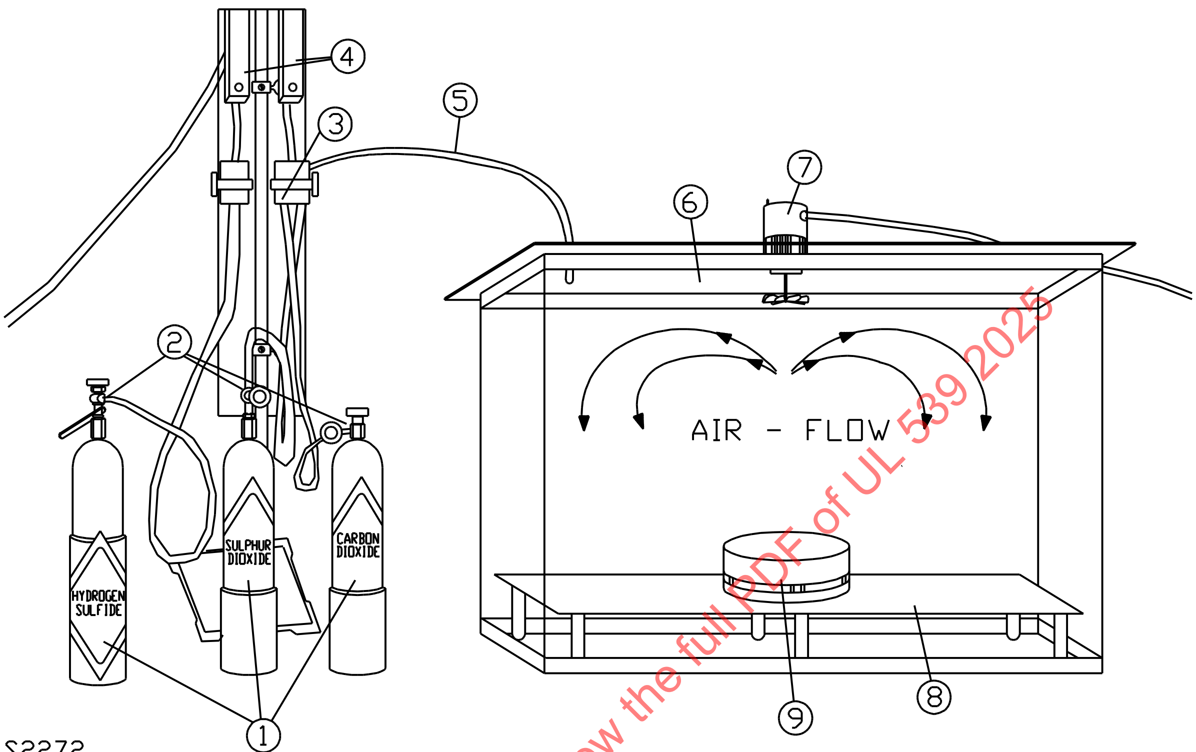
35.5 Moist Hydrogen Sulfide-Air Mixture Exposure – Two samples are to be exposed to a moist hydrogen sulfide-air mixture in a closed glass chamber for a period of 10 days. On the second through fourth and on the seventh through tenth day of exposure, the chambers are to be purged of gases from the previous day and an amount of hydrogen sulfide equivalent to 0.1 % of the volume of the chamber is to be introduced. On the fifth and sixth days of the exposure period, the chamber is to remain closed and there is not to be purging or introduction of gas. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained in the bottom of the chamber for humidity. The concentration of hydrogen sulfide by volume in air saturated with water vapor at room temperature shall be 1000 ±50 ppm (parts per million).

35.6 Moist Carbon Dioxide-Sulfur Dioxide-Air Mixture Exposure – Two samples are to be exposed to a moist carbon dioxide-sulfur dioxide-air mixture in a closed glass chamber for period of 10 days. On the second through fourth and on the seventh through tenth days of exposure, the chamber is to be purged of gases from the previous day and an amount of carbon dioxide equivalent to 1.0 % of the volume of the chamber, plus an amount of sulfur dioxide equivalent to 0.5 % of the volume of the chamber is to be added. On the fifth and sixth days of the exposure period, the chamber is to remain closed and there is not to be purging or introduction of gas. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained in the bottom of the chamber for humidity. The concentration of sulfur dioxide by volume in air saturated with water vapor at room temperature shall be 5000 ±250 ppm.

35.7 A typical test apparatus for the moist carbon dioxide-sulfur dioxide-air mixture exposure test and the moist hydrogen sulfide-air mixture exposure test is as described in Figure 35.1.

Figure 35.1

Corrosion Test Setup



1) Compressed gas cylinders (Commercial Grade SO_2, Bone Dry Grade CO_2, C.P. Grade H_2S).

2) Needle valves (to adjust flow).

3) Selector valve (selects CO_2 or SO_2).

4) Flowmeters (used in conjunction with stopwatch to measure gas volume).

5) Gas inlets to exposure chamber.

6) Glass exposure chamber with glass cover (holes in cover for gas inlet and outlet). Other type of chambers may be used provided the equivalent gas and water concentrations are maintained.

7) Small motor and fan blade [1550 rpm motor with aluminum fan blade, with ten 88.9 mm (3-1/2 in) wings providing air movement toward motor. Neoprene gasket used to seal shaft through-hole in glass cover].

8) Support platform (plastic "egg-crate" grid material).

9) Test sample. (Normally two test samples are used for this test.)

35.8 After exposure to the corrosive atmospheres, the samples are to be removed from the test chamber, allowed to remain at room temperature for at least 24 h and then subjected to the Oven Test, Section 29.

35.9 This test is to be conducted only on heat alarms of the ordinary degree rating unless there is a reason to anticipate different behavior of other ratings.

36 Alternate Corrosion Test (21-Day)

36.1 The 21-day corrosion test outlined in 36.2 – 36.4 may be conducted in lieu of the Corrosion Tests, Section 35.

36.2 Two heat alarm samples, one at maximum and one at minimum sensitivity setting, are to be placed in a 200 liter or larger test chamber on a platform approximately 50.8 mm (2 in) above the bottom of the chamber. The temperature in the chamber shall be maintained at 30 ±2 °C (86 ±3 °F) and the relative humidity at 70 ±2 % (measured directly in the chamber). The temperature and humidity are to be checked daily. Because of the corrosive atmosphere a set of wet and dry bulb thermometers shall be used for measurement of relative humidity.

36.3 The following gas mixture in air is to be supplied to the chamber at a rate sufficient to achieve an air exchange in the chamber of about five times per hour, for a period of 3 weeks: 100 ±10 parts per billion (ppb) (parts per billion = parts per 10^9 by volume) hydrogen sulfide (H_2S) plus 20 ±5 ppb chlorine (Cl_2) plus 200 ±50 ppb nitrogen dioxide (NO_2). The air inside the chamber is to be circulated by a single fan, with flow upwards from the bottom.

36.4 Following this test, the alarms shall comply with the sensitivity requirements of Section 29, Oven Test.

37 Operating Temperature Test

37.1 A heat alarm shall operate as intended and within the applicable operating temperature limits and ranges specified in Table 37.1, when subjected to an operating temperature test in a heated water, oil or air bath.

Table 37.1
Test Temperatures

Temperature classification	Operating temperature limits				Operation range	
	Minimum		Maximum			
	°C	(°F)	°C	(°F)	°C	(°F)
Low	46	(115)	56.7	(127)	5.6	(10)
Ordinary	53.3	(128)	74	(165)	5.6	(10)
Intermediate	74.4	(166)	107	(225)	8.3	(15)

37.2 Five samples of each temperature rating are to be subjected to this test. Depending on their particular design, the devices are to be suspended in a circulating water, oil or air bath, and the temperature gradually increased at the rate of 0.6 °C (1 °F) per minute until operation takes place. The temperature of the bath at the instant of operation is to be recorded.

38 Vibration Test

38.1 A heat alarm shall withstand vibration without false operation, without breakage or damage to parts or any leakage at fittings. Following the vibration test the response of a unit shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples. There shall not be any change in the sound intensity following the vibration test.

38.2 Two samples are to be secured in the intended position on a mounting board and the board, in turn, securely fastened to a variable speed vibration machine having an amplitude of 0.3 mm (0.01 in). The frequency of vibration is to be varied from 10 to 35 Hz in increments of 5 Hz until a resonant frequency is obtained. The samples are then to be vibrated at the resonant frequency for a period of 1/4 hour. If no resonant frequency is obtained, the samples are to be vibrated at 35 Hz for 4 h.

38.3 For the purpose of this test "amplitude" is defined as the maximum displacement of sinusoidal motion from a position of rest or one-half of the total table displacement. "Resonance" is defined as the maximum magnification of the applied vibration.

38.4 A heat alarm capable of repeated operation is to be subjected to the Oven Test, Section 29, before and after the vibration test. For a device not capable of repeated operation, the response data obtained from the oven test is to be compared to the response of identical as-received samples.

38.5 This test is generally to be conducted only on heat alarms of the low or ordinary degree rating unless there is a reason to anticipate different behavior of other ratings. For multiple station pneumatic fire alarm devices, the units are to be interconnected with a 3.05 mm (10 ft) length of tubing between units and between the units and any sounding appliance with which it is intended to be used.

39 Humidity Test

39.1 A heat alarm shall operate as intended and comply with the requirements of the Oven Test, Section 29, following exposure for 24 h to moist air having a relative humidity of 85 ±5 % at a temperature of 30 ±2 °C (86 ±4 °F). The units are to be tested within 5 min after removal from the humid environment.

39.2 Two samples are to be subjected to this test. This test is to be conducted on devices having a low or an ordinary degree rating only, unless different behavior of other ratings is anticipated.

40 Low Temperature Exposure Test

40.1 A heat alarm shall operate as intended and shall comply with the requirements of the Oven Test, Section 29, following exposure for 24 h to a temperature of minus 30 ±2 °C (minus 22 ±4 °F). The units are to be tested within 5 min after removal from the low temperature chamber. There shall not be false operation, damage to parts or leakage at fittings.

40.2 Two samples are to be subjected to this test. This test is to be conducted on alarms having a low or an ordinary degree rating only, unless different behavior of other ratings is anticipated.

40.3 Following the 24 h of exposure, the heat alarms are to be transitioned from the low temperature environment to the test environment defined in 40.1 within 30 s. The heat alarms may produce an alarm signal during this transition. Samples that produce an alarm signal during transition shall be allowed to remain in ambient condition until the alarm is reset and the tests required in 38.1 can be conducted.

40.4 For a pneumatic multiple station heat alarm, the maximum length of tubing specified by the manufacturer is to be connected between the unit and any alarm sounding device with which it is intended to be used before conducting the test. See also 25.3, General.

41 Survivability Test

41.1 Two samples of the heat alarm shall be exposed to a temperature of 121 ±2 °C (250 ±4 °F) for a period of 4 min. The units shall be removed from the test chamber and allowed to return to room temperature. The units are then to be subjected to the Audibility Test, Section 42, (when applicable) and the Oven Test, Section 29.

41.2 Following conditioning, the samples shall be capable of producing an audible signal of 85 dBA at 3 m (10 ft), and the sensitivity of each heat alarm shall not show a time variation of more than 50 %.

42 Audibility Test (Canada and U.S.)

42.1 General

42.1.1 Except as permitted in Supplementary Remote Sounding Appliances, Section 44, the alarm sounding appliance, either integral with the heat alarm or intended to be connected separately, shall be capable of providing for at least 4 min, a sound output equivalent to that of an omnidirectional source with an A-weighted sound pressure level of at least 85 decibels (dBA) at 3.05 m (10 ft) with two reflecting planes assumed. To determine compliance with this paragraph the methods described in 42.2 or 42.3 are to be employed. It is appropriate for alarms to be tested with the horn duty cycle specified in 27.2, Standardized Alarm Signal, defeated and emitting a continuous tone. Additionally, the signal format of a low frequency alarm shall conform to the description in Section 45, Low Frequency Alarm Signal Format.

42.2 Sound output measurement (Canada)

42.2.1 The signal format of a low frequency alarm shall conform to the description in Section 45, Low Frequency Alarm Signal Format.

42.2.2 An alarm that incorporates an audible device shall be capable of providing an output of at least 85 dBA at 3 m (10 ft) after being subjected to the Endurance Test described in 62.4, Audible Signaling Appliance, while connected to a source of rated voltage and frequency. Each alarm is to be mounted to a 19.1 mm (3/4 in) plywood board measuring 610 by 610 mm (2 by 2 ft), supported in a vertical plane, with the front of the heat alarm at 90° with the horizontal and facing the microphone. At least two samples shall be tested.

42.2.3 Units intended for multiple-station connection shall be tested in the configuration specified in 42.2.2 with the maximum line resistance as defined in 52.2.4 of the Undervoltage Test, and the audibility measured on the heat alarm when subjected to an abnormal heat condition. For a battery-operated unit, the batteries shall be depleted to a point just above or at the heat alarm trouble signal level. The sound level measurement shall be made after 4 min of alarm operation.

42.2.4 The measurement shall be made in a free field condition to minimize the effect of reflected sound energy. The ambient noise level is to be at least 10 dB below the measured level produced by the signal appliance. Free field conditions may be simulated by mounting the device on a wood surface at least 125 by 150 mm (4.9 x 5.9 in) not less than 3 m (10 ft) from the ground and with the microphone located 3 m (10 ft) from the alarm and conducting the test outdoors on a clear day with a wind velocity of not more than 8 kph (5 mph) and an ambient temperature of 15 to 25 °C (59 to 77 °F).

42.2.5 Alternately, an anechoic chamber with usable volume of not less than 28 m^3 (989 ft^3), with no dimension less than 2 m (6.5 ft), and with an absorption factor of 0.99 or greater from 100 Hz to 10 kHz for all surfaces may be used for this measurement.

42.3 Sound output measurement (United States)

42.3.1 The sound power output of the alarm shall be measured in a reverberation room using procedures outlined in ANSI ASA Standard S12.51 (Acoustics Determination of Sound Power Levels of Noise Sources using Sound Pressure Precision Method for Reverberation Rooms). The sound power in each 1/3 octave band shall be determined using the comparison method. The A-weighting factor shall be added to each 1/3 octave band. The total power is to be determined on the basis of actual power. The total power is then to be converted to an equivalent sound pressure level for a radius of 3 m (10 ft). An additional 6 dB is to be added to allow for two reflecting planes.

42.3.2 Each alarm is to be mounted to a 19.1 mm (3/4 in) plywood board measuring 610 by 610 mm (2 by 2 ft), supported in a vertical plane, and positioned at an angle of 45° to the walls of the reverberation room.

42.3.3 For this test an AC powered alarm is to be energized from a source of rated voltage and frequency. A battery powered alarm is to be energized from batteries under each of the following conditions along the trouble signal level curve illustrated in Figure 51.2, or equivalent:

a) Non-discharged battery (a battery with some unknown shelf life, such as those purchased at a retail outlet) with enough added resistance to obtain a trouble signal (Point D of Figure 51.2), or the maximum resistance for the particular battery based on documented data, whichever is less.

b) Battery depleted to the trouble signal level voltage, no added resistance.

c) Battery depleted to a voltage value between conditions A and B above which is evaluated to be the least favorable for sound output. For a straight line curve it is the midpoint voltage. For a nonlinear curve it is to be specified. The equivalent of a battery shall be identified as a voltage source with a series resistance adjusted to a level at which a trouble signal is obtained during the normal standby condition. The resistance and voltages used are to be those that were determined during the Circuit Measurement Test, Section 49.

42.3.4 At least two samples shall be tested. Units intended for multiple-station connection shall also be tested interconnected as multiple-stations with the maximum line resistance defined in 52.2.2 of the Undervoltage Test. For AC powered units employing a non-rechargeable standby battery, the measurement shall be made with the heat alarm connected to a rated AC voltage source, and then with the AC power de-energized and energy obtained from a standby battery depleted to 85 % of rated battery voltage, or at the voltage level at which a trouble signal is obtained. For an AC unit employing a rechargeable standby battery, the measurement is to be made using a fully recharged battery.

43 Alarm Duration Test

43.1 An alarm sounding appliance of an alarm powered by a primary or secondary battery that has been discharged to the trouble level condition shall provide the equivalent of 85 dBA minimum at 3.05 m (10 ft) for 1 min of continuous alarm operation and shall provide at least 82 dBA up to 4 min of alarm operation.

43.2 For Mechanically Operated Alarms, an alarm sounding means of a single or multiple station heat alarm or both, shall provide the equivalent of 85 decibels at 3.05 m (10 ft) after 1 minute of continuous alarm operation and at least 82 decibels after 4 minutes of operation.

43.3 To determine compliance with 43.1, a measurement shall be made under the following conditions. The ambient noise level is to be at least 10 dB below the measured level produced by the signaling appliance. The alarm is to be mounted 302 mm (1 ft) from the microphone placed in a direct line with the alarm. The alarm is then to be energized in the alarm condition and the sound output is to be measured at 1-min intervals, using a sound level meter employing the A-weighting network.

44 Supplementary Remote Sounding Appliances

44.1 The sound output of a supplementary remote sounding appliance, intended to be installed a sleeping area, shall meet the Low Frequency Signal Format of Section 45 and comply with the Audibility Test, Section 42.

44.2 The supplementary remote sounding appliance shall be marked with the following, or equivalent, text to indicate the specific use:

"THIS UNIT IS TO BE INSTALLED IN A ROOM OCCUPIED FOR SLEEPING"

« CET APPAREIL DOIT ÊTRE INSTALLÉ DANS UNE PIÈCE OCCUPÉE POUR DORMIR »

44.3 If the marking specified in 44.2 is applied to the alarm, the sound output shall not be less than 75 dBA.

45 Low Frequency Alarm Signal Format (optional)

45.1 A low frequency alarm shall have a fundamental frequency of 520 (F1) Hz ±10 %, with subsequent harmonic frequencies occurring at 1560 (F3), 2600 (F5) and 3640 (F7) Hz ±10 % as determined by a Fast Fourier Transform (FFT) analysis of the audible alarm signal.

45.2 The spectral analyses shall be performed in a reverberant room per the test setup as described in 40.3. The FFT measurement shall be a 30 s spectrum averaging of a 12.8 (kHz) frequency span of 2 (Hz) resolution, non-weighted.

45.3 The maximum sound pressure level (dB) of any frequency within the FFT measurement shall be at least 5 dB less than the F1 sound pressure level (dB). The minimum sound pressure level (dB) of the odd harmonics shall not be less than 20 dBA for F3, 30 dBA for F5 and 50 dBA for F7 of the fundamental F1 level.

46 Jarring Test

46.1 An alarm shall withstand jarring resulting from impact and vibration such as experienced in service, without causing an alarm or trouble signal, without dislodgement of any parts, and without impairing its subsequent operation.

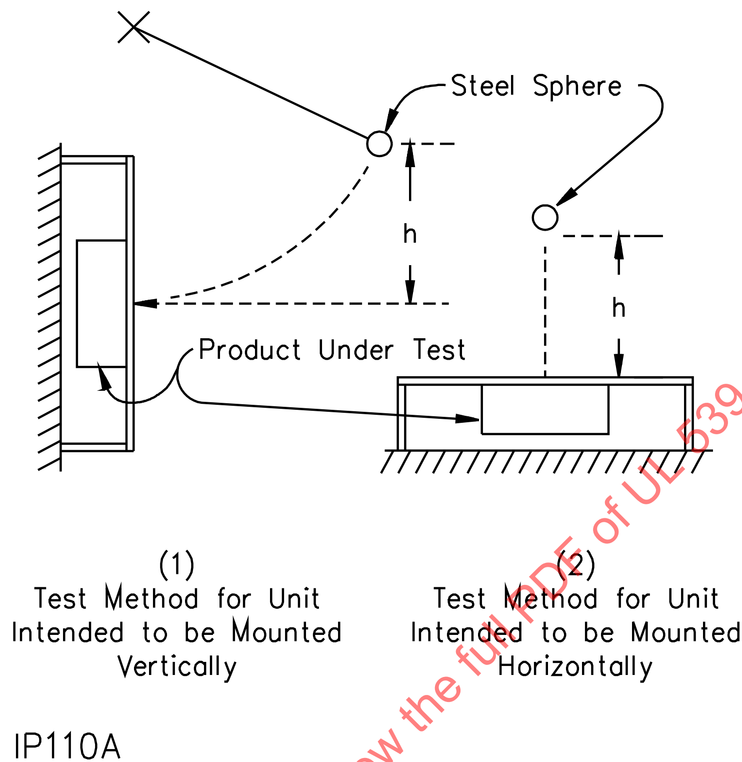
Exception: Dislodgment of parts is acceptable if the dislodged part(s) does not affect the operation of the unit, and there are no high voltage parts exposed.

46.2 The alarm and any associated equipment are to be mounted in a position of intended use, see Figure 46.1, to the center of a 1.8 by 1.2 m (6 by 4 ft), nominal 19.1 mm (3/4 in) thick plywood board which is secured in place at four corners. A 100 by 100 mm ±10 % (3.94 by 3.94 in ±10 %) steel plate, 3.2 mm ±10 % (1/8 in ±10 %) thick shall be rigidly secured to the center of the reverse side of the board.

46.3 A 4.08 J (3 ft-lb) impact is to be applied to the center of the reverse side of this board by means of a 0.54 kg (1.18 lb), 50.8 mm (2-in) diameter steel sphere either swung through a pendulum arc from a height (h) of 775 mm (2.54 ft), or dropped from a height (h) of 775 mm (2.54 ft) to apply 4.08 J (3 ft-lb) of energy. See Figure 46.1.

Figure 46.1

Jarring Test



46.4 During this test, the alarm is to be in the standby condition and connected to a rated source of supply (or mechanical power, as applicable) in accordance with Test Voltages, Section 26. Following the Vibration Test, Section 38, the response of a unit shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

47 Effect of Shipping and Storage

47.1 The sensitivity of an alarm shall not be impaired by exposure to high and low temperatures representative of shipping and storage. The exposure shall not result in warping, cracking or any other physical or electronic damage, which would impair its operation in any way or its suitability for its intended use.

47.2 Two alarms are to be subjected, in turn, to a temperature of 70 °C (158 °F) for a period of 24 h, let to cool to room temperature for at least 1 hour, exposed to a temperature of minus 30 °C (minus 22 °F) for at least 3 h, and then permitted to warm up to room temperature for at least 3 h. Following the test the response of the units shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

48 Dust Test

48.1 The sensitivity of an alarm shall not be reduced abnormally by an accumulation of dust, without an alarm or audible trouble signal being produced.

48.2 To determine compliance with 48.1, a sample in its intended mounting position is to be placed de-energized, on metal supports in an airtight chamber having an internal volume of at least 0.09 m^3 (3 ft^3).

48.3 Sixty ±3 g (2 oz) of cement dust, maintained in an ambient room temperature of 23 ±2 °C (73.4 ±3 °F) at 20 – 50 % relative humidity and capable of passing through a 200 mesh screen, is to be circulated for 15 min by means of compressed air or a blower so as to completely envelop the sample in the chamber. The air flow is to be maintained at an air velocity of 0.25 m/s (50 fpm).

48.4 Following the exposure to dust, the alarm is to be removed carefully, mounted in its intended position, energized from a source of supply in accordance with Section 26, Test Voltages, and tested for operation. The response of the units shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

49 Replacement Test, Head and Cover

49.1 An alarm employing a cover that is intended to be attached or closed by a snap type action or a removable head shall withstand 50 cycles of removal and replacement, or opening and closing, as applicable, of the cover.

49.2 An alarm is to be installed as intended in service and the cover or head removed and replaced, or opened and closed, as specified by the manufacturer. The unit then is to be subjected to the Jarring Test, Section 46.

50 Marking Tag Secureness Test

50.1 If the marking specified by 73.1 (o) is provided on a tag, the tag fastened to the product shall withstand a pull of 22 N (5 lbf) for 15 s without breakage or separation of the attachment means, and without tearing or breakage of the tag.

51 Circuit Measurement Test (Electrically-operated Heat Alarms Only)

51.1 Current input

51.1.1 Except for battery operated alarms, the input current of a heat alarm shall not exceed the marked rating by more than 10 % when the alarm is connected to a source of supply in accordance with Test Voltages, Section 26, and operated under the conditions of intended use (standby and alarm).

51.2 Battery trouble voltage determination

51.2.1 An increase in the internal resistance, or a decrease in terminal voltage, of a battery employed as the primary source of power to an alarm shall not impair operation for an alarm signal before a trouble signal is obtained. In addition, any combination of voltage and resistance at which a trouble signal is obtained shall be greater than the battery voltage and resistance combination measured over the manufacturer's specified battery life (a minimum of 1 year) period in the room ambient condition of the Battery Tests, Section 66.

51.2.2 The trouble level of a battery operated heat alarm shall be determined (using the test circuit in Figure 51.1 and the voltage-resistance curves of Figure 51.2) for each of the following voltages:

a) Rated battery voltage,

b) Trouble level voltage (assuming minimal or no series resistance), and

c) Voltages between rated and trouble level voltage.

Figure 51.1

Test Circuit

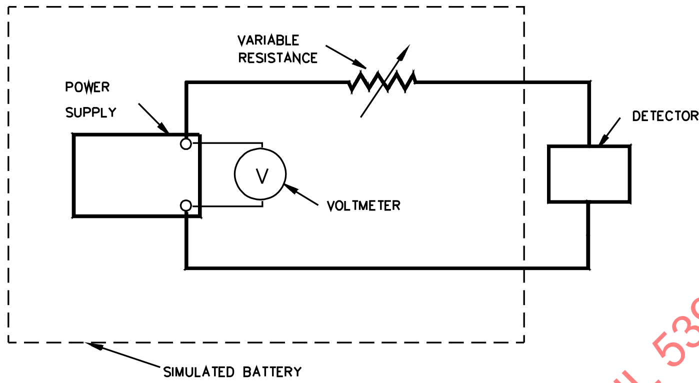


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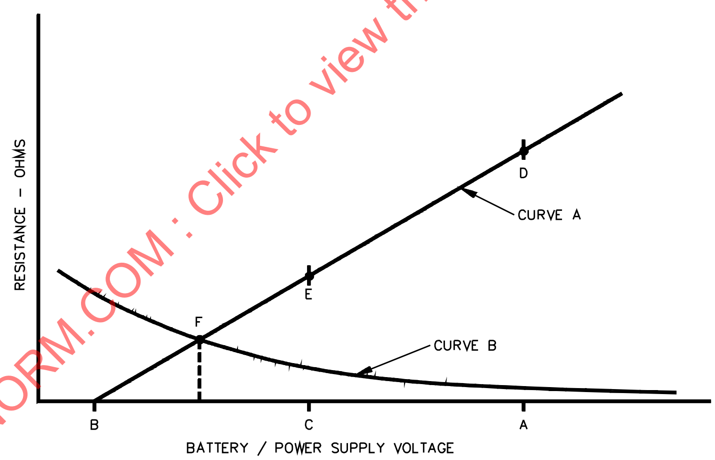
Figure 51.2

Trouble Level Determination



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A – Rated battery voltage

B – Trouble level voltage (assuming minimal resistance)

C – Voltage value between rated and trouble level

D – Trouble level resistance at rated battery voltage

E – Trouble level resistance at voltage value C

F – Maximum permissible battery resistance and minimum voltage after 1 year in long-term battery test

Curve A – Sample plot of voltage versus resistance (Alarm Trouble Level Curve) at which a trouble signal in an alarm is obtained. Audibility measurement is to be made at points between D and F

Curve B – Sample plot of battery internal resistance versus battery open circuit voltage derived from long term (minimum 1 year) battery test. Shape and slope of curve, as well as point of intersection with Curve A, varies based on battery used

51.2.3 To determine compliance with 51.2.1 each of three alarms is to be connected in series with a variable regulated direct current power supply and a variable resistor as illustrated in Figure 51.1. The trouble level is to be determined by the following steps:

a) Rated Battery Voltage – The voltage of the power supply is to be set at the rated battery voltage and the series resistor at 0 ohm. The resistor is to be increased in increments of 0.1 – 10 ohms, at a rate of not more than one increment per minute, until a trouble signal is obtained. The alarm is to be tested for alarm operation at each resistance level and at the trouble signal level.

b) Trouble Level Voltage – With the variable resistor set at 0 ohm, the voltage of the power supply connected to the alarm is to be reduced in increments of 1/10 volt per minute to the level where the trouble signal is obtained. The alarm is to be tested for alarm operation at each voltage level and at the trouble signal level.

c) Voltage Values Between Rated and Trouble Level Voltages – The voltage of the power supply is to be set at pre-specified voltages between the rated battery voltage and the trouble level voltage. The series resistor is then to be increased in increments of 0.1 – 10 ohms, at a rate of not more than one increment per minute, until a trouble signal is obtained. The alarm is to be tested for alarm operation at each resistance and voltage level and at the trouble voltage level. A number of voltage values shall be used to determine the shape of the trouble level curve.

d) Internal Resistance Increase With Constant Terminal Voltage – The voltage of the power supply is to be set at the battery rated voltage (terminal voltage of new battery under normal standby current drain) and the resistance increased from zero ohms until the heat alarm trouble signal is obtained. The rate of resistance change prior to the trouble point shall be reduced to a value required to eliminate any error due to any time lag in the trouble circuit of the heat alarm.

e) Terminal Voltage Decrease With Constant Internal Resistance – With the variable resistance set at zero ohms, the power supply voltage is to be decreased until the heat alarm trouble signal is obtained. The rate of voltage change prior to the trouble point shall be reduced to a value required to eliminate any error due to any time lag in the trouble circuit of the smoke alarm.

f) Variable Internal Resistance With Variable Terminal Voltage – The test of (a) is to be repeated with the power supply voltage set to values equal to the 25 %, 50 %, and 75 % points of the voltage range determined in (b).

51.2.4 To determine that a battery is capable of supplying alarm and trouble signal power to the alarm for at least the manufacturer's specified battery life (1 year minimum) under the room ambient condition described in the Battery Tests, Section 66 Curve A of Figure 51.2 is to be plotted from the data obtained in the measurements described in 51.2.3 and compared to Curve B of Figure 51.2, which is plotted from data generated in the 1 year battery test. The intersection of Curves A and B shall not occur before the manufacture's specified battery life (1 year minimum) and all points of Curve B to the right of point F (extended to the base line), shall be below Curve A.

52 Overvoltage and Undervoltage Tests (Electrically-operated Heat Alarms Only)

52.1 Overvoltage test

52.1.1 An alarm shall operate as intended in the standby condition while performing its signaling function and connected to a supply source of 110 % of rated value. When a nominal rated voltage value is specified, the overvoltage shall be 110 % of the test voltage specified in Test Voltages, 26. When an operating voltage range is specified, the overvoltage shall be either 110 % of the high value of the voltage range or 110 % of the test voltage specified in section 26, whichever is higher. While energized from the overvoltage condition, the response of a unit shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 31, or both (as applicable), on as-received samples.

Exception: This requirement does not apply to alarms operated by a primary battery power supply

52.1.2 For alarms intended for connection in a multiple station configuration, the minimum number of alarms specified by the installation instructions are to be interconnected with zero line resistance between alarms and tested for their intended operation.

52.1.3 For operation at the higher voltage, three alarms are to be subjected to the specified increased voltage in the standby condition for at least 16 h, or as specified by the manufacturer, and then tested for their intended signaling operation and sensitivity.

52.2 Undervoltage test

52.2.1 An alarm shall operate for its intended signaling performance while energized from a supply of 85 % of the test voltage specified by the manufacturer. For units powered from a primary battery, the test shall be conducted at the battery trouble signal voltage level. While energized from the undervoltage condition, the response of a unit shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable),on as-received samples.

52.2.2 For alarms intended for connection in a multiple station configuration, the maximum number of alarms specified by the installation instructions are to be interconnected with either 10 ohms resistance between alarms, or the maximum resistance specified in the installation instructions, and tested for intended operation.

52.2.3 When the alarm is provided with a standby battery the test is to be conducted at 85 % of the charged battery voltage. When the standby battery provides a trouble signal requiring replacement at higher than 85 % of the charged battery voltage, the test is to be conducted at the battery trouble signal voltage level.

52.2.4 For operation at the reduced voltage, three alarms are to be energized from a source of supply in accordance with Section 26, Test Voltages, following which the voltage is to be reduced to 85 % of the test voltage specified in 26.1 for AC operated alarms, or the battery trouble level voltage for battery operated alarms, and then tested for signaling operation and sensitivity.

53 Temperature Test

53.1 The materials or components employed in an alarm shall not be subjected to a temperature rise greater than the values indicated in Table 53.1, under any condition of intended operation. The temperature rise of a component in Table 53.1 in the standby condition may be exceeded, but in no case shall be greater than that for the temperature permitted under an alarm condition, if malfunction of that component results in a trouble signal.

Table 53.1
Maximum Temperature Rises

Materials and components	Normal standby, °C	(°F)	(Signaling) alarm condition, °C	(°F)
A. COMPONENTS				
1. Capacitors: [a,b]				
a. Electrolytic types	25	(45)	40	(72)
b. Other types	25	(45)	65	(117)
2. Rectifiers – At any point				
a. Germanium	25	(45)	50	(90)
b. Selenium	25	(45)	50	(90)
c. Silicon				
(i) Maximum 60 % of rated voltage	50	(90)	75	(135)
(ii) 61 % or more of rated voltage	25	(45)	75	(135)
3. Relay, solenoid, transformer, and other coils with:				
a. Class 105 insulation system:				
Thermocouple method	25	(45)	65	(117)
Resistance method	35	(63)	75	(135)
b. Class 130 insulation system:				
Thermocouple method	45	(81)	85	(153)
Resistance method	55	(99)	95	(171)
c. Class 155 insulation system:				
(i) Class 2 transformers:				
Thermocouple method	95	(171)	95	(171)
Resistance method	115	(207)	115	(207)
(ii) Power transformers:				
Thermocouple method	110	(198)	110	(198)
Resistance method	115	(207)	115	(207)
d. Class 180 insulation system:				
(i) Class 2 transformers:				
Thermocouple method	115	(207)	115	(207)
Resistance method	135	(243)	135	(243)
(ii) Power transformers:				
Thermocouple method	125	(225)	125	(225)
Resistance method	135	(243)	135	(243)
4. Resistors[c]:				
a. Carbon	25	(45)	50	(90)
b. Wire wound	50	(90)	125	(225)
c. Other	25	(45)	50	(90)
5. Solid state devices	See footnote d			
6. Other components and materials:				
a. Fiber used as electrical insulation or cord bushings	25	(45)	65	(117)

Table 53.1 Continued on Next Page

Table 53.1 Continued

Materials and components	Normal standby, °C	(°F)	(Signaling) alarm condition, °C	(°F)
b. Varnished cloth insulation	25	(45)	60	(108)
c. Thermoplastic materials	Rise based on temperature limit of the material			
d. Phenolic composition used as electrical insulation or as parts whose malfunction or deterioration results in a risk of electric shock, explosion, fire, or injury to persons[e]	25	(45)	125	(225)
e. Wood or other combustibles	25	(45)	65	(117)
f. Sealing compound	15 °C (27 °F) less than its melting point			
g. Fuses	25	(45)	65	(117)
B. CONDUCTORS				
1. Appliance wiring material[f]	25 °C (45 °F) less than the temperature limit of the wire			
2. Flexible cord (for example, SJO, SJT)	35	(63)	35	(63)
3. Conductors of field-wired circuits to be permanently connected to the product	35	(63)	35	(63)
C. GENERAL				
1. All surfaces of the product and surfaces adjacent to or upon which the product is be mounted	65	(117)	65	(117)
2. Surfaces normally contacted by the user in operating the unit (such as control knobs, push buttons, and levers):				
a. Metal	35	(63)	35	(63)
b. Nonmetallic	60	(108)	60	(108)
3. Surfaces subjected to casual contact by the user (such as the enclosure or grille):				
a. Metal	45	(81)	45	(81)
b. Nonmetallic	65	(117)	65	(117)

[a] For an electrolytic capacitor which is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure shall not be more than 65 °C (117 °F).

[b] It is not prohibited to evaluate a capacitor which operates at a temperature higher than a 65 °C (117 °F) rise on the basis of its marked temperature rating.

[c] When the temperature rise of a resistor exceeds the values shown the power dissipation shall be 50 % or less of the manufacturer's rating.

[d] The temperature of a solid-state device (for example, transistor, SCR, integrated circuits), shall not exceed 50 % of its rating during the normal standby condition. The temperature of a solid-state device shall not exceed 75 % of its rated temperature under the alarm condition or any other condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0 °C (32 °F) shall be identified as 0 %. For integrated circuits the loading factor shall not exceed 50 % of its rating under the normal standby condition and 75 % under any other condition of operation. It is permissible that both solid-state devices and integrated circuits be operated up to the maximum ratings under any one of the following conditions:

1) The integrated circuit (microcircuits) complies with the requirements of MIL-STD.883H.

2) The semiconductor devices comply with the requirements of MIL-STD 750E.

3) A quality-control program is established by the manufacturer consisting of an inspection stress test followed by operation of 100 % of all components, either on an individual basis, as part of a subassembly, or equivalent.

4) Each assembled production unit is subjected to a burn-in test, under the condition which results in the maximum temperatures, for 24 h while connected to a source of rated voltage and frequency in an ambient of at least 49 °C (120 °F) followed by a Normal Operation Test, Section 27.

[e] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds which have been investigated and determined to have special heat-resistant properties.

Table 53.1 Continued on Next Page

Table 53.1 Continued

Materials and components	Normal standby,		(Signaling) alarm condition,	
	°C	(°F)	°C	(°F)
[f] For standard insulated conductors other than those mentioned, reference shall be made to: In Canada, C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations; In the United States, National Electrical Code, NFPA 70, The maximum allowable temperature rise in any case is 25 °C (45 °F) less than the temperature limit of the wire in question.				

53.2 Except as noted in 53.3, all values for temperature rises apply to equipment intended for use in prevailing ambient temperatures, usually not higher than 23 °C (73 °F).

53.3 When equipment is intended specifically for use with a prevailing ambient temperature constantly more than 23 °C (73 °F), the test of the equipment is to be made at the higher ambient temperature, and temperature rises specified in Table 53.1 are to be reduced by the amount of the difference between that higher ambient temperature and 23 °C (73 °F).

53.4 Temperature measurements on equipment intended for recessed mounting are to be made with the unit installed in an enclosure of nominal 19.1 mm (3/4 in) wood having clearance of 50.8 mm (2 in) on the top, sides and rear, and the front extended to be flush with the heat alarm cover.

53.5 A temperature is constant when three successive readings, taken at not less than 5 min intervals, indicate no change.

53.6 Temperatures shall be measured by means of thermocouples consisting of 30 AWG (0.06 mm^2) wire. Measuring the temperature of a coil is to be accomplished by either the thermocouple or resistance method. The thermocouple method, however, is not to be employed for a temperature measurement at any point where supplementary thermal insulation is employed.

53.7 Thermocouples consisting of iron and constantan wires and a potentiometer-type indicating instrument shall be used whenever referee temperature measurements by thermocouples are necessary. The thermocouples shall be 30 AWG (0.06 mm^2) wire.

53.8 The thermocouple wire is to comply with the requirements for special thermocouples as specified in ASTM MNL 12, Manual on the Use of Thermocouples in Temperature Measurement.

53.9 The temperature of a copper coil winding is determined by the change-in-resistance method by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature by means of the equation:

$$T = \frac{R}{r}(234.5 + t) - 234.5$$

in which:

T is the temperature to be determined in °C,

R is the resistance in ohms at the temperature to be determined,

r is the resistance in ohms at the known temperature,

t is the known temperature in °C.

53.10 As it is required to de-energize the winding before measuring R, it is appropriate for the value of R at shutdown to be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time shall be plotted and extrapolated to give the value of R at shutdown.

53.11 To determine compliance with this test, an alarm is to be connected to a source of supply in accordance with Test Voltages, Section 26, and operated under the following conditions:

a) Standby – 16 h minimum. Constant temperatures

b) Alarm – 1 hour

c) Alarm – 7 h or to battery depletion. Abnormal test.

53.12 When the temperature limits for 53.11 (c) are exceeded there shall be no manifestation of a fire or approaching failure, and the alarm shall operate as intended following the test.

53.13 The alarm is to be subjected to the Dielectric Voltage-Withstand Test, Section 59, following 53.11 (b) or (c).

54 Transient Tests (Electrically-operated Heat Alarms Only)

54.1 General

54.1.1 Two electrically-operated heat alarms shall be subjected to the tests specified in 54.2 – 54.7 while energized from a source of supply in accordance with Test Voltages, 26, and connected to the device(s) intended to be used with the alarm. The alarms

a) Shall operate for their intended signaling performance,

b) Shall not initiate an alarm signal, and

c) Shall not initiate a trouble signal.

54.1.2 Alarms using a primary battery as a power supply are to be subjected to 54.4, Extraneous transients, only. When an alarm is intended for multiple-station connection, the transient tests are to be first conducted with an individual heat alarm, and secondly with two interconnected heat alarms. The interconnecting wiring shall not exceed 305 mm (12 in).

54.1.3 Different heat alarms are to be used for each test. The heat alarms shall not false alarm for more than 1 second.

54.1.4 Following the test the response of the units shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

54.2 Supply line (high-voltage) transients

54.2.1 For this test, the alarm is to be connected to a transient generator, consisting of a 2 kilovolt-amperes isolating power transformer and control equipment capable of producing the transients described in 54.2.2. The output impedance of the transient generator is to be 50 ohms.

54.2.2 The transients produced are to be oscillatory and have an initial peak voltage of 6000 volts. The rise time is to be less than 1/2 microsecond. Successive peaks of the transients are to decay to a value of no more than 60 % of the value of the preceding peak. Each transient is to have a total duration of 20 microseconds.

54.2.3 Each unit is to be subjected to 500 oscillatory transient pulses induced at a rate of once every 10 s. Each transient pulse is to be induced 90 degrees into the positive half of the 60 hertz cycle. A total of 250 pulses are to be applied so that the polarity of the transients is positive with reference to earth ground, and the remaining 250 pulses are to be negative with respect to earth ground.

54.3 Internally induced transients

54.3.1 The alarm is to be energized in the standby condition while connected to a source of supply in accordance with Test Voltages, Section 26. The supply is to be interrupted a total of 500 cycles for 1 second at a rate of not more than 6 cycles/min; following the test, the alarm is to be operated:

a) For its intended signaling performance, and

b) The response of the alarm shall not show a time variation of more than 50 % from the value obtained in the Oven Test, 29.2, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

54.4 Extraneous transients

54.4.1 A heat alarm shall not false alarm and its intended operation shall not be impaired when subjected to extraneous transients generated by the devices and appliances described in 54.4.2. In addition, the alarm shall respond to heat during application of the transient condition.

54.4.2 Two single and two sets of multiple station heat alarms are to be energized from a source of rated voltage and frequency and subjected to transients generated from the following devices located 305 mm (1 ft) from the alarm, interconnecting wires, or both. The time of application for the condition specified in (a) is to be at least 2 min. The conditions specified in (c), (d), and (e) are to be applied for 10 cycles, each application of 2 s duration, except the last application shall be of a 2-min duration. Near the end of the last cycle, an abnormal amount of heat is to be introduced onto the heat sensor to determine whether the unit is operational for heat with the transient applied.

a) Sequential arc (Jacob's ladder) generated between two 381 mm (15 in) long, 14 AWG (2.1 mm^2) solid copper conductors attached rigidly in a vertical position to the output terminals of an oil burner ignition transformer or gas tube transformer rated 120 volts, 60 hertz primary; 10,000 volts, 60 hertz, 23 milliamperes secondary. The two wires are to be formed in a taper starting with a 3.2 mm (1/8 in) separation at the bottom (adjacent to terminals) and extending to 31.8 mm (1-1/4 in) at the top.

b) Energization and transmission of random voice message of five separate transmitter-receiver units (cellular phones) in turn, and operating in the following nominal frequencies:

1) 27 megahertz,

2) 150 megahertz,

3) 450 megahertz,

4) 866 megahertz,

5) 910 megahertz, and

6) 5.8 gigahertz.

A total of six energizations in each of two orientations are to be applied from each transmitter-receiver; five to consist of 5 s on and 5 s off, followed by one consisting of a single 15-second energization. For this test, the cellular phones are to be in the same room and on the same plane as the alarm under test. The cellular phones are to be positioned to generate a field strength of 20 volts/meter at the surface of the alarm's printed-wiring board. The test is to be conducted with the antenna tip pointed directly at the alarm, and at right angle to the first position centered on the alarm.

c) Energization of an electric drill rated 120 volts, 60 hertz, 2.5 amperes.

d) Energization of a soldering gun rated 120 volts, 60 hertz, 2.5 amperes.

e) Energization of a 152-mm (6-in) diameter solenoid-type vibrating bell with no arc suppression and rated 24 volts DC.

54.5 Supply line (low-voltage) circuit transients

54.5.1 Each of two low-voltage heat alarms is to be subjected to 60 transient voltage pulses. The pulses are to be induced into:

a) The heat alarm circuit intended to be connected to the low-voltage initiating device circuit of a system control unit and

b) The low-voltage power supply circuit of the alarm.

54.5.2 For this test, each circuit is to be subjected to five different transient waveforms having peak voltage levels in the range of 100 to 2400 volts, as delivered into a 200 ohm load. A transient waveform at 2400 volts shall have a pulse rise time of 100 volts per microsecond, a pulse duration of 80 microseconds, and an energy level of 1.2 joules. Other applied transients shall have peak voltages representative of the entire range of 100 to 2400 volts, with pulse durations from 80 to 110 microseconds, and energy levels not less than 0.3 joule or greater than 1.2 joules.

54.5.3 The alarm is to be subjected to 60 transient pulses induced at the rate of six pulses per minute as follows:

a) Twenty pulses (two at each transient voltage level specified in 54.5.1) between each circuit lead or terminal and earth ground, consisting of ten pulses of one polarity, and ten of the opposite polarity (total of 40 pulses) and

b) Twenty pulses (two at each transient voltage level specified in 54.5.1) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten of the opposite polarity.

54.5.4 Following the test the response of the units shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

54.6 Surge Immunity Test (Combination Wave)

54.6.1 The alarm shall be subjected to the Surge Immunity Test without demonstrating, either during or after testing, any of the following:

a) Emission of flame, molten metal, glowing or flaming particles through any openings (preexisting or created as a result of the test) in the product;

b) Ignition of the enclosure; nor

c) Creation of any opening in the enclosure that results in energized parts becoming accessible.

54.6.2 The test method is to be conducted in accordance with the testing methods described in IEC 61000-4-5 Electromagnetic Compatibility (EMC) Part 4-5: Testing and Measurements Techniques – Surge Immunity Test. The surges (five positive and five negative) are to be applied at phase angles of 90 and 270 electrical degrees.

54.6.3 The surge impulse test levels in Table 54.1 are to be used (combination 1.2/50 μs, 8/20 μs Voltage/Current surge waveform). A separate alarm shall be used for each surge level.

54.6.4 Following the test the response of the units shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

Table 54.1
Surge Impulse Levels

Peak Voltage (kV)	Peak Current (kA)
2	1
4	2
6	3

54.7 Surge Current Test

54.7.1 Each of three previously untested representative devices of the alarm are to be subjected to the Surge Current Test without demonstrating, either during or after testing, any of the following:

a) Emission of flame, molten metal, glowing or flaming particles through any openings (preexisting or created as a result of the test) in the product;

b) Charring, glowing, or flaming of the supporting surface, tissue paper, or cheesecloth;

c) Ignition of the enclosure; nor

d) Creation of any opening in the enclosure that results in energized parts becoming accessible.

54.7.2 The alarm is to be mounted on a ceiling surface covered with a double layer of white tissue paper. Each alarm is to be loosely draped with a double layer of cheesecloth. The cheesecloth shall cover openings (for example, ventilation openings) where flame, molten metal, or other particles are not prohibited from being expelled as a result of the test. During this test it is not intended that the cheesecloth be deliberately pushed into any openings.

54.7.3 A permanently-connected alarm shall be connected to a source of supply in accordance with Test Voltages, Section 26, and shall be subjected to a surge of 20 kV ±10 % at 10 kA ±10 %. The surge shall be a combination 1.2/50 μs, 8/20 μs voltage/current surge waveform. The polarity of the impulses shall be one positive applied at a phase angle of 90° (+0, -15) and one negative applied at a phase angle of 90° (+0, -15).

54.8 Supply Line (Ring Wave Surge Voltage) Transients

54.8.1 An alarm intended to be powered from commercial AC power shall be subject to supply line transients induced directly between the power supply circuit conductors of the alarm under test.

54.8.2 For this test, the product is to be connected to a transient generator capable of producing the Location Category A3, 100 kHz Ring Wave transient as defined in ANSI/IEEE C62.41, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

54.8.3 Each unit is to be subjected to 500 oscillatory transient pulses induced at an average rate of 3 pulses every minute. Each transient pulse is to be induced 90° into the positive half of the 60 Hz cycle. A total of 250 pulses are to be applied so that the polarity of the transients is positive with reference to earth ground, and the remaining 250 pulses are to be negative with respect to earth ground.

54.8.4 The alarm is to be subjected to 500 oscillatory transient pulses a rate of 6 cycles/min. Each transient pulse is to be induced 90° into the positive half of the 60 Hz cycle.

54.8.5 Following the test the response of the units shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

55 Static Discharge Test

55.1 The components of an alarm shall be shielded so that its operation is not adversely affected when subjected to static electric discharges. The intended performance of an alarm shall not be impaired, or a false alarm obtained, when the alarm is subjected to static electric discharges. Operation of the trouble circuit during this test shall not be considered a malfunction, when the subsequent intended operation is not affected. The test is to be conducted in an ambient temperature of 23 ±3 °C (73.4 ±5 °F) at a relative humidity of 10 ±5 % and a barometric pressure of not less than 700 mm of mercury (193.5 kPa). The alarm is permitted to sound for 5 seconds or less during the test.

55.2 Each of two alarms, is to be mounted on the underside of an 18.1-mm (3/4-in) thick plywood panel in its intended mounting position and connected to a source of supply in accordance with Test Voltages, 26. When an alarm is intended to be installed on a metal back box, the box is to be connected to earth ground. A 250 picofarad low leakage capacitor, rated 10,000 volts DC, is to be connected to two high voltage, hazardous-voltage insulated leads, 0.9 m (3 ft) long, stripped 25.4 mm (1 in) at each end. A 1500 ohm resistor is to be inserted in series with one lead. The end of each lead is to be attached to a 12.7-mm (1/2-in) diameter metal test probe with a spherical end mounted on an insulating rod. The capacitor is to be charged by touching the ends of the test leads to a source of 10,000 volts DC for at least 2 seconds for each discharge. One probe is to be first touched to the alarm and the other probe then touched to earth ground. An electrostatic voltmeter is to be employed to measure the voltage and is to be removed prior to conducting the discharge.

55.3 Ten discharges are to be applied to different points on the exposed surface of the alarm, recharging the capacitors for each discharge. Five discharges are to be made with one lead connected to earth ground and the other lead probed on the alarm surface followed by five discharges with the polarity reversed. For an alarm intended to be serviced by the consumer, ten additional discharges are to be applied on all internal parts that are able to be contacted during servicing. Discharges inside the heat alarm are not to be applied when the alarm is not intended to be serviced in the field and is marked to be returned to the factory for servicing.

55.4 Following the test the response of the units shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

56 Abnormal Operation Test (Electrically-operated Heat Alarms Only)

56.1 An alarm shall operate continuously under abnormal (fault) conditions without resulting in a risk of fire or electric shock.

56.2 To determine that an alarm complies with the requirement of 56.1, it is to be operated under the most severe circuit fault conditions to be encountered in service while connected to a source of supply in accordance with Test Voltages, Section 26. There shall not be emission of flame or molten metal, or any other manifestation of a fire, or dielectric breakdown when tested in accordance with the Dielectric Voltage-Withstand Test, Section 59, after the abnormal test.

56.3 In determining that an alarm complies with the requirement with respect to circuit-fault conditions, the fault condition is to be maintained continuously until constant temperatures are attained, or until burnout occurs, when the fault does not result in the operation of an overload protective device. Shorting of the secondary of the power supply transformer and shorting of a limited-life electrolytic capacitor represents typical fault conditions. The shorting of an electrolytic capacitor(s) and operation in the alarm condition for more than 1 hour represents typical abnormal conditions. See 30.4, Component failure and 67.3, Burnout test.

57 Sensitivity Test Feature

57.1 A sensitivity test feature shall be provided on a heat alarm, to simulate either mechanically or electrically a specified level of heat. The test feature shall be accessible from outside the alarm, with the alarm installed as intended. The maximum permissible measured level shall not exceed 107 °C (225 °F).

57.2 A minimum of two samples shall be subjected to this test. The temperature simulated by the test feature is to be determined by conducting a curve plot of heat versus an instrument (meter) reading, or equivalent.

58 Leakage Current Test (Electrically-operated Heat Alarms Only)

58.1 The leakage current of a heat alarm shall not exceed 0.5 milliampere, AC or DC, after being subjected to 168 h in air having a relative humidity of 93 ±2 % at a temperature of 40 ±2 °C (104 ±4 °F) while energized from a source of supply in accordance with Test Voltages, Section 26, when measured as follows:

a) Between any exposed surface of an alarm that is contacted by a person and earth ground and

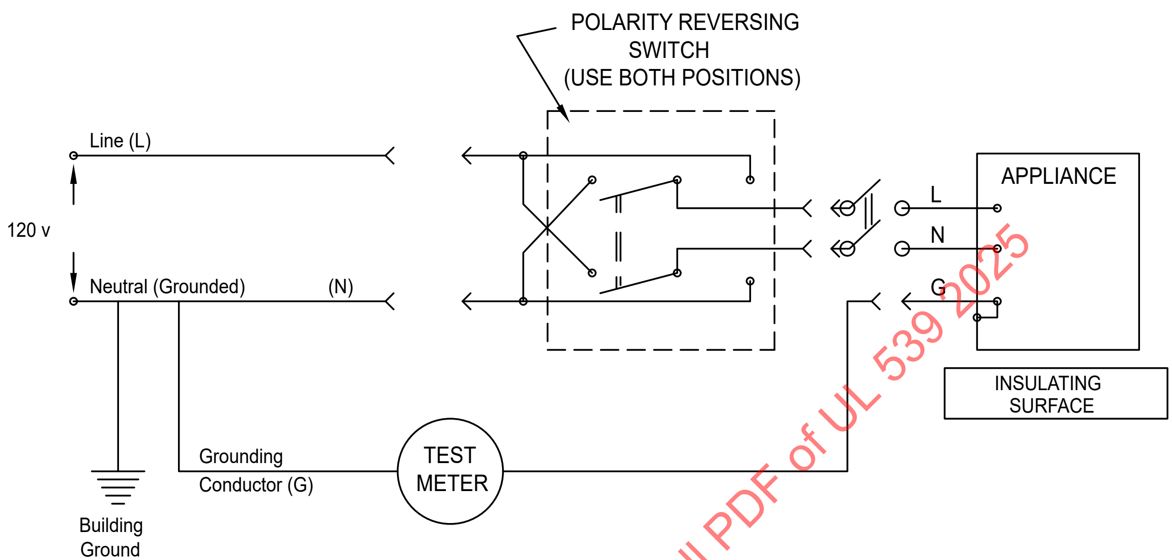
b) Between any interior parts of an alarm that are contacted by a person during servicing and earth ground.

All grounding connections to the unit being tested are to be disconnected prior to making the measurement. The leakage current measurement is to be made at the supply connection polarity indicated on the installation wiring diagram supplied with the alarm and also with the polarity reversed. See Figure 58.1.

Exception: This requirement does not apply to heat alarms operating from a primary battery.

Figure 58.1

Leakage Current Measurement Circuit



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58.2 For this test the alarm is to be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately reenergized from a rated source of supply. The leakage measurement then is to be made within 5 min of energization while in the standby and alarm conditions. The leakage current value is to be rms values for DC (nonfiltered rectified AC) and sinusoidal waveforms up to 1 kilohertz. For frequencies above 1 kilohertz the leakage current limit is to be the value given multiplied by the frequency in kilohertz up to a maximum multiplier of 100.

58.3 The test meter employed to measure the leakage current is to be an average responding AC milliammeter that indicates the rms value of a pure sine wave, having an error of not greater than 5 %, and a maximum input impedance of 1000 ohms. For DC measurements, a DC milliammeter, with a maximum impedance of 1000 ohms in the test circuit, is to be employed.

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

58.5 When an alarm is intended for multiple station connection, leakage currents are to be measured with the maximum number of alarms intended to be interconnected, unless it is established by circuit analysis that the leakage current is independent of interconnection.

59 Dielectric Voltage-Withstand Test (Electrically-operated Heat Alarms Only)

59.1 An alarm shall withstand for 1 min without breakdown, the application of a sinusoidal AC potential of a frequency within the range of 40 – 70 Hz, or a DC potential, between live parts and the enclosure, between live parts and exposed dead-metal parts (see 59.2), and between live parts of circuits operating at different potentials or frequencies (see 59.3). The test potential is to be:

a) For circuits rated 30 V AC rms (42.4 V DC or AC peak) or less – 500 V AC (707 V, when a DC potential is used);

b) For circuits rated greater than 30 and equal to or less than 150 V AC rms (42.4 and 212 VDC) – 1000 V AC (1414 V, when a DC potential is used);

c) For circuits rated more than 150 V AC rms (212 V DC) – 1000 V AC plus twice the rated voltage (1414 V plus 2.828 times the rated AC rms voltage, when a DC potential is used). See 54.4 – 54.6.

59.2 Exposed dead-metal parts are non-current-carrying metal parts that are capable of becoming energized and are accessible from outside of the enclosure of a product.

59.3 For the application of a potential between live parts of circuits operating at different potentials or frequencies, the voltage is to be the applicable value specified in 57.1 (a), (b), or (c), based on the highest voltage of the circuits under test. Electrical connections between the circuits are to be disconnected before the test potential is applied.

59.4 Where the charging current through a capacitor or capacitor-type filter connected across-the-line, or from line-to-earth ground is sufficient to prevent maintenance of the specified AC test potential, the capacitor or filter is to be tested using a DC test potential in accordance with 54.1.

59.5 The test potential shall be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. The method of applying the test voltage is to be such that there are no transient voltages that result in instantaneous voltage being applied to the circuit exceeding 105 % of the peak value of the specified test voltage. The applied potential is to be:

a) Increased from 0 V at a uniform rate so as to arrive at the specified test potential in approximately 5 s; and then

b) Maintained at the test potential for 1 min without an indication of a breakdown.

Manual or automatic control of the rate of rise is not prohibited.

59.6 A printed-wiring assembly or other electronic circuit component that is capable of short-circuiting (or being damaged by) the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly is then to be tested instead of an entire unit.

60 Tests of Thermoplastic Materials

60.1 Accelerated air-oven aging test

60.1.1 There shall not be warping that impairs intended operation or exposes hazardous-voltage uninsulated current-carrying parts when representative samples of a polymeric material are in a circulating-air oven for the number of days associated with the test temperature per the equation below, and at a relative humidity of 0 – 10 %.

$$t_{\text{test-time}} = t_{\text{real-time}} / 2^{(T_{\text{oven}} - T_{\text{installation}})/10}$$

Where

$t_{real\ time}$ = 257 days,

T_{oven} = oven temperature (70 °C minimum)

$T_{installation}$ = maximum installation temperature (as specified by the manufacturer)

For example, for a heat alarm with a maximum installation ambient temperature of 38 °C (100 °F), tested at an oven temperature of 90 °C (194 °F), the calculation below would apply:

$$t_{test\text{-}time} = 257/2^{(90-38)/10}$$
$$t_{test\text{-}time} = 7\ days$$

60.1.2 Three representative samples shall be mounted on supports as intended in service and placed in the oven. Following the aging period indicated in 60.1.1, the samples shall be viewed (while in the oven) for distortion, removed, permitted to cool to room temperature, and then reexamined for compliance with the requirements of 60.1.1. The heat alarm cover shall be allowed to fall off only when hazardous-voltage parts are not exposed, operation for heat detection is not affected, and the cover is able to be replaced as intended.

60.2 Flame test 19 mm (3/4 in)

60.2.1 When equipment is tested as described in 60.2.2 – 60.2.6, the material shall not flame for more than 1 min after two 30-second applications of a test flame, with an interval of 1 min between applications of the flame. The sample shall not be completely consumed.

Exception: Parts that are molded from materials that are classed as 5VA, 5VB, V-0, V-2 are not required to be subjected to the flammability test described in 60.2.2 – 60.2.6.

60.2.2 Three samples of the equipment are to be placed in a forced draft circulating air oven maintained at a uniform temperature not less than 10 °C (18 °F) higher than the maximum temperature of the material measured under normal operating conditions, and not less than 70 °C (158 °F) in any case. The samples are to remain in the oven for 7 days. After cooling to room temperature for a minimum of 4 h, the samples are to be tested as described in 60.2.3 – 60.2.6.

Exception: It is permissible that the test be conducted on only three unconditioned test samples when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

60.2.3 Three samples of the part are to be subjected to the flame test described in 60.2.5. In the performance of the test, the equipment is to be supported in its normal operating position in a draft free location. Nonpolymeric portions are not to be removed and insofar as possible, the internal mechanism of the equipment is to be in place. The flame is to be applied to an inside surface of the sample at a location judged ignitable because of its proximity to a source of ignition. Each sample is to be tested with the flame applied to a different location.

Exception: It is permissible that the test be conducted on only three unconditioned test samples when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

60.2.4 With reference to 60.2.3, the sections judged capable of becoming ignited are to be those adjacent to coil windings, splices, open-type switches, or arcing parts.

60.2.5 The flame of a Bunsen or Tirrill burner having a tube with a length of 100 ±10 mm (3.94 ±0.39 in) and an inside diameter of 9.5 ±0.3 mm (0.374 ±0.12 in) is to be adjusted to have a 19 mm (3/4 in) height of yellow flame with no blue cone. Two 30 second applications of the tip of the flame are to be made to each section of the equipment specified as indicated above, with 1 min intervals between the applications. A supply of technical-grade methane gas is to be used with a regulator and meter for uniform gas flow.

Exception: Natural gas having a heat content of 37 MJ/m^3 (1000 Btu/ft^3) at 23 °C has been found to provide similar results and is appropriate for use.

60.2.6 When one sample from a set of three does not comply with 60.2.3, an additional set of three samples shall be tested. All samples from the second set shall comply with 60.2.1.

60.3 Flame test 127 mm (5 in)

60.3.1 When equipment is tested as described in 60.3.2 – 60.3.6, all of the following results shall be obtained:

a) The material shall not continue to burn for more than 1 min after the fifth 5-second application of the test flame, with an interval of 5 s between applications of the flame;

b) Flaming drops, or flaming or glowing particles that ignite surgical cotton 305 mm (12 in) below the test specimen, shall not be emitted by the test sample at any time during the test; and

c) The material shall not be destroyed in the area of the test flame to such an extent that the integrity of the part is affected with regard to containment of fire or exposure of high voltage parts.

60.3.2 Three samples of the complete equipment or three test specimens of the molded part shall be subjected to this test. Consideration is to be given to leaving in place components and other parts that influence the performance. The test samples are to be conditioned in a full draft circulating air oven for 7 days at 10 °C (18 °F) greater than the maximum use temperature and not less than 70 °C (158 °F) in any case. Prior to testing, the samples are to be conditioned for a minimum of 40 h at 23.0 ±2.0 °C (73.4 ±4 °F) and 50 ±5 % relative humidity. The flame is to be applied to an inside surface of the sample at a location judged to be ignitable because of its proximity to a source of ignition. When more than one part is near a source of ignition, each sample is to be tested with the flame applied to a different location.

Exception: The test be shall be conducted on only three unconditioned test samples only when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

60.3.3 The three samples shall perform as described in 60.3.1. When one sample does not comply, the test is to be repeated on a set of three new samples with the flame applied under the same conditions as for the unsuccessful sample. All the new specimens shall comply with 60.3.1.

60.3.4 The Bunsen or Tirrill burner with a tube length of 100 ±10 mm (3.94 ±0.39 in), and an inside diameter of 9.5 ±0.3 mm (0.374 ±0.12 in), is to be placed remote from the specimen, ignited, and adjusted so that when the burner flame is 127 mm (5 in), the height of the inner blue cone is 38 mm (1-1/2 in). The tube is not to be equipped with end attachments, such as a stabilizer.

60.3.5 When a complete enclosure is used to conduct the flame test, the sample is to be mounted as intended in service, as long as it does not impair the flame testing, in a draft-free test chamber, enclosure, or laboratory hood. A layer of surgical cotton is to be located 305 mm (12 in) below the point of application of the test flame. The 127 mm (5 in) flame is to be applied to any portion of the interior of the part judged as capable of being ignited (by its proximity to live or arcing parts, coils, wiring, or other possible sources of ignition) at an angle of 20 degrees from the vertical so that the tip of the blue cone touches the specimen. The test flame is to be applied to three different locations on each of the three samples tested. A supply of technical-grade methane gas is to be used with a regulator and meter for uniform gas flow.

Exception No. 1: It is permissible that the flame be applied to the outside of an enclosure when the equipment is of the encapsulated type or of such size that the flame cannot be applied inside.

Exception No. 2: Natural gas having a heat content of 37 MJ/m^3 (1000 Btu/ft^3) at 23 °C has been found to provide similar results and is appropriate for use.

60.3.6 The flame is to be applied for 5 s and removed for 5 s. The operation is to be repeated until the specimen has been subjected to five applications of the test flame.

61 Overload Test (Electrically-operated Heat Alarms Only)

61.1 Alarm

61.1.1 A heat alarm shall be capable of operating as intended after being subjected to 50 cycles of alarm signal operation at a rate of not more than 6 cycles per minute with the supply circuit to the alarm at 115 % of the rated test voltage. Each cycle shall consist of starting with the alarm energized in the standby condition, initiation of an alarm by heat or equivalent means, and restoration of the alarm to standby.

Exception: This requirement does not apply to alarms operated from a primary battery.

61.1.2 Rated test loads are to be connected to those output circuits of the alarm which are energized from the alarm power supply, such as remote indicators, relays, and other devices. The test loads shall be those devices, or the equivalent, normally intended for connection. When an equivalent load is employed for a device consisting of an inductive load, a power factor of 60 % is to be employed. The rated loads are established initially with the alarm connected to a source of supply in accordance with Test Voltages, Section 26, following which the voltage is increased to 115 % of rating.

61.1.3 For direct current rated signaling circuits, an equivalent inductive test load is to have the required DC resistance for the test current and the inductance (calibrated) to obtain a power factor of 60 % when connected to a 60 hertz AC potential equal to the rated DC test voltage. When the inductive load has both the required DC resistance and the required inductance, the current equals 0.6 times the current measured with the load connected to a DC circuit when the voltage of each circuit is the same.

61.2 Separately energized circuits

61.2.1 Separately energized circuits of an alarm, such as dry contacts, shall be capable of operating as intended after being subjected for 50 cycles of signal operation at a rate of not more than 6 cycles per minute while connected to a source of supply in accordance with Test Voltages, Section 26, with 150 % rated loads at 60 % power factor applied to output circuits which do not receive energy from the alarm. There shall be no electrical or mechanical failure of the switching circuit.

61.2.2 The test loads shall be set at 150 % of rated current while connected to a separate power source of supply in accordance with Test Voltages, Section 26.

62 Endurance Test

62.1 Mechanically-operated alarms

62.1.1 There shall not be mechanical malfunction of a spring wound-type heat alarm and the unit shall operate as intended and comply with the requirements of the Oven Test, Section 29, following 100 cycles of operation at a rate of not less than once per hour.

62.1.2 Two samples of the low or ordinary degree rating shall be subjected to this test. Each cycle shall consist of a complete rundown and rewinding operation. Following the 100 cycles, the units shall be subjected to the Oven Test, Section 29.

62.2 Electrically-operated alarms

62.2.1 An alarm shall operate as intended after being subjected to 6000 cycles of 5 second alarm signal operation, at a rate of not more than 10 cycles per minute, with the alarm connected to a source of supply in accordance with Test Voltages, Section 26, and with related devices or equivalent loads connected to the output circuits. There shall not be electrical or mechanical failure or evidence of failure of the alarm components. It is appropriate for battery operated units to be connected to an equivalent filtered DC power supply source for this test.

62.2.2 The response of the unit shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

62.3 Separately energized circuits

62.3.1 Separately energized circuits of an alarm shall operate as intended, when operated for 6000 cycles at a rate of not more than 10 cycles per minute at a 50 % duty cycle. When an electrical load is involved, the contacts of the device shall be made to make and break the normal current at the voltage specified by Test Voltages, Section 26. The load is to represent that which the device is intended to control. The Endurance Tests of the separately energized circuits shall be conducted either separately or in conjunction with the Endurance Tests of the alarm. There shall not be electrical or mechanical malfunction of the alarm nor malfunction or welding of any relay contacts.

Exception: When the contact rating is at least twice that of the load controlled, this test is not required.

62.4 Audible signaling appliance

62.4.1 The audible signaling appliance of each of two alarms shall operate as intended when the alarms are operated for 8 h of alternate 5-min periods of energization and de-energization in the standby and alarm conditions, followed by 72 h of continuous energization in an alarm condition. For this test, the alarms are to be connected to a source of rated voltage and frequency. For a battery-operated alarm, a filtered DC supply is to be employed that has an output voltage equivalent to the fresh battery voltage.

62.5 Test means

62.5.1 A test means provided on an alarm shall operate as intended after being operated for 1500 cycles at the rate of not more than 10 cycles per minute. The time of actuation of a test means is to be long enough to obtain at least 1 second of alarm. For this test one alarm is to be connected to a rated source of supply voltage and frequency. This test is to be conducted either separately or in conjunction with the Endurance Tests of the alarm.

63 Polarity Reversal Test

63.1 A heat alarm shall operate as intended after being connected in each polarity. While energized under either polarity, the alarm shall comply with the requirements of the Electric Shock Current Test, Section 64. This includes high-voltage cord connected and fixed wiring (splice lead) types, battery types (main or standby), and multiple station interconnection leads. Each polarity is to be applied for at least 24 h on all units unless a trouble signal or alarm signal is obtained. For battery operated alarms intended to be connected by a polarized clip assembly the reverse polarity is to be applied for a minimum of 1 second. A trouble or alarm signal is to be permitted under any incorrect polarity applied. A maximum 1-second alarm is permitted when the correct polarity is connected.

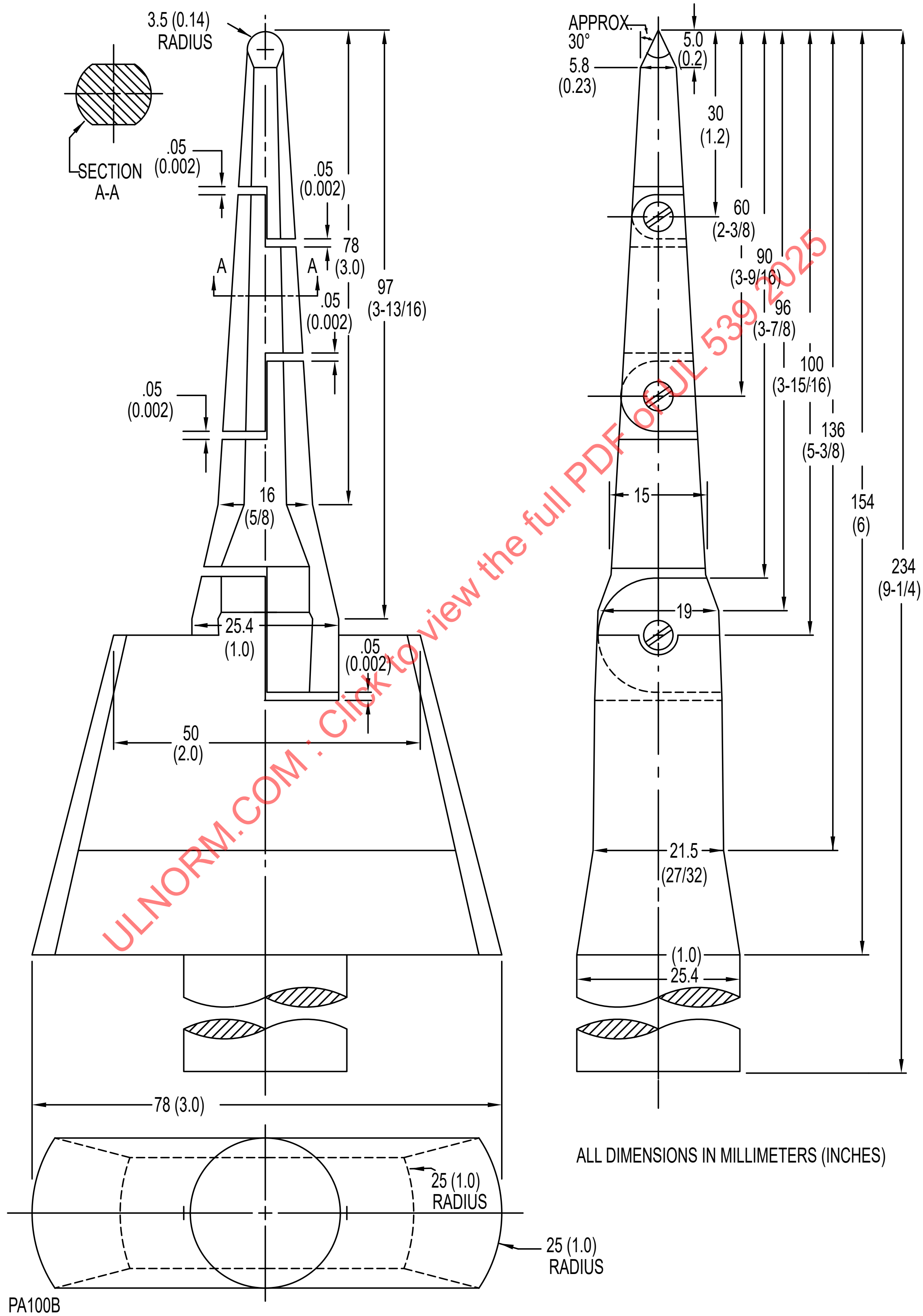
63.2 Two samples are to be subjected to this test. Following the test, the response of the unit shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, the Rate-of-Rise Operation Test, Section 33, or both (as applicable), on as-received samples.

64 Electric Shock Current Test

64.1 If the open circuit potential, between any part that may be contacted by the probe shown in Figure 64.1 either during normal operation or during operator servicing (servicing as defined in the operating or installation instruction) and either earth ground or any other exposed accessible part, exceeds 42.4 volts peak, the part shall comply with the requirements of 64.2 and 64.4.

Figure 64.1

Articulated Probe



64.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 64.1 when the resistor is connected between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part.

Table 64.1
Maximum Current During Operator Servicing

Frequency, hertz[a]	Maximum current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000	19.6
5000	22.0
6000	25.1
7000 or more	27.5

[a] Linear interpolation between adjacent values may be used to determine the maximum allowable current corresponding to frequencies not shown. The table applies to repetitive nonsinusoidal or sinusoidal waveforms.

64.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 64.2 shall not exceed the following:

a) The value determined by the following equation:

$$T \leq \left(\frac{20\sqrt{2}}{I} \right)^{1.43}$$

in which:

T is the interval, in seconds, between the time that the instantaneous value of the current first exceeds 7.1 milliamperes and the time that the current falls below 7.1 milliamperes for the last time;

I is the peak current in milliamperes; and

b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 s if the current is repetitive. Typical calculated values of maximum acceptable transient current duration are shown in Table 64.2.

Table 64.2
Maximum Transient Current Duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak, seconds
7.1	7.22
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	0.919
40.0	0.609
50.0	0.443
60.0	0.341
70.0	0.274
80.0	0.226
90.0	0.191
100.0	0.164
150.0	0.092
200.0	0.061
250.0	0.044
300.0	0.034
350.0	0.027
400.0	0.023
450.0	0.019
500.0	0.016
600.0	0.013
700.0	0.010
809.0	0.0083

64.4 The maximum capacitance between the terminals of a capacitor that is accessible during operator servicing shall comply with the following equations:

$$C = \frac{88{,}400}{E^{1.43}\,(\ln E - 1.26)} \quad for\ 42.4 \leq E \leq 400$$

$$C = 35{,}288E^{-1.5364} \quad for\ 400 \leq E \leq 1000$$

in which:

C is the maximum capacitance of the capacitor in microfarads and

E is the potential in volts across the capacitor prior to discharge; E is to be measured 5 s after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or the like.

Typical calculated values of maximum capacitance are shown in Table 64.3.

Table 64.3
Electric Shock – Stored Energy

Potential across capacitance prior to discharge, volts	Maximum capacitance, microfarads
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.7
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.00
45	150.00
42.4	169.00

64.5 With reference to the requirements in 64.2 and 64.3, the current is to be measured while the resistor is connected between ground and each accessible part individually or all accessible parts collectively if the parts are simultaneously accessible. The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, if the parts are simultaneously accessible.

64.6 With reference to the requirements in 64.5, parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is to be considered to be able to contact parts simultaneously if the parts are within a 102- by 203-mm (4- by 8-in) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 1.83 m (6 ft) apart.

64.7 Electric shock current refers to all currents, including capacitively coupled currents.

64.8 If the product has a direct-current rating, measurements are to be made with the product connected in turn to each side of a 3-wire, direct current supply circuit.

64.9 Current measurements are to be made with any operating control, or adjustable control that is subject to user operation, in all operating positions, and either with or without a vacuum tube, separable connector, or similar component in place. These measurements are to be made with controls placed in the position that causes maximum current flow.

65 Strain Relief Test

65.1 General

65.1.1 A cord or lead that relies upon a thermoplastic enclosure or part for strain relief is to be subjected to the applicable tests specified in 65.2.1 – 65.3.1 following exposure to the temperature conditioning test described in 60.1 and 60.2.

65.2 Power-supply cord

65.2.1 When tested in accordance with 65.3.3, the strain relief means provided on the flexible cord shall withstand for 1 min, without displacement, a pull of 156 N (35 lbf) applied to the cord with the connections within the alarm disconnected.

65.2.2 A 15.9 kg (35 lb) weight is to be suspended on the cord and supported by the alarm so that the strain relief means are stressed from any angle that the construction of the alarm permits. The strain relief does not comply when, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress has resulted on the connections.

65.3 Special field-wiring terminals

65.3.1 To determine suitability as a field-wiring connection in compliance with 21.4, (special field wiring connections) representative samples shall comply with all of the tests specified in 65.2 and 65.3.

65.3.2 A terminal connection shall withstand the application of a straight pull of 22.2 N (5 lbf), applied for 1 min to the wire in the direction which would most likely result in pullout, without separating from the terminal.

65.3.3 Six samples of the terminal are to be connected to the wire sizes with which they are intended to be used, in accordance with the manufacturer's published instructions. When a special tool is required to assemble the connection, it is to be used. Each sample is to be subjected to a gradually increasing pull on the wire until the test pull of 22.2 N (5 lbf) is reached and maintained at 22.2 N (5 lbf) for 1 min.

65.4 Field-wiring leads

65.4.1 Each lead employed for field connections, including a battery clip lead assembly, shall withstand for 1 min a pull of 44.5 N (10 lbf) without any evidence of damage or of transmittal of stress to internal connections. A connector used in the lead assembly shall withstand a pull 22.3 N (5 lbf) without any evidence of damage, transmittal of stress to internal connections, or separation.

66 Battery Tests

66.1 Where a replaceable battery is employed as the main source of power for a heat alarm, it shall provide power to the unit under intended ambient conditions for at least 1 year (or whatever longer period specified by the manufacturer) in the standby condition, including novelty and weekly alarm testing, and then operate the alarm for a minimum of 4 min of alarm, followed by 7 days of trouble signal. See 28.3.1 (Battery powered primary or secondary units). Where a nonreplaceable battery is employed as the main source of power, it shall provide power to the unit under intended ambient conditions for at least 10 years in the standby condition, including novelty and weekly testing, and then operate the alarm for a minimum of 4 min of alarm, followed by 7 days of trouble signal.

66.2 Six samples of the battery, or sets of batteries when more than one is used for primary power, are to be tested under each of the following ambient conditions for a minimum of 1 year (longer time period if specified by the manufacturer, or 10 years if powering an alarm where the battery is not intended to be replaced) while connected to the heat alarm or a simulated load to which the battery is to supply power.

a) A room ambient temperature of 23 ±3 °C (73.4 ±5 °F), 30 – 50 % relative humidity, 760 mm Hg.

b) High temperature = (T_{HI} – 38 °C) + 45 °C or (T_{HI} – 100 °F) + 113 °F;

c) Low Temperature = 0 °C (32 °F) or for rated T_{LO} less than 0 °C (32 °F), T_{LO} shall be the manufacturers rated temperature. The Low temperature shall not be greater than 0 °C (32 °F).

d) Temperature = (T_{HI} – 38 °C) + 30 °C or (T_{HI} – 100 °F) + 86 °F, and 85 ±5 % relative humidity.

Where T_{LO} and T_{HI} are the respective low and high end operating temperatures.

66.3 For the test, either alarm samples or test loads simulating a maximum standby current drain are to be employed. The alarm load is to be the audible appliance intended to be used in the heat alarm or an appropriate load simulating maximum alarm conditions. The batteries are to be tested in the mounting clips employed in the alarm.

66.4 Terminals or jacks are to be provided on each test means to facilitate measurement of battery voltage, standby, and alarm currents. The measuring means is to be separated from the battery test means by a wiring harness or equivalent at least 0.9 m (3 ft) long.

66.5 Prior to placing the battery test setups in the various ambient conditions, each battery is to be subjected to 25 cycles of alarm representing novelty testing. Each cycle is to consist of 5 s of alarm and at least 5 min between each application.

66.6 During the course of the test, the battery voltage and current in standby and alarm condition are to be recorded periodically. The alarm voltage is to be recorded 3 s after energization. The standby voltage and current are to be recorded prior to the alarm measurements. The heat alarm is to be placed into an alarm condition weekly. The duration of the weekly alarm test signal is to be 3 s.

66.7 At the end of the specified 1-year test period, all batteries shall have a capacity capable of operating the alarm signal for a minimum of 4 min, followed by 7 days of trouble signal. To obtain the trouble signal level it is sometimes required to continue the test with the standby current drain for longer than 1 year. Batteries shall be subjected to the conditions described in 64.2 (b) – (d) for a minimum of 1 year unless the alarm is marked to indicate the battery limitations for the condition involved. In no case shall the length of conditioning be less than 6 months.

67 Power Supply Tests

67.1 General

67.1.1 When a separate power supply is used to provide energy to one or more alarms, it is to be subjected to the tests in 67.2 – 67.3.

67.2 Volt-amperes capacity

67.2.1 The volt-amperes capacity of the output circuit of a power supply that is separate from the alarms shall not be more than 100 volt-amperes and not more than 30 volts rms, 60 hertz or 42.4 volts peak or DC.

67.2.2 To determine compliance with the requirements of 67.2.1, a variable resistive load is to be connected to the output circuit of the power supply. With the power supply connected to a rated source of supply, the load is to be varied between open circuit to short circuit in an elapsed time of no less than 1-1/2 nor more than 2-1/2 min. Voltage and current measurements are to be recorded for each value and the maximum VA is to be calculated. When an overcurrent protective device is provided, it shall be shunted out during the test, when required.

67.3 Burnout test

67.3.1 There shall be no damage to the enclosure, charring or burning of the cheesecloth, nor emission of flame or molten metal when a power supply is operated under the conditions described in 67.3.2. While still in a heated condition following this test, the power supply shall comply with the requirements of the Leakage Current Test, Section 56, and the Dielectric Voltage-Withstand Test, Section 59.

67.3.2 With the output shorted, the supply circuit of the power supply is to be connected to a rated source of voltage and frequency, with the enclosure grounded, and operated for at least 7 h or until burnout occurs. A single layer of mercerized cotton cheesecloth is to be loosely draped over the device during the test. When accessible fuses are provided on the power supply, they are to be shunted out, and inaccessible fuses are to remain in the circuit.

68 Conformal Coatings on Printed-Wiring Boards

68.1 General

68.1.1 Conformal coatings are for use only on printed wiring boards where the acceptability of the combination has been investigated for flammability in accordance with:

a) In Canada: CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials, and the dielectric property after environmental, humidity, and thermal conditioning in accordance with CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials.

b) In the United States: The Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and the dielectric property after environmental, humidity, and thermal conditioning in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E.

68.2 Low voltage printed-wiring boards

68.2.1 The following test program is to be utilized to determine the acceptability of a conformal coating in lieu of full electrical spacings for circuits at potential of 30 volts rms or less.

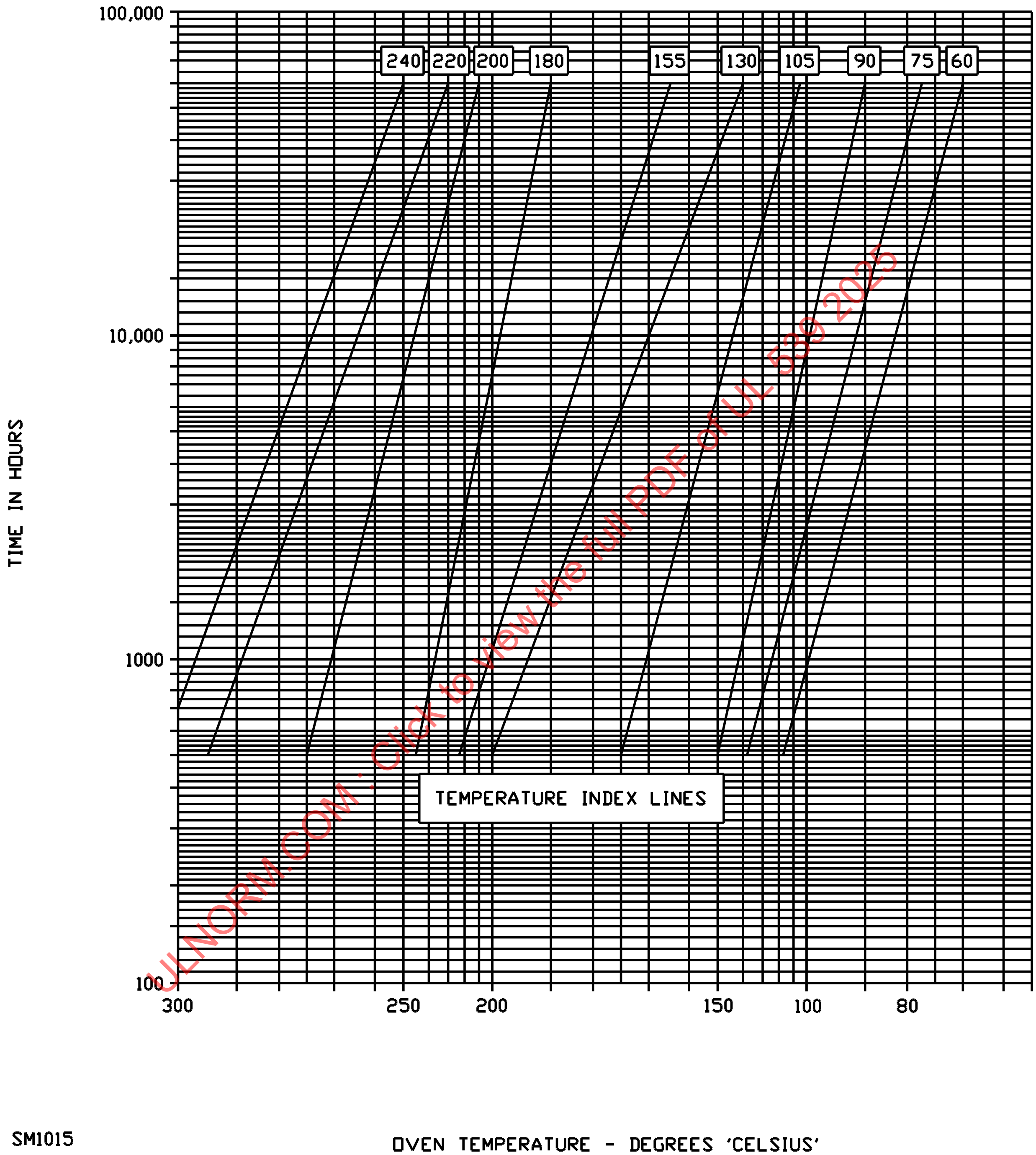
68.2.2 Eight samples of the printed-wiring board without electrical components installed, and coated with the conformal coating, shall be subjected to this test. Test leads are to be attached to the printed-wiring (before the application of the coating) to provide for convenient application of the specified test potential.

68.2.3 Four specimens are to be conditioned to room ambient by exposure to ambient air at a temperature of 23 ±2 °C (73 ±4 °F) and 50 ±5 % relative humidity for not less than 24 h. Following the conditioning, the four samples shall be subjected to the Dielectric Voltage-Withstand Test, Section 59, for the 0 – 30 volt range. There shall not be indication of dielectric breakdown as a result of the test. All specimens shall be smooth, homogeneous, and free of heat deformation such as bubbles and pin holes, as determined by visual examination.

68.2.4 Four samples are to be exposed to ambient air at a temperature chosen from the applicable temperature index line shown in Figure 68.1, Aging time versus aging temperature, corresponding to the "in service" operating temperature of the coating. The aging temperature chosen from the index line shall correspond to not less than 1000 h of exposure. However, any value of temperature chosen shall correspond to not less than 300 h of exposure. The samples are then to be subjected to the Dielectric Voltage-Withstand Test, Section 59, for the 0 – 30 volts range. All specimens shall be smooth, homogeneous, and free of defects such as bubbles and pin holes, as determined by visual examination. There shall not be crazing, chipping, or other visual evidence of deterioration or separation of the coating from the board after conditioning. There shall not be indication of a dielectric breakdown.

Figure 68.1

Aging Time Versus Aging Temperature



68.2.5 As a permitted alternative to the use of conformal coating for circuits at a potential of 30 volts rms (42.4 volts DC or AC peak) or less, and less than 100 volt-amperes, four samples of the printed wiring board shall be subjected to the following tests. The samples shall be conditioned for 168 h in air having a relative humidity of 93 ±2 % at a temperature of 40 ±2 °C (104 ±4 °F). Following the conditioning, the four samples shall be subjected to the Dielectric Voltage-Withstand Test, Section 59, for the 0 – 30 volts range. There shall not be indication of dielectric breakdown as a result of the test.

68.3 High voltage printed-wiring boards

68.3.1 The following test program is to be utilized to determine the acceptability of a conformal coating in lieu of full electrical spacing for circuits at potential greater than 30 volts rms. The test shall be performed between tracks on the printed-wiring board. The coating shall not be less than 0.2 mm (0.008 in) thick.

68.3.2 Three samples of the printed-wiring board without electrical components installed, and coated with the conformal coating, shall be subjected to this test. Test leads are to be attached to the printed wiring board (prior to the application of the coating) for convenient application of the specified test potential. Each sample shall be subjected to a 5,000 volt AC dielectric voltage-withstand test potential for 1 min.

a) A 7 day heating-cooling cycling period, each cycle consisting of 4h "on" at 105 °C (189 °F) followed by 4h "off" at 25 °C (77 °F);

b) A 7 day oven conditioning period of 100 °C (212 °F);

c) A 7 day oven conditioning period at 85 % relative humidity at 65 °C (149 °F); and

d) A dielectric voltage-withstand test potential at 2,500 volts AC repeated 10 times.

There shall not be peeling or other deterioration of the coating material as a result of the conditioning.

68.3.3 A sample of the coated printed-wiring board, equipped with test leads, without electrical components installed, shall be subjected to this test. The sample shall be subjected to an atmosphere having a relative humidity of 93 ±2 % at a temperature of 32 ±2 °C (89° ±4 °F) for a period of 24 h, followed by a 500 volt dielectric voltage-withstand test with the sample maintained in the conditioning atmosphere. There shall not be indication of a dielectric breakdown.

69 Evaluation of Reduced Spacings on Printed-Wiring Boards

69.1 In accordance with the exception of 24.1.1, printed-wiring board traces of different potential having reduced spacings shall comply with:

a) The dielectric voltage-withstand test described in 69.2 and 69.3; or

b) The shorted trace test described in 69.4 and 69.5.

69.2 A printed-wiring board, as specified in 69.1 (a), shall withstand for 1 min without breakdown the application of a dielectric withstand potential between the traces having reduced spacings, in accordance with 59.1, as appropriate.

69.3 Power-dissipating component parts, electronic devices, and capacitors connected between traces having reduced spacings, are to be removed or disconnected so that the spacings and insulations, rather than these component parts, are subjected to the full dielectric voltage-withstand test potential.

69.4 Printed-wiring board traces, as specified in 69.1 (b), are to be short-circuited, one location at a time, and the test is to be conducted as described in 69.1. As a result of this test:

a) The overcurrent protection associated with the branch circuit to the unit shall not open; and

b) A wire shall not open.

When the circuit is interrupted by opening of a component, the test is to be repeated twice, using new components when required. When a printed wiring board trace opens, the gap is to be electrically shorted and the test continued until ultimate results occur, and the procedure is to be repeated for each occurrence of a trace opening.

Exception: After opening of an internal overcurrent protective device, the test is not required to be repeated.

69.5 The test of 69.4 is to be continued for 1 h or until one of the conditions described below occurs. When, at the end of 1 h, no condition described below has occurred, and it is indicated that such a condition is imminent, the test is to be continued until ultimate results are obtained (usually 7 h).

a) Ignition or charring of the cheesecloth indicator (charring is deemed to have occurred when the structural integrity of the threads has been destroyed due to the temperature rise; or

b) Fuse from the enclosure to ground opens.

69.6 Immediately following each fault described in 69.4, within one min of the conclusion of the test, the product shall be subjected to the Dielectric Voltage Withstand Test, Section 59.

70 Heat Alarms for Use in Unconditioned Areas

70.1 General

70.1.1 A heat alarm intended for use in unconditioned areas such as garages and attics shall comply with the requirements specified in Sections 70.2 – 70.5 in addition to the requirements specified in all other sections of this standard unless specifically noted.

70.2 Marking

70.2.1 In addition to the applicable requirements in Section 72, Markings, a heat alarm for use in unconditioned areas shall be permanently and legibly marked with the following additional information and shall be readily visible after installation:

a) Reference to manufacturer’s published instructions;

b) The type of product, such as,

1) In Canada: « Alarme de Chaleur Pour Zone Inconditionnée » or equivalent. It is not prohibited that this marking be incorporated with (c); or

2) In the United States: “Unconditioned Area Heat Alarm”

c) Identification of switches, lights and indicators

70.3 Temperature and Humidity Tests

70.3.1 Two heat alarms shall operate as specified in the following tests:

a) Two heat alarms are to be conditioned as specified in the Low Temperature Exposure test, see Section 40; the samples are to be conditioned for at least 72 h at minus 40 ±2 °C (minus 40 ±4 °F), and

b) Two heat alarms are to be conditioned for ten days in 93 ±2 % humidity at 60 ±2 °C (140 ±4 °F) as specified in the Humidity Test, Section 34.

70.3.2 The sensitivity of fixed-temperature heat alarms, after they are subjected to Unconditioned Space temperature environments, shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, on as-received samples. No false alarm or operation shall occur following the exposure. The sensitivity of heat alarm operating on the rate-of-rise principle, shall not show a variation of more than 50 % from the value obtained in the Rate-of-Rise Operation Test, Section 33, on as-received samples. No false operation shall occur during the temperature and humidity conditioning as specified in 70.3.1.

70.3.3 During each test condition, the alarm is to be connected to a source of rated voltage. Battery operated alarms shall be powered by a battery installed in the alarm that meets or exceeds 70.3.4 during each test condition. The tests in 70.3.1 may be conducted sequentially on the same two samples or on individual alarms as recommended by the mfg. In addition, fresh batteries may be used for each environmental condition specified in 70.3.1 but the tests shall be conducted using each battery model specified in the marking or the installation instructions.

70.3.4 All batteries included with the heat alarm for use in Unconditioned Areas, shall at a minimum have a published operational specification range no greater than minus 20 °C and not less than 60 °C (no greater than minus 4 °F and no less than 140 °F).

70.3.5 Primary and recommended replacement batteries shall identify the maximum and minimum temperature range as specified in Section 66.

70.3.6 Batteries shall be tested in accordance with all applicable battery tests outlined within this standard and the operating range specified for the battery noted in 70.3.4 in accordance with the method specified in the Battery Tests, Section 66.

70.4 Corrosion (Salt Spray) Test

70.4.1 An alarm shall operate as intended and shall not false alarm after exposure for 48 h to a salt spray in accordance with the procedure specified in the Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117.

70.4.2 Two alarms, one at maximum and one at minimum sensitivity, are to be subjected to the salt spray while in a de-energized condition. Following the exposure, the samples are to be removed, dried for at least 24 h in an air circulating oven or air dried for at least 48 h.

70.4.3 Following the Salt Spray Test, sensitivity of fixed-temperature heat alarms shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, on as-received samples. No false alarm or operation shall occur following the exposure. The sensitivity of heat alarm operating on the rate-of-rise principle, after they are subjected to corrosive atmospheres, shall not show a variation of more than 50 % from the value obtained in the Rate-of-Rise Operation Test, Section 33, on as-received samples.

70.5 Vibration Test

70.5.1 After vibration in accordance with 70.5.2, a heat alarm shall not false alarm or be adversely damaged.

70.5.2 Two alarms are to be subjected to vibration test outlined in Vibration Test, Section 38 for 4 h.

70.5.3 Following the vibration test, sensitivity of fixed-temperature heat alarms shall not show a time variation of more than 50 % from the value obtained in the Oven Test, Section 29, on as-received samples. No false alarm or operation shall occur following the exposure. The sensitivity of heat alarm operating on the rate-of-rise principle, shall not show a variation of more than 50 % from the value obtained in the Rate-of-Rise Operation Test, Section 33, on as-received samples.

71 Manufacturing and Production Tests

71.1 General

71.1.1 To verify compliance with these requirements in production, the manufacturer is to provide the necessary production control, inspection, and tests. The program is to include the Production Line Dielectric Voltage-Withstand Test for High-Voltage Products, 71.2, and the Sensitivity Calibration Tests, 71.3, except that other test arrangements may be considered and employed if determined to achieve the results contemplated. A record of complying heat alarms and the alarm serial number or equivalent is to be maintained.

71.1.2 The sensitivity of a tested heat alarm is to be checked by using the manufacturer's test equipment and calibration procedures to determine that the sensitivity is within the specified production limits

71.2 Production line dielectric voltage-withstand test for high-voltage products

71.2.1 Each heat alarm rated at more than 30 V AC rms (42.4 V DC or AC peak) shall withstand, without breakdown, as a routine production-line test, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 Hz, or a DC potential, between high-voltage live parts and the enclosure, high-voltage live parts and exposed dead metal parts, and live parts of circuits operating at different potentials or frequencies. The test potential is to be:

a) For a heat alarm rated 250 V AC rms or less – either 1000 V (1414 V, if a DC potential is used) applied for 60 s or 1200 V (1697 V, if a DC potential is used) applied for 1 s.

b) For a heat alarm rated more than 250 V – either 1000 V plus twice the rated AC rms voltage (1414 V plus 2.828 times the rated AC rms voltage, if a DC potential is used) applied for 60 s or 120 V plus 2.4 times the rated voltage (1697 V plus 3.394 times the rated AC rms voltage, if a DC potential is used) applied for 1 s.

71.2.2 When there is the possibility of short circuit or damage to a printed-wiring assembly or other electronic-circuit component by application of the test potential, the component is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly may be tested instead of an entire heat alarm.

71.2.3 A 500 VA or larger transformer, the output voltage of which can be varied, is to be used to determine compliance with 71.2.1. The requirement of a 500 VA or larger transformer can be waived if the high potential testing equipment used is such that it maintains the specified voltage at the heat alarm during the test.

71.2.4 The test equipment is to make a visible indication when the test potential is applied and an audible or visible indication, or both, of breakdown. In the event of breakdown, manual reset of an external switch is required, or an automatic reject of the product under test is to result. Other arrangements may be considered and may be used if determined to achieve the results contemplated.

71.3 Sensitivity calibration tests

71.3.1 Rate-of-rise heat alarms

71.3.1.1 Each production heat alarm that operates on the rate-of-rise principle shall be subjected to calibration tests by the manufacturer before shipment to determine that the unit does not operate when the rate of temperature rise is 6.7 °C (12 °F) per minute or less, and until a temperature of at least 54 °C (130 °F) is reached [starting from a temperature of 29.4 – 32.2 °C (85 – 90 °F)].

71.3.1.2 Five samples of rate-of-rise heat alarms are to be tested in the testing oven under various uniform temperature-rise conditions. Typical rates of rise of temperature such as 6.7, 8.3, and 11.1 °C (12, 15, and 20 °F) per minute and the intended (rated) temperature rate of rise are to be employed. Each unit is to remain in the oven ambient at least 5 min prior to a test run.

71.3.2 Fixed-temperature heat alarms

71.3.2.1 Samples of each temperature rating of a fixed-temperature, self-restoring heat alarm shall be subjected to a water bath test, oil bath test, or air oven test by the manufacturer before shipment to determine that the unit:

a) Functions to positively make or break the electrical contacts, depending upon whether it is of the open-circuit or closed-circuit construction and

b) Complies with the tolerance specified in the Operating Temperature Test, Section 37.

71.3.2.2 Samples of each temperature rating of a fixed-temperature, non-restorable (spot-type) heat alarm shall be subjected to a water bath test, oil bath test, or air oven test by the manufacturer to determine that the unit operates within the temperature range specified in the Operating Temperature Test, Section 37.

INSTRUCTIONS

72 General

72.1 Each unit shall be provided with the following manufacturer's published instructions that shall include the following:

a) Typical installation layout for the unit(s), indicating recommended locations and mounting.

b) Descriptive product information:

1) Name and address of manufacturer or private labeler

2) Model number

3) Electrical rating in volts, amperes, or watts, and frequency. Not required for battery-operated alarms

4) Temperature rating of heat alarm, when provided;

5) Test instructions and frequency.

6) Maintenance instructions such as cleaning and lamp and battery replacement.

7) Name and address of firm where the heat alarm is to be sent for servicing.

c) Replacement parts, such as lamps or batteries, shall be identified in the instructions by a part number, manufacturer's model number, or the equivalent, and information included as to where a user is able to obtain the part.

d) Temperature rating of the heat alarm device.

e) Spacing rating

f) The following or equivalent wording: "This unit is required to be installed in conjunction with one or more smoke alarms. Required protection is described in these manufacturer's published instructions provided with this alarm".

g) The following information for a low-degree unit. The minimum letter height shall be 3.2 mm (1/8 in) for the word "CAUTION" and 2.4 mm (3/32 in) for the remainder of the text. The word "CAUTION" shall be used with the following or equivalent text: "To avoid a false alarm, do not use where maximum room temperature will exceed (+)".

(+) Temperature that is 11 °C (20 °F) below rating is to be inserted.

h) Description of the various situations against which the heat alarm may not be effective, for example:

1) Fires where the victim is intimate with a flaming initiated fire; for example, when a person's clothes catch fire while cooking;

2) Fires where the heat is prevented from reaching the heat alarm due to a closed door or other obstruction;

3) Incendiary fires where the fire grows so rapidly that an occupant's egress is blocked even with properly located heat alarms

i) Detailed information on the alarm and trouble signals and an indication where false alarms or trouble signals would be anticipated.

j) Identification of the manufacturer's published instructions by number or equivalent.

k) An indication that the device shall not be installed in locations where the normal ambient temperature is below 4.4 °C (40 °F) or exceeds 46 °C (115 °F), unless the alarm has been determined to be capable of being used at installation points with higher or lower ambient temperatures.

l) Reference to a source(s) of power limited cable for multiple station interconnection or connection of supplementary devices.

m) The manufacturer shall either provide information on an evacuation plan or include a copy of a separate booklet, or equivalent.

n) For multiple station heat alarms, identify the manufacturer and model number of compatible alarms and accessories, such as, but not limited to smoke alarms, heat alarms, carbon monoxide alarms, signaling devices and/or switching modules;

o) For heat alarm-transmitters intended to be installed with compatible audible signal receiver units, instructions shall include the limitations of use in typical single level and multilevel dwelling units as well as in apartment buildings where it is possible that adjacent apartments have similar systems.

p) Note specifying that heat alarms are not to be used with heat alarm guards unless the combination has been evaluated and found suitable for that purpose.

q) For heat alarms powered by a non-replaceable battery, the instructions shall provide a description of the proper use of the battery activation and deactivation features. This information shall specify that each feature is intended for one time use only.

72.2 The instructions may be incorporated on the outside of the unit, on a separate sheet, or as part of a manual. If not included directly on the device the instructions or manual shall be referenced in the marking information on the unit.

72.3 The instructions shall be marked to specify that the resistance of the interconnecting wiring shall be a maximum of 10 ohms, unless otherwise specified by the manufacturer. See 21.9.2. The interconnect wiring to be used shall be in accordance with the provisions of the applicable electrical code:

a) In Canada: C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations.

b) In the United States: Articles 210 and 3003. (B) of the National Electrical Code, NFPA 70.

MARKINGS

NOTE: In Canada, there are two official languages, French and English. Attention is drawn to the fact that some Canadian authorities may require markings to be in both official languages. Reference Annex C for acceptable French translations of the markings specified in this standard.

73 General

73.1 Except as indicated in 73.7, a heat alarm shall be clearly and permanently marked where it will be visible after installation with the following information. Unless the letter height is specified all markings shall be at least 1.2 mm (3/64 in). Removal of a unit from an installed position by removing not more than one screw to view the marking is considered as complying with the requirement regarding visibility after installation. See 73.2.

a) Name or identifying symbol and the address of manufacturer or private labeler.

b) Model number; and serial number or date code, or equivalent.

c) Temperature rating of the fire alarm device.

d) Spacing rating.

e) The statement "Do Not Paint" and/or the symbol indicated below to warn against painting of the temperature sensitive element and the markings. The letters shall be minimum 3.2 mm (1/8 in) high.

The symbol shall be minimum 12.7 mm (1/2 in) diameter.

f) The following or equivalent wording:

"Operation – Responds To A Heat Producing Fire Only. Unit Will Actuate When The Temperature Of The Surrounding Air Reaches The Marked Temperature Rating (Plus Or Minus A Few Degrees) Provided The Air Temperature Increase Is 0.6 °C (1 °F) Per Minute Or Less. At Faster Rates Of Temperature Rise, The Surrounding Air Temperature At Which The Unit Will Actuate Will Be Above The Marked Rating, The Temperature Differential Depending On The Rate Of Rise Of Temperature Produced By A Fire. This Temperature Differential Results From The Time Lag Before The Temperature Element Absorbs The Necessary Heat From The Surrounding Air To Actuate."

g) Name and address of firm where the heat alarm is to be sent for servicing or replacement.

h) For mechanically powered heat alarms, instructions for setting or rewinding of a spring wound heat alarm to be included on the alarm.

i) For mechanically powered heat alarms, identification of the power supervisory feature used on the alarm plus an indication of its function. See Power Supervisory Feature, Section 15.

j) Correct mounting position if a heat alarm is intended to be mounted in a definite position. This information may appear in the installation instructions.

k) Reference to an installation diagram, owner's manual, or both.

l) Operation of a test feature,.

m) The following or equivalent wording: "This unit is required to be installed in conjunction with one or more smoke alarms. For information on required protection refer to manual (or instruction sheet) provided with this alarm."

n) Maintenance Instructions such as cleaning and battery replacement.

o) The following statement on each single and multiple station heat alarm conspicuously tagged or marked to be visible after installation. The word "WARNING " shall be in letters minimum 3.2 mm (1/8 in) high, and the balance of the text shall be in letters at least 1.2 mm (3/64 in) high.

In Canada:

« AVERTISSEUR DE CHALEUR »

« AVERTISSEMENT : DIRECTIVE AU PROPRIÉTAIRE. NE DOIT ÊTRE ENLEVÉ PAR PERSONNE, SAUF PAR L'OCCUPANT. Des informations imprimées décrivant l'installation, le fonctionnement, les essais, l'entretien, la planification de l'évacuation et le service de réparation appropriés doivent être fournies avec cet équipement. »

In the United States:

"HEAT ALARM"

"WARNING: OWNER'S INSTRUCTION NOTICE. NOT TO BE REMOVED BY ANYONE EXCEPT OCCUPANT. This equipment should be installed in accordance with the National Fire Protection Association's Standard 72 (National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269). Printed information describing proper installation, operation, testing, maintenance, evacuation planning, and repair service is to be provided with this equipment."

p) The following marking on the outside of a low-degree unit. The minimum letter height shall be 3.2 mm (1/8 in) for the word "CAUTION" « MISE EN GARDE » and 2.4 mm (3/32 in) for the remainder of the text. The word "CAUTION" « MISE EN GARDE » shall be used with the following or equivalent text: "to avoid a false alarm, do not use where maximum room temperature will exceed (+)."

(+) Temperature that is 11 °C (20 °F) below rating is to be inserted.

q) Electrical rating, in volts, amperes, or watts, and frequency. Not required for battery or mechanically operated alarms.

r) Distinction between alarm and trouble signals on those units employing both.

s) The following or equivalent qualifying statement on a battery-operated alarm where battery operation, under other than normal room temperature conditions during the long term (minimum 1 year) battery tests, is less than 1 year:

"CONSTANT EXPOSURES TO HIGH OR LOW TEMPERATURES OR HIGH HUMIDITY MAY REDUCE BATTERY LIFE"

t) For battery operated alarms employing replaceable batteries, reference to a source for battery replacement. (This information may appear in the user's manual instead.)

u) For a battery operated alarm employing replaceable batteries, the word "WARNING" and the following or equivalent marking shall be included on the unit: "Use Only Batteries Specified In Marking. Use Of A Different Battery Will Have A Detrimental Effect On Heat Alarm Operation." The letter height shall be a minimum of 3.2 mm (1/8 in) for "WARNING" and 1.2 mm (3/64 in) for the rest of the notice.

v) For a heat alarm employing a non-rechargeable standby battery, the marking information described in Secondary Power Supply, 20.2, shall be in letters not less than 1/8 in (3.2 mm) high.

w) Test instructions and frequency for electrically operated alarms. Not less than once per week for battery-powered alarms and not less than once per month for AC or AC with secondary power supply.

x) For a battery operated heat alarm employing a non-replaceable 10-year battery, the words "10 Year Battery. Replace Alarm After __________ " or equivalent marking shall be provided on the unit. The letter height shall be a minimum of 3.2 mm (1/8 in) unless it is in a contrasting color, visible from 1.83 m (6 ft) after the unit has been installed as intended.

y) For a battery-operated heat alarm employing a non-replaceable battery, a statement indicating that the unit is sealed, with no serviceable parts, and that the maintenance and testing specified elsewhere on the marking must be performed.

z) For a battery operated heat alarm employing a non-replaceable battery, a description of how to use the deactivation feature and indication that once deactivated the heat alarm is incapable of being reactivated and must be replaced.

aa) Information required to appear directly on the alarm shall be readily visible after installation. Except for 73.1 (e), the removal or opening of an enclosure cover not requiring a tool, or an equivalent arrangement to view the marking is not prohibited.

bb) Sealed units intended to be returned to the manufacturer for servicing shall be marked as follows on the outside of the alarm: "RETURN TO (+) FOR SERVICING," or equivalent. It is not prohibited for units on which the cover is removable, and that are also intended to be returned to the manufacturer for servicing, to have the marking on the inside of the alarm.

(+) Name and address of manufacturer or supplier.

73.2 With regard to the requirement in 9.3.2, a warning flag, hinged cover as described in Electrically Operated Alarms, Section 9, (inside or outside), or equivalent, shall be marked with the word "WARNING" and the following or equivalent text: "Heat Alarm is Non-Operational." The letter height shall be a minimum of 9.5 mm (3/8 in) unless it is in a contrasting color, visible from 1.83 m (6 ft).

73.3 Heat alarms with replaceable battery warranties exceeding one year shall:

a) Include a disclaimer that indicates that the battery warranty period is not a performance claim or

b) Have the performance claims of the manufacturer verified per Section 64, Battery Tests.