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Heat Detectors for Fire Protective Signaling Systems

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UL Standard for Safety for Heat Detectors for Fire Protective Signaling Systems, UL 521

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This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-6B	October 3, 2002
7-25	February 19, 1999
26-28B	October 3, 2002
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A1-A2	October 3, 2002
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UL 521

Standard for Heat Detectors for Fire Protective Signaling Systems

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover heat detectors for fire protective signaling systems intended to be installed in ordinary indoor and outdoor locations in accordance with the Standard for Automatic Fire Detectors, NFPA 72E.

1.2 Heat detectors covered by these requirements employ either normally open contacts or normally closed contacts, provide an electronic signal, or consist of a heat-sensitive cable. The requirements do not cover heat detectors for journal-alarm or unit-alarm devices.

1.3 Deleted October 3, 2002

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.1.2 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.

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

2.1.4 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.

2.2 Units of measurement

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

2.3 Undated references

2.3.1 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.

3 Glossary

3.1 For the purpose of this standard the following definitions apply. Heat detectors may combine two or more of the following characteristics in one device, such as a fixed-temperature, a spot-type capable of repeated operation, or a rate-of-rise type also employing a fixed-temperature element.

3.2 COMPONENT, LIMITED-LIFE – A component that is expected to fail and be periodically replaced and the failure of which is supervised, if failure of the component affects the intended operation, sensitivity, or both. Typical examples of such components include incandescent lamps, electronic tube heaters, and functional heating elements.

3.3 COMPONENT, RELIABLE – An electrical 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 fewer failures per million hours as determined for a ″Ground Fixed″ (GF) environment by MIL-HDBK 217B, or equivalent (see Supplement SA).

3.4 ELECTRONIC-TYPE HEAT DETECTOR – A device that uses electronic circuitry to respond to an abnormal high temperature or rate of temperature rise.

3.5 FIXED-TEMPERATURE TYPE HEAT DETECTOR – A device that will respond when its operating element becomes heated to a predetermined level. The temperature of the air surrounding the device at the moment of operation will vary, depending on the rate at which the temperature is rising.

3.6 HEAT DETECTOR – A device that detects an abnormal high temperature or rate of temperature rise.

3.7 HEAT-SENSITIVE CABLE – A line-type device whose sensitive element comprises two current-carrying wires held separated by a heat-sensitive insulation that softens at the rated temperature, thus allowing the wires to make electrical contact.

3.8 LINE-TYPE HEAT DETECTOR – A device in which detection is continuous along a path.

3.9 NONRESTORABLE HEAT DETECTOR – A device whose sensing element is intended to be destroyed by the process of detecting a fire.

3.10 RATE-COMPENSATION HEAT DETECTOR – A device that will respond when the temperature of the surrounding air reaches the predetermined level, regardless of the rate of temperature rise.

3.11 RATE-OF-RISE HEAT DETECTOR – A device that will respond when the temperature rises at a rate exceeding a predetermined amount.

3.12 RESTORABLE HEAT DETECTOR – A device whose sensing element is not destroyed during intended service by the processes of detecting a fire. Restoration may be manual or automatic.

3.13 SELF-RESTORING HEAT DETECTOR – A restorable detector whose sensing element is intended to be returned to normal automatically.

3.14 SPOT-TYPE HEAT DETECTOR – A device whose detecting element is concentrated at a particular location.

3.15 TWO-WIRE DETECTOR – A detector that signals over and obtains its power from the initiating device circuit of a fire alarm system control unit. Additional terminals or leads may be provided for annunciation or control of supplementary functions.

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4 Installation and Operating Instructions

4.1 A copy of the installation and operating instructions and related schematic wiring diagrams and installation drawings shall be used as a guide in the examination and test of the detector. For this purpose, a printed edition is not required. The information may be included in a manual or technical bulletin.

4.2 The instructions and drawings shall include such directions and information as deemed by the manufacturer to be necessary for installation, testing, maintenance, operation, and use of the detector.

5 Compatibility Information

5.1 General

5.1.1 Compatibility between a two-wire electronic heat detector that receives its power from the initiating device circuit of a fire alarm system control unit is dependent upon the interaction between the circuit parameters, such as voltage, current, frequency, and impedance, of the detector and the initiating device circuit.

5.1.2 A detector that does not receive its power from the initiating device circuit of a control unit (conventionally a detector having four or more wires for field connection or a heat detector with dry contacts) may be employed with any electrically compatible fire alarm system control unit without the need for compatibility consideration as its connection does not impose any load on the initiating circuit. Under an alarm condition, the four-wire detector acts as a switch (similar to a manual station) to place the system in alarm.

5.1.3 As a two-wire detector obtains its power from the initiating device circuit of a system control unit, its operation is dependent on the characteristics of the circuit to which it is connected as the detector imposes a resistive and capacitive load on the circuit. Similarly, the load imposed upon the initiating circuit by a connected detector must not prevent alarm response by a control unit to a detector in alarm, nor prevent a trouble response to an open circuit after the last detector.

5.1.4 The connection of a two-wire electronic heat detector is restricted to the specific control units with which a compatibility evaluation has been made.

5.1.5 A supplementary signaling device [such as an audible appliance, relay, or annunciator lamp (LED)] that is integral with a two-wire heat detector and that is also powered from an initiating device circuit of a fire alarm system control unit shall not be used if its operation, including level of audibility and light output, is inhibited by the operation limitation of the initiating device circuit.

5.2 Method of evaluation

5.2.1 In accordance with 5.1.1 – 5.1.5, to determine whether any combination of control unit and electronic heat detector or detectors is compatible, whether the detectors are the same model or a mixture of one or more models or types, the tests indicated in (a) and (b) are to be conducted:

a) The Dynamic Load Immunity Test, Section 41.

b) The Two-Wire Smoke Detector Compatibility Tests in the Standard for Control Units for Fire-Protective Signaling Systems, UL 864.

For the test in (b), a load representing the maximum number of detectors intended to be connected to the control unit initiating device circuit, whether one model or a mixture of several models, is to be employed.

5.3 Changes affecting compatibility

5.3.1 To maintain compatibility integrity after installation of a compatible combination that can be affected by replacement detectors or a modification of either the detectors or the control unit, the product that is changed shall be assigned a different model number, or change in compatibility identification marking.

5.3.2 A compatibility identifier marking consists of any six-digit or less alphanumeric combination, such as a date code, part number, model number, or the like used to identify the latest revision that has not resulted in a new model number, but that impacts compatibility.

6 Temperature Designation

6.1 Heat detectors of the fixed-temperature spot type are designated according to temperature of operation as indicated in Table 6.1.

Table 6.1
Temperature rating

Temperature rating	Temperature rating range, °F	(°C)
Low	100 – 134	37.8 – 56.7
Ordinary	135 – 174	57.2 – 78.9
Intermediate	175 – 249	79.4 – 120.6
High	250 – 324	121 – 162.2
Extra High	325 – 399	163 – 203.8
Very Extra High	400 – 499	204 – 259.4
Ultra High	500 – 575	260 – 302

6.2 Low-degree rated heat detectors apply only to self-restoring type detectors. Low-degree heat detectors are intended only for installation in controlled ambient conditions, such as in a computer room.

CONSTRUCTION

GENERAL

7 Mounting

7.1 A heat detector shall be provided with means for mounting.

7.2 The mounting means shall be electrically insulated from current-carrying parts of the device.

7.3 The intended means of mounting shall not result in any distortion of the device so as to alter the operating temperature adjustment.

7.4 A heat detector shall be supported independently of its connection to the installation wiring.

8 Servicing and Maintenance Protection

8.1 The thermoresponsive element adjustment shall not be capable of being readjusted after shipment from the factory. The means for calibration, if accessible or apparent, shall be modified, guarded, or sealed such that the means for calibration are not subject to manipulation by hand or ordinary tools subsequent to the factory calibration.

8.2 A calibration means is considered 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, recessed head, and the like, 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 at all other locations.

8.3 An uninsulated live part of a high-voltage circuit and moving parts that can cause risk of injury to persons within the enclosure shall be located, guarded, or enclosed to reduce the risk of unintentional contact by persons performing service functions that may be performed with the equipment energized.

8.4 An electrical component that may require examination, adjustment, servicing, or maintenance while energized shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for service without subjecting the user to a risk of electric shock from adjacent uninsulated live parts.

9 Materials

9.1 If a sealing compound is used, its melting point shall be at least 15°F (8.3°C) higher than the temperature rating of the thermostat, but not less than 149°F (65°C).

9.2 Diaphragms and spring parts shall be made of a nonferrous material such as phosphor bronze, nickel silver, or the equivalent. If ferrous materials are employed, they shall be hermetically sealed or plated so as not to be affected by corrosion.

9.3 A fusible alloy, if used as the operating member of a heat detector, shall not be affected by the conditions to which it will be exposed in service, as represented by the tests described in the Performance section of this standard.

9.4 All exposed parts that could be affected by corrosion shall be protected by enameling, galvanizing, sherardizing, plating, or equivalent means.

9.5 Polymeric materials of a detector shall be constructed to resist the abuses likely to be encountered in service. The degree of resistance to abuse inherent in the detector shall preclude total or partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other serious defects, which alone or in combination result in an increase in the risk of fire, electric shock, or injury to persons.

FIELD-WIRING CONNECTIONS

10 Leads

10.1 If wire leads are used in lieu of wiring terminals, the leads shall not be smaller than No. 18 AWG (0.82 mm^2). The leads shall not be less than 6 inches (152 mm) in length, shall be provided with strain relief, and shall employ a minimum 1/32-inch (0.8-mm) wall of insulation, or the equivalent. A separate lead shall be provided for each incoming and outgoing wire of a spot-type heat detector having normally open contacts. For a heat sensitive cable, the stripped ends of each wire shall be used for field connections. See 12.2.1.

11 Terminals

11.1 A wire binding screw shall not be smaller than No. 6 (3.5 mm diameter) for connection of not more than one No. 14 AWG (2.1 mm^2) or smaller conductor. A terminal screw intended for connection of a conductor larger than No. 14 AWG shall not be smaller than No. 8 (4.2 mm diameter).

11.2 A terminal plate tapped for a wire binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick for a No. 8 (4.2 mm diameter) or larger screw, not less than 0.030 inch (0.76 mm) thick for a No. 6 (3.5 mm diameter) screw and shall have not less than two full threads in the metal.

Exception: A terminal plate may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Other constructions may be employed if they provide equivalent strength.

11.3 A wire binding screw shall thread into metal.

11.4 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 will be prevented from turning or shifting in position if such motion may result in reduction of spacings below the minimum required values. See Spacings – Electrical, General, Section 14. This may 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.

11.5 In a heat detector of the normally open-contact type, a separate terminal screw shall be provided for each incoming and outgoing wire.

COMPONENTS – ELECTRICAL

12 General

12.1 Insulating material

12.1.1 Material for the support of live parts shall be nonflammable and moisture-resistant insulating material such as porcelain, phenolic or cold-molded composition, or other material determined to comply with requirements for the support of live parts.

12.1.2 The insulation of coil windings of relays, transformers, and the like shall resist the absorption of moisture.

12.2 Current-carrying parts

12.2.1 A current-carrying part shall be of a non-ferrous metal such as silver, copper, or copper alloy.

12.2.2 Electrical parts of a heat detector rated more than 30 volts shall be located or enclosed so as to reduce the risk of unintentional contact with uninsulated live parts.

12.2.3 Live screwheads or nuts on the underside of an insulating base intended for surface mounting shall be countersunk not less than 1/8 inch (3.2 mm) and shall be covered with a sealing compound.

Exception: If such parts are staked, upset, or prevented from loosening by an equivalent means, they may be insulated from the mounting surface by material other than sealing compound.

13 Contacts

13.1 A heat detector having normally closed contacts and intended for fire alarm service shall be capable of being used in conjunction with a system control unit, transmitter, or similar system component by which its alarm operation is indicated, so that an open-circuit fault in the heat detector circuit will not result in an alarm signal. This does not apply to heat detectors employed for releasing-device service where opening of the circuit results in operation of the releasing device, as in the case of fire doors and dampers.

13.2 If the heat detector operates by making contact (not by fusing) between metal parts, there shall be a wiping, scraping, or spring action between the parts unless the contact is made in a tightly closed housing that will prevent fouling by dust.

13.3 If contacts are not of the fusible or mercury type, the contacts shall have tips of silver, gold, or other material having similar conductivity and durability.

SPACINGS – ELECTRICAL

14 General

14.1 The spacings in a heat detector shall not be less than those indicated in Table 14.1. These values apply to the spacings between any uninsulated live part and:

a) An uninsulated live part of opposite polarity,

b) A metal enclosure including attached metal pieces and fittings for wiring connections,

c) An uninsulated grounded metal part other than the enclosure, and

d) The plane of the heat detector mounting surface.

14.2 Enamel insulated wire is considered to be the same as an uninsulated live part in determining compliance with the spacing requirements.

14.3 If a short circuit between uninsulated live parts of the same polarity would affect the intended signaling operation of the device, the spacing between such parts shall be not less than that required by 14.1.

Table 14.1
Minimum spacings

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

[a] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material used where spacings would otherwise be insufficient, shall not be less than 0.028 inch (0.71 mm) thick; except that a liner or barrier not less than 0.013 inch (0.33 mm) thick may be used 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 will not be adversely affected by arcing. Insulating material having a thickness less than that specified may be used if it is determined to be suitable 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 No. 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 the like.

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

PERFORMANCE

GENERAL

15 Test Units and Data

15.1 General

15.1.1 Heat detectors that are fully representative of production units are to be used for each of the following tests unless otherwise specified. The temperature and sensitivity settings provided on the samples for testing will define the production temperature ratings and sensitivities.

15.2 Component reliability data

15.2.1 Data on detector components, for example, capacitors, resistors, solid-state devices, and the like shall be provided for evaluation of the components for the intended application. If a Mil-Spec. is referenced, a copy of the specification is to be provided for review.

15.2.2 The data required by 15.2.1 shall include the following or equivalent information:

a) General description of the detector manufacturer’s quality assurance (QA) program. This data shall include incoming inspection and screening, in-process quality assurance, burn-in data, and testing. This applies to complete and partial assemblies as well as individual components.

b) Component Fault Analysis. Effect of failure, open and short, of capacitors and limited life components on operation of a detector.

c) Maximum supplier’s ratings for each component as well as the actual maximum operating values (voltage and current) in the detectors.

d) A description of component screening and burn-in test data for solid-state devices or integrated circuits that operate at greater than the limits described in note b of Table 38.1.

e) General calibration procedure of test instruments employed by the manufacturer in the calibration of a detector.

f) A general description of the circuit operation under standby, alarm, and trouble conditions.

15.3 Miscellaneous data

15.3.1 The following information shall be provided:

a) Identification of all the insulating, thermoplastic, and metallic materials in the construction of each detector to be tested;

b) Mounting position and spacing allocation desired for the detector;

c) Rate of temperature rise setting for a rate-of-rise type heat detector;

d) Final form of marking to be applied and its location;

e) Description of the oven to be used by a manufacturer in conducting the manufacturing and production tests at the factory; and

f) Special applications for a low-degree rated heat detector.

15.3.2 Electronic heat detectors shall be provided with a control panel, monitoring instrument, or equivalent to monitor operation of the detector.

16 Test Voltages

16.1 Unless specifically noted otherwise, the test voltage at rated frequency of a heat detector shall be as specified in Table 16.1.

Table 16.1
Test voltages

Nameplate voltage rating[a]	Test voltage[b]
110 to 120	120
220 to 240	240
Other	Marked nameplate rating

[a] The voltage rating shall be applied at the voltage waveform(s) specified in the markings.
[b] Detectors rated at frequencies other than 60 hertz are to be tested at their rated nameplate voltage and frequency.

17 Test Samples

17.1 The samples specified in Table 17.1 are to be provided for testing.

Table 17.1
Test samples

Type detector	Rating	Number of samples or footage
Electronic	Low and ordinary degree	25
	Each additional rating	15
Fixed temperature	Low and ordinary degree	
	Non resettable	50
	Resettable	25
	Each additional rating	15
Rate-of-rise	Each sensitivity setting	55
Combination FT	Each fixed temperature rating	15
and ROR	Each rate-of-rise sensitivity setting	55
Heat sensitive cable	Each temperature rating	250-foot

18 Sensitivity-Spacing Allocation

18.1 Installation spacing limitations of a heat detector shall be developed by tests in the testing oven or by fire tests. See the Oven Test, Section 19, and the Fire Test, Section 20.

18.2 The sensitivity of a heat detector is expressed in terms of spacing limitations. Spacing limitations refer to the maximum distance permitted between heat detectors mounted on smooth ceilings at a specific height. See 20.2.

18.3 Low-degree rated and ordinary-degree rated heat detectors shall be sufficiently sensitive to qualify for at least a 15-foot (4.57-m) spacing limitation. Only low-degree rated and ordinary-degree rated heat detectors shall be employed in determination of spacings. Spacing limitations for intermediate-degree and higher rated heat detectors are based on spacings obtained for the highest ordinary-degree rating within the subgroup shown in Table 18.1.

Table 18.1
Heat detectors

Temperature rating	Temperature rating range, °F (°C)	Maximum installation temperature, °F (°C)	Temperature range subgroups – °F (°C)			
			Group A	Group B	Group C	Group D
Low	100 – 134 (37.8 – 56.7)	20°F (11.1°C) below rating	100 – 108 (37.8 – 42.2)	109 – 117 (42.8 – 47.2)	118 – 126 (47.8 – 52.2)	127 – 134 (52.8 – 56.7)
Ordinary	135 – 174 (57.2 – 78.9)	100 (37.8)	135 – 144 (57.2 – 62.2)	145 – 154 (62.8 – 67.8)	155 – 164 (68.3 – 73.3)	165 – 174 (73.9 – 78.9)
Intermediate	175 – 249 (79.4 – 120.6)	150 (65.6)	175 – 194 (79.4 – 90)	195 – 214 (90.6 – 101.1)	215 – 234 (101.7 – 112.2)	235 – 249 (112.8 – 120.6)
High	250 – 324 (121 – 162.2)	225 (107.2)	250 – 269 (121 – 131.7)	270 – 289 (132.2 – 142.8)	290 – 309 (143.3 – 153.9)	310 – 324 (154.4 – 162.2)
Extra High	325 – 399 (163 – 203.8)	300 (148.9)	325 – 344 (163 – 173.3)	345 – 364 (173.9 – 184.4)	365 – 384 (185 – 195.6)	385 – 399 (196.1 – 203.8)
Very Extra High	400 – 499 (204 – 259.4)	375 (190.6)	400 – 424 (204 – 217.8)	425 – 449 (218.3 – 231.7)	450 – 474 (232.2 – 245.6)	475 – 499 (246.1 – 259.4)
Ultra High	500 – 575 (260 – 302)	475 (246.1)	500 – 519 (260 – 270.6)	520 – 539 (271.1 – 281.7)	540 – 559 (282.2 – 292.8)	560 – 575 (293.3 – 302)

18.4 Low-degree rated and ordinary-degree rated heat detectors with spacings of 15 feet (4.57 m) may be tested for sensitivity in the testing oven described in 19.4 – 19.11. If the device does not operate within 2 minutes, the Fire Test, Section 20, is to be conducted.

18.5 A heat detector does not comply if it fails to qualify for a 15-foot (4.57-m) spacing; for example, does not operate:

a) Within 2 minutes in the Oven Test, Section 19, when subjected to the maximum temperature exposure attaining 205°F (96.1°C) or

b) When subjected to the Fire Test, Section 20.

TESTS

19 Oven Test

19.1 A heat detector that operates in 2 minutes or less when subjected to the time-temperature condition shown by Figure 19.1 is eligible for a 15-foot (4.57-m) installation spacing. Heat detector samples shall be uniform in operation when mounted in the same position. They shall be tested in each of the different positions permitted by the design. Operation is considered uniform if the heat detectors operate within the applicable temperature range indicated in the tabulation under the Operating Temperature Test, Section 22. See Table 22.1.

19.2 Performance under this time-temperature condition is to be studied to determine the responsiveness of the device, its uniformity, and its qualifications for a 15-foot (4.57-m) 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.

19.3 To verify uniform performance of a heat detector, the test is to be repeated four times 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 detector, it may be necessary to repeat the oven tests with test samples rotated 90 degrees and 180 degrees from the original test position.

19.4 The testing oven is to consist of an oval stainless steel container approximately 31 inches (787 mm) long and 10 inches (254 mm) wide by 16 inches (406 mm) high, made of material with a minimum thickness of 0.108 inch (2.74 mm). One of the curved end sections is to be hinged. See Figure 19.2.

Figure 19.1
Time temperature curve – 15 foot (4.57 m) spacings

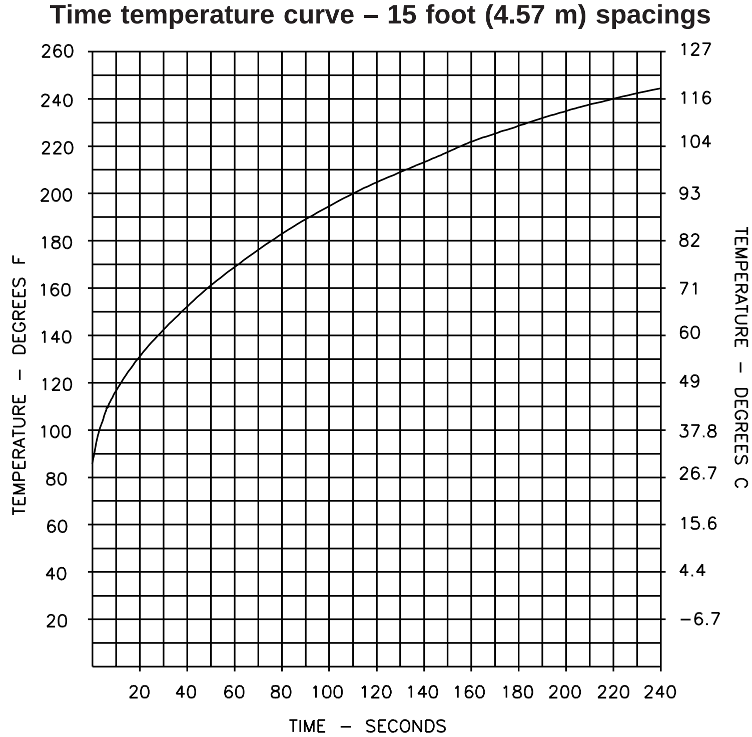

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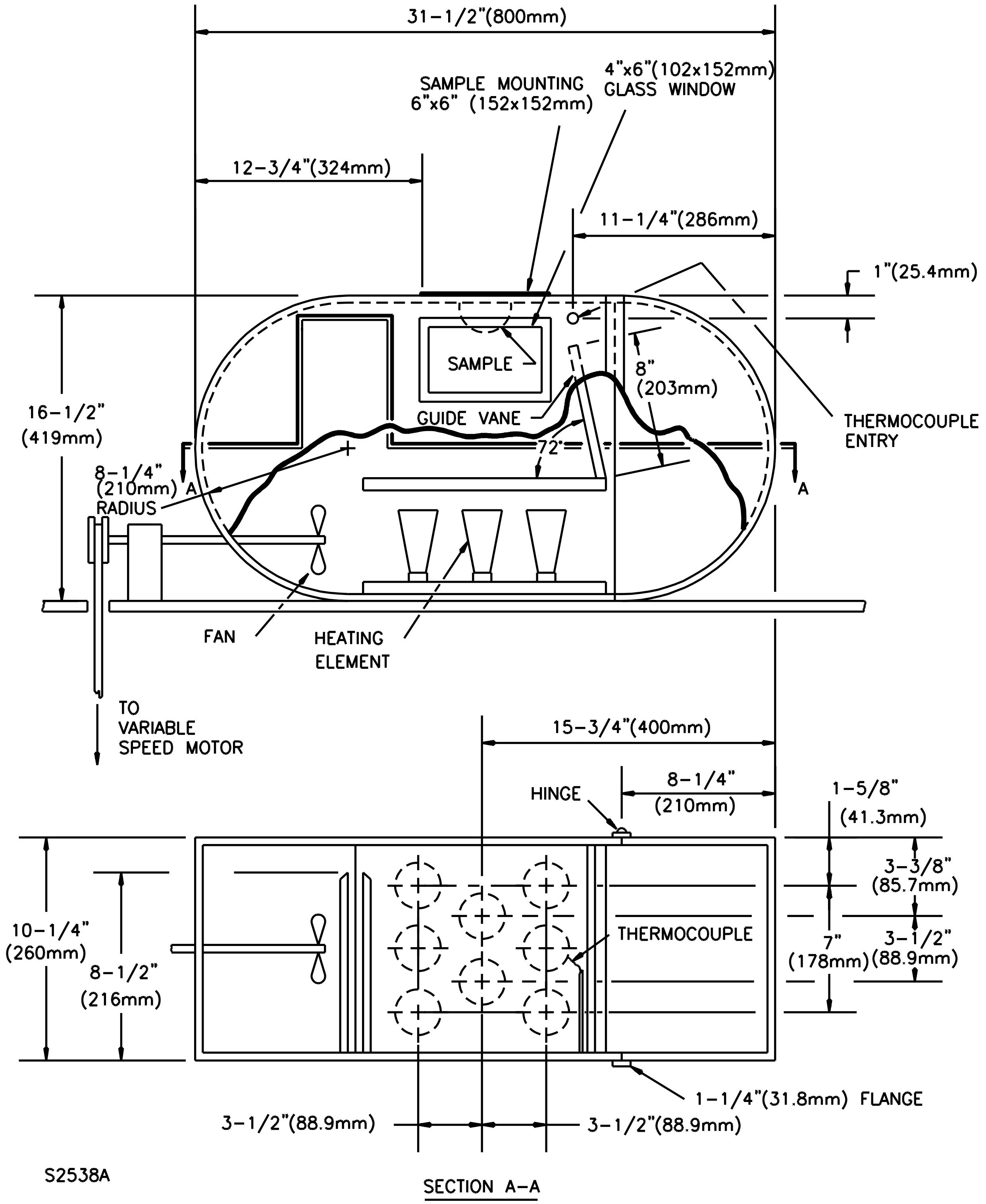
Figure 19.2
Heat detector testing oven



19.5 A section 6 by 6 inches (152 by 152 mm) at the top is to be fitted with a removable wooden cover. The heat detectors to be tested are mounted one at a time on this cover.

19.6 Two glass windows, 4 by 6 inches (102 by 152 mm) in size, are to be provided in the sides of the oven for observation of the samples under test.

19.7 The interior of the oven is to be divided horizontally by a baffle over the heater chamber located in the central lower section. One end of the horizontal baffle is to be joined to a guide vane extending upward at an angle of 72 degrees into the oven chamber. The vane is to direct the air currents to ensure greater uniformity of temperature in the oven.

19.8 Eight 1000-watt cone-shaped heating coils threaded into Edison-base lampholders are to furnish the heat. They are to be connected so that six of the heating coils are controlled by means of a data acquisition and control instrument. The other two heating coils are for supplying additional heat when necessary.

19.9 An air current through the bank of heaters is to be created by means of a four-blade 5-inch (127-mm) fan located behind the heating coils and connected to a shaft that extends to the outside of the oven. A variable-speed motor is to be mounted on a bracket inside the lower cabinet and is to operate the fan through a pulley and belt arrangement. The speed of the motor is to be adjusted and the pitch of the fan blades is to be such that the velocity of the air current is 230 – 245 feet per minute (1.17 – 1.24 m/s) over the sample under test.

19.10 Temperatures are to be measured by means of a type J thermocouple inserted through a tube extending to the inside of the test chamber, located in the same plane as the device under test, on the upstream side. The air velocity is to be measured prior to testing by a velometer inserted in the oven at a point approximately 1-1/4 inches (31.8 mm) from the top of the oven in the same location as the heat detector. The velocity is to be measured with the detector removed.

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

19.12 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 data obtained in tests with the device mounted in the least favorable position.

19.13 For heat sensitive cable a 3-foot (0.91-m) length, concentrically wound in a coil having a maximum diameter of 4 inches (102 mm), is to be used.

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

19.15 Wire connections are to be made between the terminals or leads of the heat detector and an indicating circuit consisting of an incandescent lamp connected to a 6-volt direct current (dc) source or the equivalent. The lamp current is to be approximately 50 milliamperes under closed circuit conditions.

19.16 After installation in the oven, the heat detector is to be subjected to the time-temperature condition illustrated in Figure 19.1. Oven temperature at the start of the test is to be 85 – 90°F (29.4 – 32.2°C).

19.17 Upon operation of the heat detector, 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.

20 Fire Test

20.1 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 19, and at the intended spacing, shall operate within 130 seconds. The temperature profile of the fire is to be monitored by a type J thermocouple located at the 10-foot (3.05-m) spacing, 7 inches (178 mm) below the ceiling, and on the same diagonal as the detectors. The temperature profile shall be within the limits shown in Figure 20.1. At least two trials are to be conducted.

20.2 Fire tests are to be conducted in a 60 by 60 foot (18.3 by 18.3 m) test room with a smooth ceiling at a height of 15 feet, 9 inches (4.80 m). The heat detectors are to be installed at their designated spacings in line with the sprinkler and fire test pan. See Figure 20.2 for the layout.

20.3 The fire tests are to be produced by burning denatured alcohol consisting of 190 proof ethanol to which 5 percent 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 20.1. 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 15-foot (4.57-m) spacing curve shown by Figure 19.1.

20.4 The fire tests are to be conducted to develop information regarding the operating time of the heat detectors when installed at their recommended spacing schedule as compared with the operating time of automatic sprinklers installed on a standard 10 by 10 foot (3.05 by 3.05 m) spacing schedule. Operation of the heat detectors within 130 seconds will qualify the device for the spacing on which it was installed.

20.5 For a heat sensitive cable, a 20-foot (6.1-m) length is to be installed on the ceiling to form a 90-degree angle, with two legs, each 10 feet (3.05 m) long located at 90 degrees. The fire source is to be located at a 45-degree angle from the point of intersection of the two legs.

Figure 20.1
Temperature profile UL 521/539 fire test
Time temperature limits

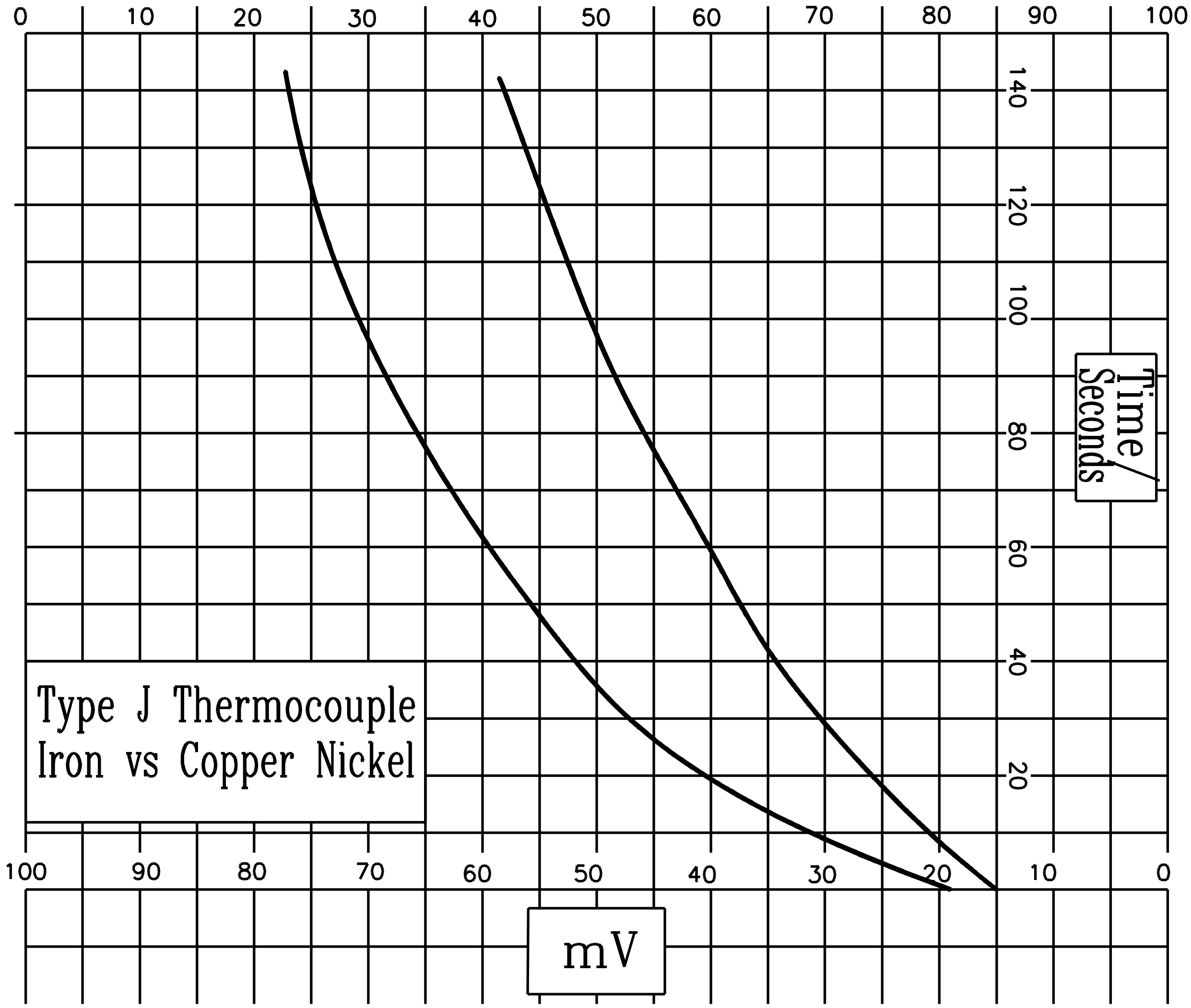


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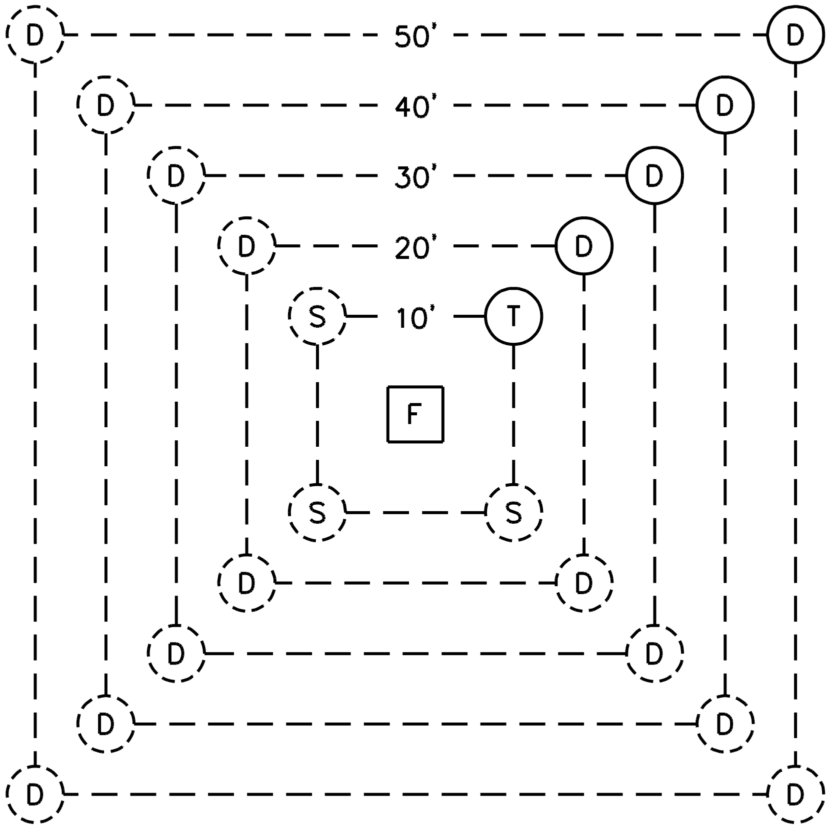
Figure 20.2
Fire test layout



Legend:

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

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

T — Thermocouple installed during Fire Test at 7 inches (178mm) 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 — 60 by 60 feet (18.3 by 18.3m), with a 15 foot 9 inch (4.80m) smooth ceiling.

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21 High-Temperature Exposure Test

21.1 Heat detectors shall not operate and the fusible element of a nonrestorable heat detector type shall not ″creep″ when subjected to high temperature exposure tests for 30 days. The minimum temperature differential between the heat detector rating and the test temperature is to be 10°F (5.6°C) for the low rating range, 15°F (8.3°C) for the ordinary and intermediate ranges, and 20°F (11.1°C) for the high rating range and above. See Table 21.1.

Table 21.1
High temperature exposure

Temperature rating	Temperature rating range,		Test temperature – degrees below rating,	
	°F	(°C)	°F	(°C)
Low	100 – 134	37.8 – 56.7	10	5.6
Ordinary	135 – 174	57.2 – 78.9	15	8.3
Intermediate	175 – 249	79.4 – 120.6	15	8.3
High	250 – 324	121 – 162.2	20	11.1
Extra high	325 – 399	163 – 203.8	20	11.1
Very extra high	400 – 499	204 – 259.4	20	11.1
Ultra high	500 – 575	260 – 302	20	11.1

21.2 A heat detector shall withstand the high temperature exposure and operate as intended when subjected to the Operating Temperature Test, Section 22, the Rate-of-Rise Operation Test, Section 23, or the Oven Test, Section 19, whichever is applicable.

21.3 Five sample heat detectors of each temperature rating are to be tested for their intended operating temperature (if capable of repeated operation), or rate-of-rise temperature, after which they are to be placed in an oven maintained at the temperature specified in 21.1. Connections are to be made as described in 19.15 between the devices and a power source, and means are to be provided for indicating operation of each of the devices under test.

21.4 For a heat sensitive cable, samples as described in 19.13 are to be used.

21.5 The sample heat detectors are to be removed from the oven after the 30-day period and allowed to remain at room temperature for 24 hours before being examined for ″creepage″ where applicable, and then subjected to the Oven Test, Section 19, the Operating Temperature Test, Section 22, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable. The average response obtained shall not be greater than 50 percent of the value recorded on as-received samples.

22 Operating Temperature Test

22.1 A fixed-temperature heat detector shall operate within the temperature tolerance range according to its rating as given in Table 22.1 when subjected to an operating temperature test in a water bath, oil bath, air oven, or equivalent method. Heat sensitive cable is to be as described in 19.13.

Table 22.1
Operating temperature

Temperature rating	Rating limits				Operating range,	
	Minimum,		Maximum,			
	°F	(°C)	°F	(°C)	°F	(°C)
Low	100	37.8	134	56.7	10	5.6
Ordinary	135	57.5	174	78.9	15	8.3
Intermediate	175	79.4	249	120.6	15	8.3
High	250	121	324	162.2	20	11.1
Extra high	325	163	399	203.8	20	11.1
Very extra high	400	204	499	259.4	30	16.7
Ultra high	500	260	575	301.6	30	16.7

22.2 Depending on their construction, the heat detectors are to be suspended in a water bath, oil bath, air oven, or the equivalent, the temperature of which is to be gradually increased at the rate of 1°F (0.56°C) per minute until operation takes place. Each heat detector is to be monitored for operation as described in 19.15, and the temperature of the test medium is to be recorded at the instant of operation.

22.3 The range of operation included in Table 22.1 shall include the temperature rating of the device.

23 Rate-of-Rise Operation Test

23.1 Heat detectors 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 12°F (6.7°C) per minute or less until a temperature of at least 130°F (54°C) is reached [starting from a temperature of 85 to 90°F (29.4 to 32.2°C)].

23.2 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 12, 15, and 20°F (6.7, 8.3, and 11.1°C) 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 minutes prior to a test run.

24 Low-Temperature Exposure Test

24.1 Three heat detectors shall comply with the requirements of the Oven Test, Section 19, the Operating Temperature Test, Section 22, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable, after exposure for 24 hours to a temperature of minus 22 ±3.6°F (minus 30 ±2°C). The units are to be tested immediately after the contacts return to the normal position. Heat sensitive cable is to be as described in 19.13.

24.2 This test is generally to be conducted only on heat detectors of the low-degree rating and ordinary degree rating unless there is a reason to anticipate behavior different from those of other ratings.

25 Corrosion Tests

25.1 General

25.1.1 The sensitivity of fixed-temperature heat detectors, after they are subjected to corrosive atmospheres, shall not show a time variation of more than 50 percent from the value obtained in the Oven Test, Section 19, on as-received samples. No false operation shall occur during the exposure. The sensitivity of heat detectors operating on the rate-of-rise principle, after they are subjected to corrosive atmospheres, shall not show a variation of more than 50 percent from the value obtained in the Rate-of-Rise Operation Test, Section 23, on as-received samples. No false operation shall occur during the exposure to the corrosive atmospheres or at a temperature rise of 12°F (6.7°C) per minute or less until a temperature of at least 130°F (54°C) is reached [starting from a temperature of 85 to 90°F (29.4 to 32.2°C)].

25.1.2 Samples of heat detectors capable of repeated operation are to be tested first for sensitivity in the testing oven before the corrosion tests. Samples of heat detectors not capable of repeated operation are not to be tested for sensitivity before the corrosion tests. Heat detectors operating on the rate-of-rise principle are to be subjected to the Rate-of-Rise Operation Test, Section 23, before and after exposure to the corrosive atmospheres.

25.1.3 Five samples are to be exposed to each applicable test atmosphere for 10 days. Heat sensitive cable is to be preformed as described in 19.13.

25.1.4 After exposure to the corrosive atmosphere, the samples are to be removed from the test apparatus and allowed to remain at room temperature for at least 24 hours, following which they are to be checked for sensitivity, using the test connection described in 19.15.

25.2 Indoor-use heat detectors

25.2.1 Hydrogen sulfide

25.2.1.1 Hydrogen sulfide is to be supplied to the test chamber from a commercial cylinder containing the gas under pressure. An amount of hydrogen sulfide equal to 0.1 percent of the volume of the test chamber is to be introduced into the chamber each working day. A small amount of water is to be maintained at the bottom of the chamber. The chamber is to be at room temperature throughout the test period.

25.2.2 Carbon dioxide-sulfur dioxide

25.2.2.1 Sulfur dioxide and carbon dioxide are to be supplied to the test chamber from commercial cylinders containing these gases under pressure. Amounts of sulfur dioxide equal to 0.5 percent of the test chamber volume and carbon dioxide equal to 1.0 percent of the chamber volume are to be introduced into the chamber each working day. A small amount of water is to be maintained at the bottom of the chamber. The chamber is to be at room temperature throughout the test period.

25.3 Outdoor-use heat detectors

25.3.1 Hydrogen sulfide

25.3.1.1 Hydrogen sulfide is to be supplied to the test chamber from a commercial cylinder containing the gas under pressure. An amount of hydrogen sulfide equal to 1 percent of the volume of the test chamber is to be introduced into the chamber each working day. A small amount of water is to be maintained at the bottom of the chamber. The chamber is to be at room temperature throughout the test period.

25.3.2 Carbon dioxide-sulfur dioxide

25.3.2.1 Sulfur dioxide and carbon dioxide are to be supplied to the test chamber from commercial cylinders containing these gases under pressure. An amount of sulfur dioxide equivalent to 1.0 percent of the volume of the test chamber, and an equal volume of carbon dioxide are to be introduced into the chamber each working day. A small amount of water is to be maintained at the bottom of the chamber. The chamber is to be at room temperature throughout the test period.

25.3.3 Salt spray

25.3.3.1 The apparatus for salt spray (fog) testing consists of a fog chamber, the inside of which measures 48 by 30 by 36 inches (1.2 by 0.76 by 0.91 m), a salt solution reservoir, a supply of conditioned compressed air, one dispersion tower constructed in accordance with Salt Spray (Fog) Testing, ASTM B117-73, for producing a salt fog, specimen supports, provision for heating the chamber, and necessary means of control.

25.3.3.2 The dispersion tower for producing the salt fog is located in the center of the chamber and is supplied with humidified air at a pressure of 17 – 19 pounds per square inch gauge (psig) (117 – 131 kPa) so that the salt solution is aspirated as a fine mist or fog into the interior of the chamber.

25.3.3.3 The salt solution is to consist of 20 percent by weight of common salt (sodium chloride) in distilled water. The pH value of the collected solution is to be between 6.5 and 7.2 with a specific gravity of 1.126 to 1.157 at 95°F (35°C). The temperature of the chamber is to be maintained at 95 ±2°F (35 ±1°C) throughout the test period.

25.3.3.4 The device is to be suspended vertically in the fog chamber.

25.3.3.5 Drops of solution which accumulate on the ceiling or cover of the chamber are to be diverted from dropping on the specimens, and drops of solution that fall from the specimens are not to be recirculated, but are to be removed by a drain located at the bottom of the apparatus.

26 Determination of Stress Cracking Test

26.1 General

26.1.1 The diaphragm enclosure of a rate-of-rise heat detector that contains more than 15 percent zinc shall not show any evidence of cracking after being subjected to an ammonia stress cracking test or salt immersion cycling, depending on the material employed.

26.2 Ammonia stress cracking test

26.2.1 A diaphragm enclosure, made of copper alloy, of a rate-of-rise heat detector shall be subjected to the test procedures outlined in Ammonia Stress Cracking Test, ASTM G37.

26.2.2 Test samples shall be subjected to the physical stresses imposed on or within a part as the result of assembly with other components.

26.2.3 Three samples of the rate-of-rise heat detector, not painted or coated, shall be subjected to this test. Upon removal from the solution, the samples are to be examined visually for cracking.

26.3 Salt immersion cycling test

26.3.1 A diaphragm enclosure, made of aluminum or steel, of a rate-of-rise heat detector shall withstand 2000 cycles, each cycle consisting of 10 minutes immersion and 50 minutes drying, without cracking or degradation, in a salt solution of 3.5 percent by weight of sodium chloride in de-ionized water.

26.3.2 The salt solution is to have a pH between 6.5 and 7.2 and is to be contained in a plastic tank.

26.3.3 Three samples of the rate-of-rise heat detector, not painted or coated, are to be subjected to this test and then examined visually for cracking.

27 Bond Secureness Test

27.1 The bond between a diaphragm enclosure of a rate-of-rise heat detector and the support base shall withstand exposure to the following conditions and then comply with the Rate-of-Rise Operation Test, Section 23. Different samples are to be employed for each test condition. Heat detectors without a fixed temperature feature are to be provided for this test.

a) High Temperature-Humidity Exposure– Five samples are to be exposed for 10 days, in turn, to a temperature of 150°F (65.6°C) in a circulating air oven, followed by exposure to a 95 ±2 percent relative humidity environment maintained at 140°F (60°C).

b) Temperature Cycling Test – Five samples are to be subjected for 10 days to temperature cycling, each cycle consisting of exposure for 24 hours at minus 40°F (minus 40°C) followed by 24 hours at 140°F (60°C), for a total of 5 cycles.

27.2 Following exposure to each test condition, the samples are to be removed from each test apparatus, allowed to remain at room temperature for at least 24 hours, and then subjected to the Rate-of-Rise Operation Test, Section 23.

28 Humidity Test

28.1 Three heat detectors shall comply with the requirements of the Oven Test, Section 19, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable, after exposure for 24 hours to moist air having a relative humidity of 85 ±5 percent, at a temperature of 86 ±3°F (30 ±2°C). The units are to be tested immediately after removal from the humidity environment.

28.2 This test is generally to be conducted only on heat detectors of the low-degree rating or ordinary-degree rating unless there is a reason to anticipate behavior different from those of other ratings. Heat sensitive cable is to be preformed as described in 19.13.

29 Transient Tests

29.1 General

29.1.1 Two electronic heat detectors:

a) Shall operate for their intended signaling performance;

b) Shall not initiate a false alarm or a trouble signal; and

c) Shall not have their sensitivities affected adversely after being subjected to 500 internally induced transients, extraneous transients, 500 (high-voltage) supply line transients, and 60 supply line (low-voltage) circuit transients, while energized from a source of supply as specified in Test Voltages, Section 16, and connected to the devices intended to be used with the detector.

Revised 29.1.1 effective October 4, 2004

29.2 Internally induced transients

29.2.1 The detector is to be energized in the standby condition from a source of supply as specified in Test Voltages, Section 16. The supply is to be interrupted a total of 500 cycles. Each interruption is to be for approximately 1 second at a rate of not more than 6 interruptions per minute. Following the test the detector is to be operated for its intended signaling performance.

29.3 Extraneous transients

29.3.1 A detector 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 29.3.2. In addition, the detector shall respond to heat during application of the transient condition.

29.3.2 To determine compliance with 29.3.1, two detectors are to be energized from a source of rated voltage and frequency and subjected to transients generated from the following devices located 1 foot (305 mm) from the detector, interconnecting wires, or both. The time of application for condition a) shall be at least 2 minutes. Conditions (c), (d), and (e) are to be applied for 10 cycles, each application of 2 seconds duration, except the last application shall be of a 2-minute duration. Near the end of the last cycle, the detector is to be subjected to an abnormal amount of heat to determine whether the unit is operational with the transient applied.

a) Sequential arc (Jacob's ladder) generated between two 15 inch (381 mm) long, No. 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 separation of 1/8 inch (3.2 mm) at the bottom (adjacent to terminals) and extending to 1-1/4 inches (31.8 mm) at the top.

b) Energization and transmission of random voice message of three separate transmitter-receiver units (walkie-talkies) in turn, each having a 5 watt output and operating in the following nominal frequencies:

1) 27 megahertz,

2) 150 megahertz,

3) 450 megahertz,

4) 866 megahertz, and

5) 910 megahertz.

A total of six energizations in each of two orientations are to be applied from each transmitter-receiver; five to consist of 5 seconds on and 5 seconds 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 detector under test. The cellular phones are to be positioned to generate a field strength of 20 volts/meter at the power-sensing antenna adjacent to the detector under test. The test is to be conducted with the antenna tip pointed directly at the detector, and at a right angle to the first position, centered on the detector.

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 6-inch (152-mm) diameter solenoid-type vibrating bell[a] with no arc suppression and rated 24 volts dc.

[a] Edwards Model 439D-6AW vibrating bell rated 0.075 ampere, 20/24 volt dc or equivalent.

Revised 29.3.2 effective October 4, 2004

29.4 Supply line (high-voltage) transients

29.4.1 A high-voltage ac-operated detector shall be subjected to supply line transients induced directly into the power supply circuit.

29.4.2 For this test, the detector is to be connected to a transient generator, consisting of a 2 kVA isolating power transformer and control equipment capable of producing the transients described in 29.4.3. See Figure 29.1. The output impedance of the transient generator is to be 50 ohms.

29.4.3 The transients produced are to be oscillatory and are to have an initial peak voltage of 6000 volts. The rise time is to be less than 1/2 microsecond. Successive peaks of the transient are to decay to a value of not more than 60 percent of the value of the preceding peak. Each transient is to have a total duration of 20 microseconds and is to be applied once every 10 seconds.

29.4.4 The unit is to be subjected to 500 oscillatory transient pulses included at a rate of six transients per minute. 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.

29.4.5 Following this test, all samples shall comply with the requirements of the Oven Test, Section 19, using the 15-foot (4.57-m) spacing curve (see Figure 19.1) or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

29.5 Supply line (low-voltage circuit) transients

29.5.1 Each of two low-voltage detectors shall be subjected to 60 transient voltage pulses. The pulses are to be induced into:

a) The detector 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 detector.

29.5.2 For this test, each circuit shall be subjected to a minimum of four 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 is to have a pulse rise time of 100 volts per microsecond, a pulse duration of approximately 80 microseconds, and an energy level of approximately 1.2 joules. Other applied transients are to have peak voltages representative of the entire range of 100 to 2400 volts, with pulse durations from 80 to 1100 microseconds, and energy levels not less than 0.03 joule or greater than 1.2 joules.

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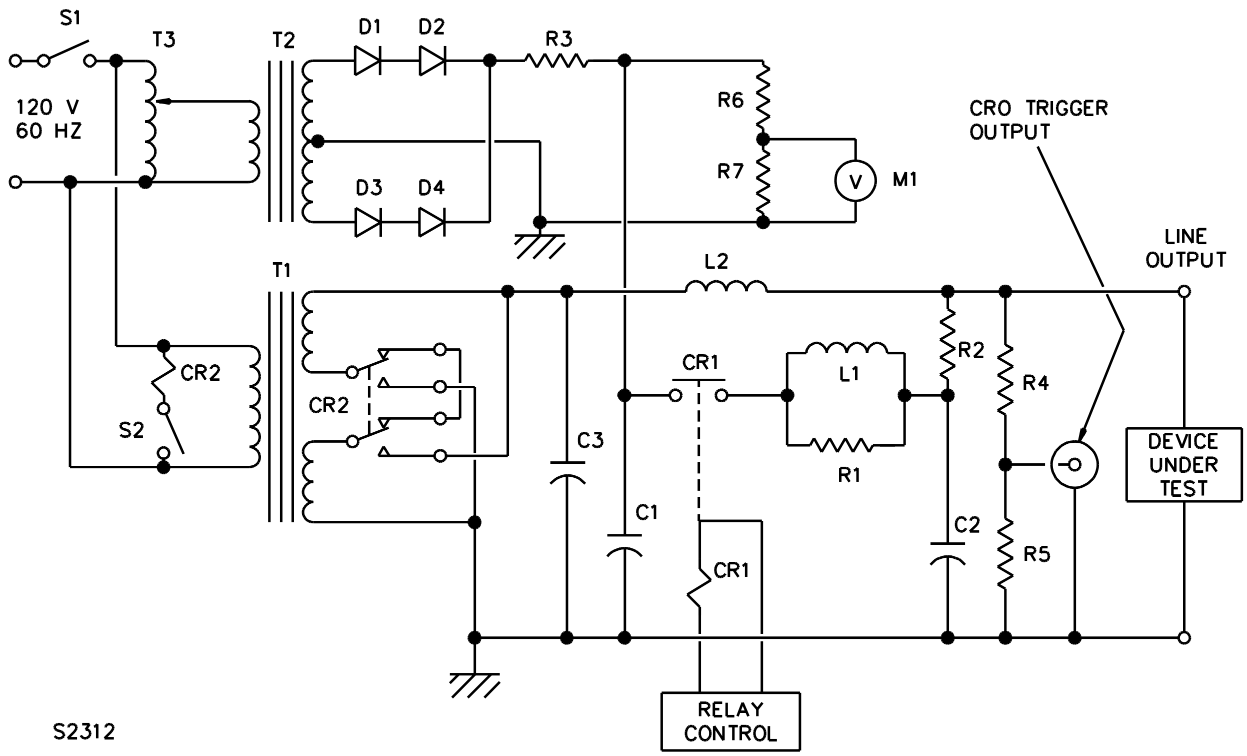
Figure 29.1
Surge generator circuit



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C1 – Capacitor, 0.025 µF, 10 kV

C2 – Capacitor, 0.006 µF, 10 kV

C3 – Capacitor, 10 µF, 400 V

CR1 – Relay, coil 24 VDC. Contacts, 3-pole, single throw, each contact rated 25 A, 600 VAC maximum: All three poles wired in series

CR2 – Relay, coil 120 VAC. Contacts DPDT. Provides either 120 V or 240 V test circuit.

D1 – D4 – Diodes, 25 kV PIV each

L1 – Inductor, 15 µH [33 turns, No. 22 AWG wire, wound on 0.835 inch (21.2 mm) diameter PVC tubing]

L2 – Inductor, 70 µH [45 turns, No. 14 AWG wire, wound on 2.375 inch (60.33 mm) diameter PVC tubing]

M1 – Meter, 0 – 20 VDC

R1 – Resistor, 22 Ohms, 1 W, composition

R2 – Resistor, 12 Ohms, 1 W, composition

R3 – Resistor, 1.3 Megohms (12 in series, 110k Ohms each, 1/2 W)

R4 – Resistor, 47k Ohms (10 in series, 4.7k Ohms each, 1/2 W carbon)

R5 – Resistor, 470 Ohms, 1/2 W

R6 – Resistor, 200 Megohms, 2 W, 10 kV

R7 – Resistor, 0.2 Megohms (2 in series, 100k Ohms each, 2 W, carbon)

S1 – Switch, SPST

S2 – Switch, SPST, key-operated, 120 VAC, 1 A

T1 – Transformer, 2 kVA, 120 V primary, 1:1 (120 V or 240 V output)

T2 – Transformer, 90 VA, 120/15,000 V

T3 – Variable autotransformer, 2.5 A

29.5.3 The detector shall 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 29.5.2) 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 29.5.2) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten of the opposite polarity.

29.5.4 At the conclusion of the test, all samples shall comply with the requirements of the Oven Test, Section 19, using the 15-foot (4.57-m) spacing curve (see Figure 19.1), or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

30 Vibration Test

30.1 A heat detector shall withstand vibration without false operation, breakage, or damage to the parts. Following this test, all samples shall comply with the requirements of the Oven Test, Section 19, using the 15-foot (4.57-m) spacing curve (see Figure 19.1), or the Rate-of-Rise Operation Test, Section 23, whichever is applicable. Heat sensitive cable is to be preformed as described in 19.13 on a 6 by 6 by 3/4-inch (152 by 152 by 19.1 mm) pine board with uninsulated staples applied at each end and 9 inches (229 mm) between staples.

30.2 Five heat detectors are to be secured in a position of intended use on a mounting board and the board, in turn, is to be securely fastened to a variable-speed vibration machine having an amplitude of 0.01 inch (0.2 mm) [total displacement of 0.02 inch (0.5 mm)]. The frequency of vibration is to be varied from 10 to 35 hertz in increments of 5 hertz until the resonant frequency is obtained. The samples are then to be vibrated at the maximum resonant frequency for a period of 15 minutes. If no resonant frequency is obtained, the samples are to be vibrated at 35 hertz for a period of 4 hours. Each heat detector is to be individually connected to a lock-in circuit consisting of an indicating lamp and a power source, see 19.15, as a means of indicating false operation during the test run.

30.3 Restorable heat detectors are to be tested first for sensitivity in the Oven Test, Section 19, before the vibration test. Upon completion of the vibration test, the samples are to be checked for sensitivity. Heat detectors operating on the rate-of-rise principle are to be subjected, before and after vibration, to the Rate-of-Rise Operation Test, Section 23.

30.4 This test is generally to be conducted only on heat detectors of the ordinary-degree rating unless there is a reason to anticipate behavior different from those of other ratings.

31 Overload Tests

31.1 Electronic heat detector

31.1.1 A detector shall operate for its intended signaling operating after being subjected to 50 cycles of alarm signal operation at a rate of not more than 6 cpm with the supply circuit to the detector at 115 percent of rated test voltage. Each cycle is to consist of starting with the detector energized in the standby condition, initiation of an alarm, and restoration of the detector to the standby condition.

31.1.2 Rated test loads are to be connected to the output circuits of the detector energized from the detector power supply. The test loads are to be those devices, such as remote indicators, relays, and the like, or their equivalent, intended for connection. If the equivalent load consists of an inductive load, a power factor of 60 percent is to be employed. The rated loads are to be established initially with the detector connected to a source of supply as specified in Test Voltages, Section 16. Then the voltage is to be increased to 115 percent of rating.

31.1.3 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 percent when connected to a 60 hertz potential equal to the rated dc test voltage. When the inductive load has both the required dc resistance and the required inductance, the current measured with the load connected to an ac circuit will be equal to 0.6 times the current measured with the load connected to a dc circuit when the voltage of each circuit is the same.

31.2 Separately energized circuits and non-electric type heat detectors

31.2.1 Separately energized circuits of a detector, such as dry contacts, shall operate as intended after being subjected for 50 cycles of signal operation at a rate of not more than 6 cpm while connected to a source of supply in accordance with the requirements specified in Test Voltages, Section 16, with 150 percent rated loads at 60 percent power factor applied to output circuits that do not receive energy from the detector. There shall not be electrical or mechanical malfunction of the switching circuit.

31.2.2 The test loads are to be adjusted to carry 150 percent of rated current while connected to a separate source of supply as specified in Test Voltages, Section 16.

32 Endurance Tests

32.1 Electronic heat detector

32.1.1 Following the Overload Test – Electronic Heat Detector (see 31.1.1 – 31.1.3), the same detector shall operate for its intended signaling operation after being subjected to 6000 cycles of 5-second alarm signal operation at a rate of not more than 10 cpm with the detector connected to a source of supply as specified in Test Voltages, Section 16, and with related devices or equivalent loads connected to the output circuits. There shall not be electrical or mechanical malfunction or evidence of malfunction of the detector components.

32.1.2 Following the endurance test, all samples shall comply with the requirements of the Oven Test, Section 19, using the 15 foot (4.57 m) spacing curve (See Figure 19.1), or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

32.2 Separately energized circuits and non-electric type heat detectors

32.2.1 Following the overload test – separately energized circuits and non-electric type heat detectors (see 31.2.1 and 31.2.2), the same separately energized circuits of the detector shall operate as intended when operated for 6000 cycles at a rate of not more than 10 cpm at a duty time cycle of 50 percent off and 50 percent on. If an electrical load is involved, the contacts of the device are to make and break the normal current at the voltage specified by Test Voltages, Section 16. The load is to represent that which the device is intended to control. The endurance tests of the separately energized circuits may be conducted in conjunction with the endurance test of the detector. There shall not be electrical or mechanical malfunction of the detector nor malfunction or welding of any relay contacts.

33 Rain Test

33.1 Heat detectors intended for outdoor use shall be subjected to a 24-hour water spray, without wetting of electrical parts or entry of water into functional areas.

33.2 The sensitivity of heat detectors intended for outdoor use shall not be affected when representative samples are subjected to the water spray and then to the Dielectric Voltage-Withstand Test, Section 34, and the Rate-of-Rise Operation Test, Section 23, or the Oven Test, Section 19, whichever is applicable.

33.3 The test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 33.1. Spray heads are to be constructed in accordance with the details shown in Figure 33.2. The water pressure for all tests is to be maintained at 5 psig (34.4 kPa) at each spray head. The distance between the center nozzle and the unit is to be approximately 39 inches (1000 mm). The unit is to be brought into the focal area of the three spray heads in such a position and under such conditions that the greatest quantity of water will enter the unit while it is mounted on a vertical surface in a position of intended use. The spray is to be directed at an angle of 45 degrees to vertical toward the unit or openings closest to current-carrying parts. The total exposure is to be for 24 hours.

Revised 33.3 effective October 4, 2004

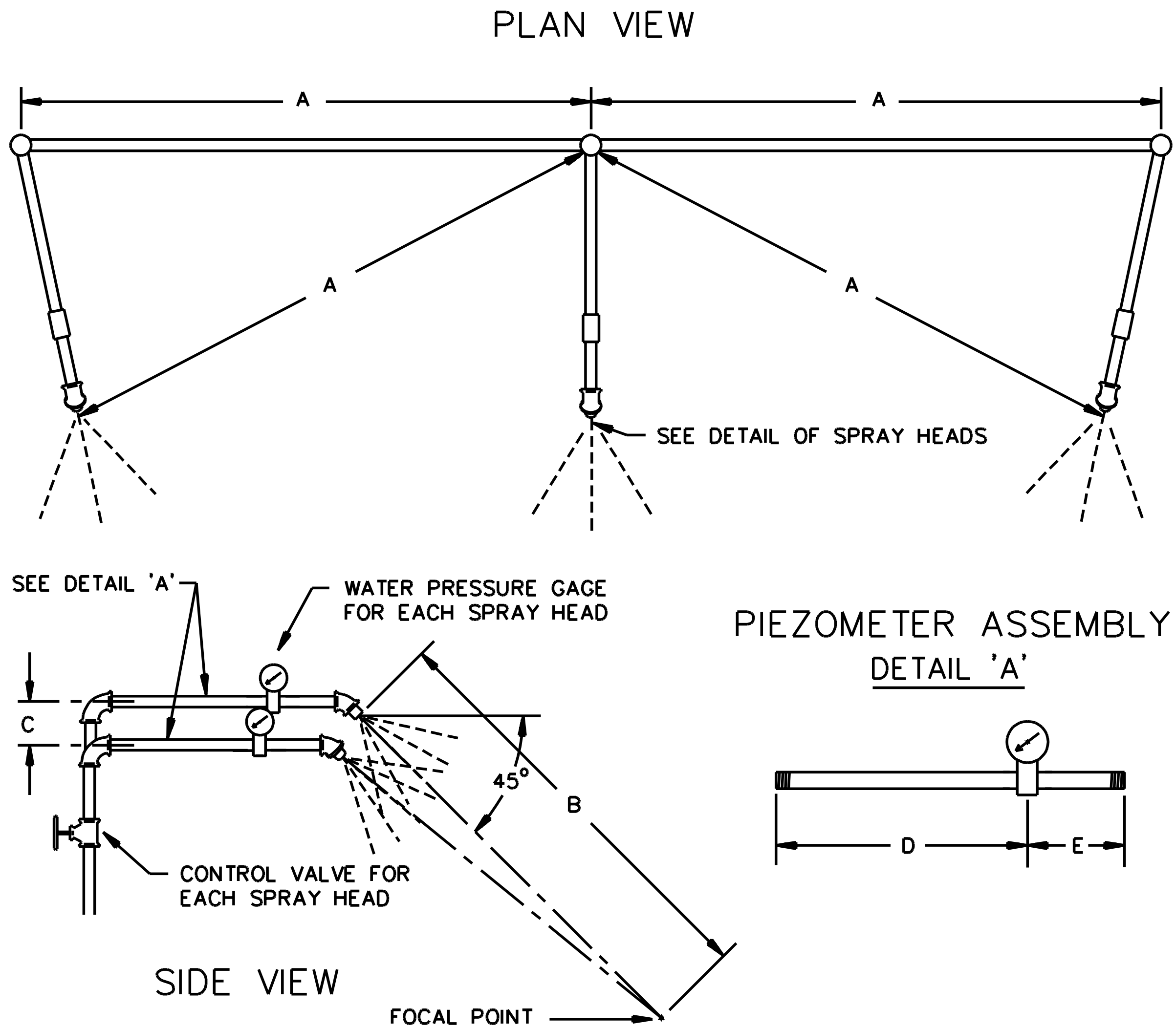
33.4 Three heat detectors are to be secured in a position of intended use on a flat mounting board in accordance with the manufacturer’s installation instructions. The board is then to be secured in a vertical position to a vertical wooden support.

33.5 Following the exposure, the outside of each sample is to be carefully wiped clear of water, and a visual examination is to be made of the interior to determine any entry of water. For a rate-of-rise heat detector, the air chamber is to be physically removed from the base and examined for internal entry of water. This is to be conducted following the Dielectric Voltage-Withstand Test, Section 34, and the Rate-of-Rise Operation Test, Section 23.

33.6 After the visual examination, each heat detector is then to be removed from its mounting surface and subjected, in turn, to the Dielectric Voltage-Withstand Test, Section 34, followed by the Oven Test, Section 19, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

Figure 33.1
Rain-test spray-head piping

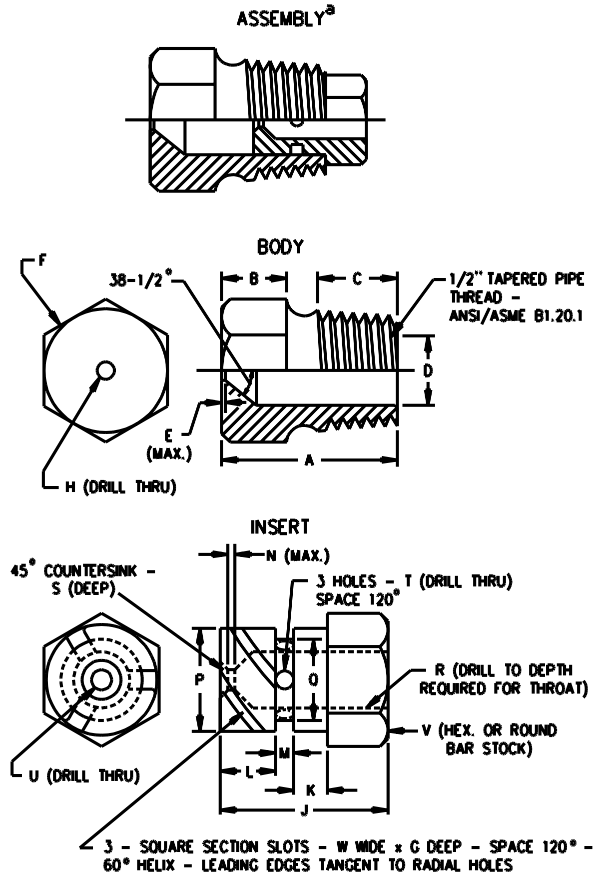
Revised Figure 33.1 effective October 4, 2004



Item	inch	mm
A	28	710
B	39	1000
C	2-1/4	55
D	9	230
E	3	75

RT101G

Figure 33.2
Rain-test spray head



Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.80
H	(No.9)[b]	5.0	U	(No. 40)[b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional – To serve as a wrench grip.

RT100E

34 Dielectric Voltage-Withstand Test

34.1 A heat detector shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal ac potential of a frequency within the range of 40 – 70 hertz, or a dc potential, between live parts and the enclosure, live parts and exposed dead metal parts, and live parts of circuits operating at different potentials or frequencies. The test potential is to be (also, see 34.2):

a) For a heat detector rated 30 volts ac rms (42.4 volts dc or ac peak) or less – 500 volts (707 volts, if a dc potential is used).

b) For a heat detector rated 250 volts ac rms or less, but more than 30 volts ac rms – 1000 volts (1414 volts, if a dc potential is used).

c) For a heat detector rated more than 250 volts ac rms – 1000 volts plus twice the rated voltage (1414 volts plus 2.828 times the rated ac rms voltage, if a dc potential is used).

34.2 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 34.1 (a), (b), or (c), based on the highest voltage of the circuits under test instead of the rated voltage of the heat detector. Electrical connections between the circuits are to be disconnected before the test potential is applied.

34.3 For testing of a heat sensitive cable, a 3-foot (0.9-m) length is to be closely wrapped with aluminum foil around the center 2-foot (0.6-m) section and the end of each wire bared for 1 inch (25.4 mm). The potential is to be applied between the conductors and foil.

34.4 The test potential may 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. Starting at zero, the potential is to be increased at a rate of approximately 200 volts per minute until the required test value is reached and is to be held at that value for 1 minute.

34.5 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 detector.

35 Marking Label Adhesion Tests

35.1 General

35.1.1 After being subjected to the conditions described in 35.2.1 – 35.5.1, a pressure-sensitive label or a label secured by cement or adhesive is considered to be of a permanent nature if immediately following removal from each test medium:

a) Each specimen demonstrates good adhesion and the edges are not curled;

b) The label resists defacement or removal as demonstrated by scraping with a 2-pound force (9 N) across the test panel with a flat metal blade 5/64 inch (2 mm) thick, held at right angles to the test panel; and

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

35.2 Air oven-aging test

35.2.1 Three specimens of the label, applied to test surfaces as in the intended application, are to be placed in an air oven maintained at the temperature indicated in Table 35.1 for 240 hours and then allowed to cool in a controlled atmosphere maintained at 23 ±2°C (73.4 ±3.6°F) and 50 percent relative humidity for 72 hours.

Table 35.1
Air-oven test temperatures

Maximum installation temperature of surface of applied label,[a]		Air oven test temperature,	
°C	(°F)	°C	(°F)
60	140	87	189
80	176	105	221
100	212	121	250
125	257	150	302
150	302	180	356
175	347	210	410
200	392	230	446
225	437	250	482
250	482	280	536

[a] See Table 53.1.

35.3 Immersion test

35.3.1 Three specimens of the label, applied to test surfaces as in the intended application, are to be placed in a controlled atmosphere maintained at 23 ±2°C (73.4 ±3.6°F) with a 50 ±5 percent relative humidity for 24 hours. The samples are then to be immersed in water at a temperature of 23°C (73.4°F) for 48 hours.

35.4 Standard-atmosphere test

35.4.1 Three specimens of the label, applied to test surfaces as in the intended application, are to be placed in a controlled atmosphere maintained at 23 ±2°C (73.4 ±3.6°F) with 50 ±5 percent relative humidity for 72 hours.

35.5 Unusual-condition exposure test

35.5.1 If the labels are exposed to unusual conditions in service, such as oil, grease, cleaning solutions, or the like, three samples of the label, applied to test surfaces as in the intended application, are to be placed in a controlled atmosphere maintained at 23 ±2°C (73.4 ±3.6°F) with a 50 ±5 percent relative humidity for 24 hours. The specimens are then to be immersed for 48 hours in a solution representative of service use and maintained at the temperature the solution would attain in service, but in no case less than 23°C (73.4°F).

36 Circuit Measurement Test

36.1 The input and output current of each circuit of an electronic type detector shall not exceed the marked rating of the detector by more than 10 percent when operated under conditions of intended use and with the detector connected to a source supply as specified in Test Voltages, Section 16. Measurements are also to be made of components such as capacitors to determine that they are being employed within the manufacturer's ratings.

36.2 For two-wire detectors, surge current, minimum accessory voltage, start-up time, equivalent capacitance, maximum ripple, normal supervisory current, and alarm current and impedance are to be measured at the detector's rated input voltage values and at the nominal voltage value. The measured current values shall be within the rated values.

37 Overvoltage and Undervoltage Tests

37.1 General

37.1.1 An electronic type detector shall:

a) Operate as intended in the standby condition at maximum and minimum sensitivity settings and

b) Perform its intended signaling function, while connected to a supply source of 110 percent of rated value.

Sensitivity measurements at the increased voltage shall comply with the requirements of the Oven Test, Section 19, the Operating Temperature Test, Section 22, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

37.1.2 For operation at the higher voltage, three detectors are to be subjected to the specified increased voltage in the standby condition for not less than 16 hours or other warm-up period as recommended by the manufacturer, and then each tested for their intended signaling operation and sensitivity.

37.2 Undervoltage test

37.2.1 A detector shall operate for its intended signaling performance while energized from a source of supply of 85 percent of the test voltage specified by Test Voltages, Section 16. Sensitivity measurements at the reduced voltage shall comply with the requirements of the Oven Test, Section 19, the Operating Temperature Test, Section 22, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

37.2.2 For operation at the reduced voltage, three detectors are to be subjected to the specified reduced voltage and tested for their intended signaling operation and sensitivity.

37.2.3 Following operation at 85 percent of rated voltage, reduction of the supply voltage to zero at a rate of 5 volts per minute shall not result in energization of the alarm circuit.

37.2.4 A two-wire detector intended for connection to a two-wire initiating device circuit is to be tested at 100 percent of its rated voltage range.

38 Component Temperature Test

38.1 The materials or components employed in a detector shall not be subjected to a temperature rise greater than the values indicated in Table 38.1 under any condition of intended operation. The temperature rise of a component in Table 38.1 in the standby condition may be exceeded, but in no case shall be greater than for the temperature permitted under an alarm condition, if malfunction of that component results in a trouble signal.

Table 38.1
Maximum temperature rises

Device or material	Normal standby, °C	(°F)	Alarm condition, °C	(°F)
A. COMPONENTS				
1. Capacitors	25	45	40	72
2. Fuses	25	45	65	117
3. Rectifiers – at any point				
a) Germanium	25	45	50	90
b) Selenium	25	45	50	90
c) Silicon				
(1) Maximum 60 percent or rated voltage	50	90	75	135
(2) 60 percent rated voltage	25	45	75	135
4. Relays and other coils with:				
a) Class 105 insulated windings				
Thermocouple method	25	45	65	117
Resistance method	35	63	75	135
b) Class 130 insulated windings				
Thermocouple method	45	81	85	153
Resistance method	55	99	95	171
5. Resistors[a]				
a) Carbon	25	45	50	90
b) Wire wound	50	90	125	225
c) Other	25	45	50	90
6. Sealing compounds	15°C (27°F) less than its melting point			
7. Solid-state devices	See Note[b]			
B. INSULATED CONDUCTORS[c]				
1. Appliance wiring material	25°C (45°F) less than the temperature limit of the wire			

Table 38.1 Continued on Next Page

Table 38.1 Continued

Device or material	Normal standby, °C	(°F)	Alarm condition, °C	(°F)
2. Flexible cord	35	63	35	63
C. ELECTRICAL INSULATION – GENERAL				
1. Fiber used as electrical insulation or cord bushings	25	45	65	117
2. Phenolic composition used as electrical insulation or as parts where deterioration will result in a risk of fire or electric shock	25	45	125	225
3. Varnished cloth	25	45	60	108
D. GENERAL				
1. Mounting surfaces	25	45	65	117
2. Wood or other combustible material	25	45	65	117

[a] The temperature rise of a resistor other than a line voltage dropping resistor may exceed the value shown if the power dissipation is 50 percent or less of the resistor manufacturer's rating.

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

1) The component complies with the requirements of MIL-STD 883E.

2) A quality control program is established by the manufacturer consisting of inspection and test of 100 percent of all components, either on an individual basis, as part of a subassembly, or equivalent.

3) Each assembled production unit is subjected to a burn-in test, under the condition that results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F) followed by a recalibration of the sensitivity and a retest.

[c] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code, ANSI/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.

38.2 Except as noted in 38.3, all values for temperature rises apply to equipment intended for use in prevailing ambient temperatures that usually are not higher than 25°C (77°F).

38.3 If equipment is intended specifically for use in a prevailing ambient temperature constantly more than 25°C (77°F), the test of the equipment is to be made at the higher temperature, and the maximum temperature rises specified in Table 38.1 are to be reduced by the amount of the difference between that higher ambient temperature and 25°C.

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

38.5 A temperature is considered to be constant when three successive readings, taken at not less than 5 minute intervals, indicate no change.

38.6 Temperatures are to be measured by means of thermocouples consisting of wires not larger than No. 24 AWG (0.21 mm^2). The preferred method of measuring the temperature of a coil is the thermocouple method, but either the thermocouple or resistance method may be used, except that the thermocouple method is not to be employed for a temperature measurement at any point where supplementary thermal insulation is employed.

38.7 Thermocouples consisting of No. 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer-type indicating instrument shall be used whenever referee temperature measurements by a thermocouple are necessary.

38.8 The thermocouple wire is to comply with the requirements specified in the Initial Calibration Tolerances for Thermocouples table in the Standard for Temperature Measurement of Thermocouples, ANSI/ISA MC96.1.

38.8 revised October 3, 2002

38.9 The temperature of a copper coil winding is to be determined by the 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 degrees C;

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

r is the resistance in ohms at the known temperature; and

t is the known temperature in degrees C.

38.10 As it is generally necessary to de-energize the winding before measuring R, the value of R at shutdown may 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 may be plotted and extrapolated to give the value of R at shutdown.

38.11 The detector is to be connected to a source of supply as specified in Test Voltages, Section 16, and operated under the conditions specified in items (a)– (c):

a) STANDBY – (16 hours minimum). Constant temperatures.

b) ALARM – (1 hour).

c) ALARM – (7 hours abnormal test).

No Text on This Page

38.12 For 38.11(c), the temperature limits may be exceeded but there shall not be manifestation of a fire or impending malfunction, and the detector shall operate as intended following the test.

38.13 The detector is to be subjected to the Dielectric Voltage-Withstand Test, Section 34, following the tests specified in 38.11 (b) or (c).

39 Electrical Supervision Test

39.1 The electrical circuits formed by conductors extending from the installation wiring connections of a detector for interconnection to a power supply source or system control unit initiating device circuit shall be electrically supervised so that a trouble signal indication is obtained at the connected control unit under any of the following fault conditions if the fault prevents operation of the detector for fire alarm signals:

a) Single open or single ground fault of the connecting field wiring.

b) Failure of a limited-life component. See 3.3.

c) De-energization of the detector power supply circuit.

d) Removal of a separable detector head from its base, unless the head is secured to the base after installation by a means that requires a special tool to release.

39.2 The requirements of 39.1 do not apply to the following:

a) Circuits of detectors intended only for releasing device service.

b) Circuits for trouble-indicating devices.

c) The neutral of a 3-, 4-, or 5-wire alternating current or direct current light-and-power-supply circuit.

d) A supplementary source of power used as an auxiliary means for maintaining normal operation of a detector when the main supply source is interrupted.

e) The leads of a trickle-charged battery.

f) A circuit for a supplementary signal annunciator, signal-sounding appliance, or similar appliance, provided that a break or a ground fault in no way affects the operation of the detector other than to cause the omission of the supplementary feature.

39.3 Interruption and restoration of any source of electrical power connected to a detector shall not cause an alarm signal.

39.4 The operation of any manual switching part of a detector unit other than its ″normal″ position while the detector is in the standby condition shall be indicated by a trouble signal, or by a lamp or other visual annunciator, if the ″off-normal″ position of the switch interferes with the operation of the detector.

39.5 If one leg of the power supply system to a detector is intended to be connected to a grounded circuit, a ground fault in the other leg shall result in an audible trouble signal at either the detector, the control unit, or the power supply to which the detector is connected. Such faults shall not result in an alarm signal.

39.6 To determine if a detector complies with the requirements for electrical supervision, the detector is to be tested with the representative system combination 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 system combination is then to be restored to the standby condition prior to establishing the next fault.

40 Stability Test

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

a) A detector shall operate for its intended signaling performance after being subjected for 14 days to an ambient temperature of 66 ±3°C (150 ±5.4°F). Two samples are to be placed in a circulating air oven and energized for 14 days 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 hours.

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

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

40.2 Two detectors are to be mounted in a position of intended use, energized from a source of supply in accordance with Test Voltages, Section 16, and subjected to each of the test conditions in 40.1.

40.3 For 40.1(a), the detector is to be mounted on wooden supports simulating intended installation and is to be connected to indicating lamps or equivalent means to indicate a false alarm.

40.4 For 40.1(c), the detector is to be plunged from one humidity level to the other in not more than 3 seconds per plunge and maintained at each humidity level for not less than 1/2 hour between plunges.

40.5 At the conclusion of conditions 40.1 (a) – (c), the detector shall comply with the requirements of the Oven Test, Section 19, the Operating Temperature Test, Section 22, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

41 Dynamic Load Immunity Test

41.1 A control unit having initiating device circuits intended for use with two-wire smoke detectors with pulsing normal operating current shall not false alarm due to the random pulsing load presented by the maximum number of detectors permitted to be connected to the circuit.

41.2 In order to determine compliance with 41.1, the maximum number of two-wire smoke detectors specified in the installation wiring diagram are to be connected to an initiating device circuit and the control unit is to be energized from a source of rated voltage and frequency. The combination is to be operated in the normal supervisory condition for 30 days. During this time, there shall not be false alarms. The test is to be repeated for each type and combination of smoke detector specified on the installation wiring diagram.

Exception: A control unit that provides an alarm retard on the initiating device circuit of 1 to 3 seconds need not be subjected to this test if the two-wire detectors intended to be connected to the control unit have power pulse durations, in seconds, equal to or less than the reciprocal of the maximum number of detectors.

42 Polarity Reversal Test

42.1 An electronic type heat detector shall operate in its intended manner after being connected in each polarity for at least 24 hours or until a trouble or alarm signal is obtained. For a battery-operated detector 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.

42.2 Two samples are to be subjected to this test. At the conclusion of the test, the samples shall comply with the requirements of the Oven Test, Section 19, the Operating Temperature Test, Section 22, or the Rate-of-Rise Test, Section 23, whichever is applicable.

43 Replacement Test, Head and Cover

43.1 A detector 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 closure, where applicable, and shall comply with the requirements of the Jarring Test, Section 44.

43.2 A detector is to be installed as intended in service and the cover or head removed and replaced, or opened and closed, as recommended by the manufacturer. The unit is then to be subjected to the Jarring Test, Section 44.

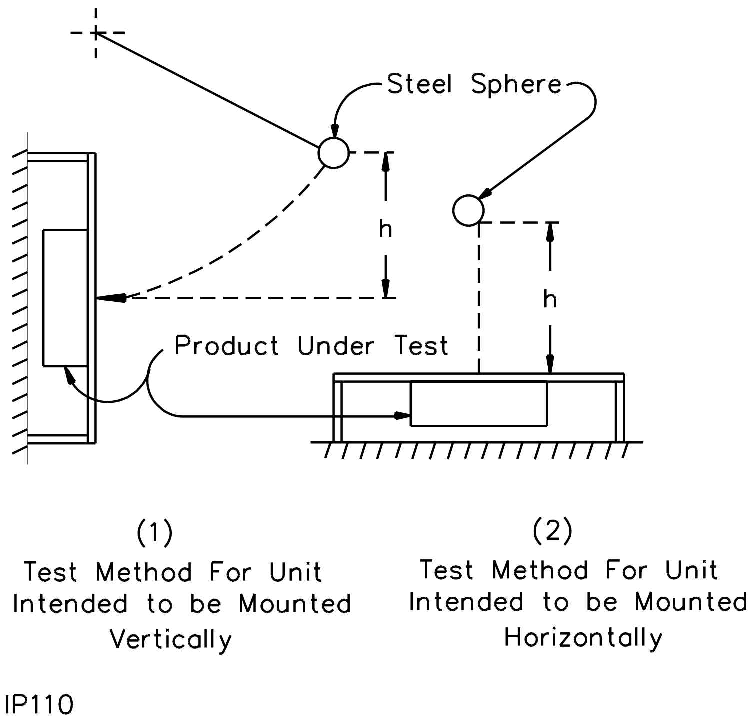
44 Jarring Test

44.1 A detector shall withstand jarring resulting from impact and vibration such as might be experienced in service, without causing an alarm signal, without dislodgement of any parts, and without impairing its subsequent operation. A momentary trouble signal resulting from the jarring may occur provided that the detector operation is not affected. Dislodgement of parts may occur provided that the dislodged part(s) does not affect the operation of the unit, and no high-voltage parts are exposed.

44.2 The detector (and associated equipment, if any) is to be mounted, in turn, as intended for use (see Figure 44.1) to the center of a 6 by 4 foot (1.8 by 1.2 m) nominal 3/4 inch (19.1 mm) thick plywood board that is to be secured in place at four corners. A 3 foot-pound (4.08 joule) impact is to be applied to the center of the reverse side of this board by means of a 1.18 pound (0.54 kg), 2 inch (50.8 mm) diameter steel sphere swung through a pendulum arc from a height (h) of 2.54 feet (775 mm), or dropped from a height (h) of 2.54 feet, depending upon the mounting of the equipment.

44.3 This test is to be conducted with the detector in the standby condition and connected to a rated source of supply in accordance with Test Voltages, Section 16. Following the jarring the detector shall comply with the requirements of the Oven Test, Section 19, the Operating Temperature Test, Section 22, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

Figure 44.1
Jarring test



45 Static Discharge Test

45.1 The intended performance of a detector shall not be impaired or a false alarm obtained, when the detector is subjected to static electric discharges. Operation of the trouble circuit during this test is not to be considered a malfunction if 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 percent and a barometric pressure of not less than 700 mm of mercury (193.5 kPa).

45.2 Each of the two detectors is to be mounted on the underside of a 3/4-inch (19.1-mm) thick plywood panel in its intended mounting position and connected to a source of supply in accordance with Test Voltages, Section 16. If a detector is intended to be installed on a metal backbox, 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 insulated leads, 3 feet (0.9 m) long, stripped 1 inch (25.4 mm) 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 1/2-inch (12.7-mm) 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 touched to the detector and then the other probe is to be touched to earth ground. An electrostatic voltmeter is to be employed to measure the voltage but is to be removed prior to conducting the discharge.

45.3 Discharges are to be applied at 5-minute intervals to different points on the exposed surface of the detector as well as to internal locations that are accessible during cleaning or field adjustments, recharging the capacitor for each discharge. Ten discharges are to be made with the test probe. Ten additional discharges are to be applied on all internal parts that could be contacted during servicing. Discharges inside the detector are not to be applied if the detector is not intended to be serviced in the field but is marked to be returned to the factory for servicing.

45.4 Following the discharges the detector shall comply with the requirements of the Oven Test, Section 19, the Operating Temperature Test, Section 22, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

46 Dust Test

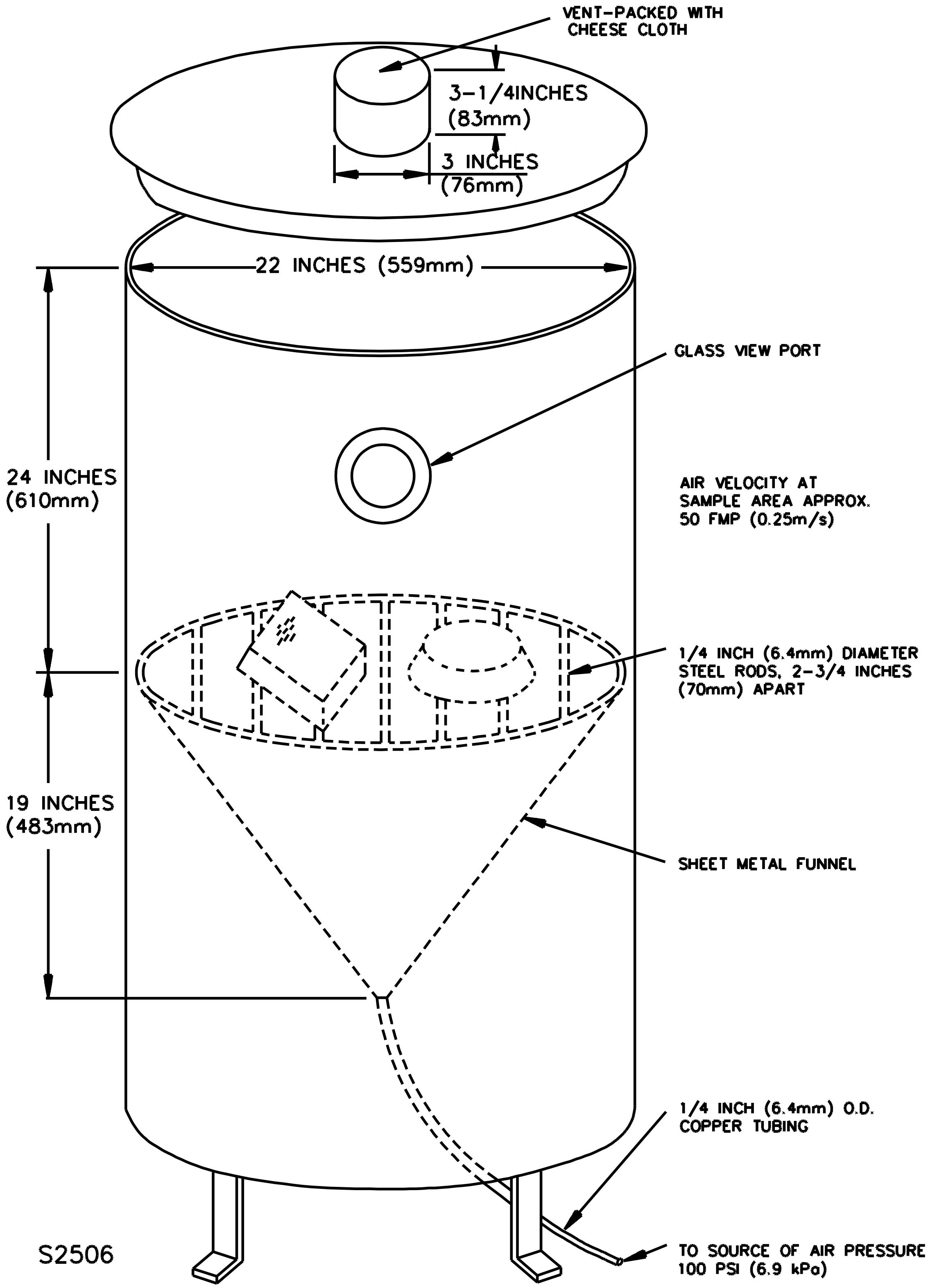
46.1 The sensitivity of a detector shall not be reduced by an accumulation of dust. The alarm or trouble circuit may be energized.

46.2 To determine compliance with 46.1, two samples are to be placed, de-energized, on metal supports in an air tight chamber having an internal volume of at least 3 cubic feet (0.09 m^3). See Figure 46.1.

46.3 Approximately 2 ounces (0.06 kg) of cement dust, maintained in an ambient room temperature of approximately 23 ±2°C (73.4 ±3.6°F) at 20 – 50 percent relative humidity and capable of passing through a 200 mesh screen, are to be circulated for 15 minutes 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 at least 50 fpm (0.25 m/s).

46.4 Following the exposure to dust the detector is to be removed carefully, mounted in its intended position, energized from a source of supply in accordance with Test Voltages, Section 16, and tested for sensitivity. Sensitivity measurements following the exposure to dust shall comply with the requirements of the Oven Test, Section 19, the Operating Temperature Test, Section 22, or the Rate-of-Rise Operation Test, Section 23, whichever is applicable.

Figure 46.1
Dust test chamber



47 Tests on Polymeric Materials

47.1 General

47.1.1 Polymeric materials intended for the sole support of current-carrying parts or as an enclosure of a detector shall be subjected to the tests specified in 47.2.1 – 47.3.6. If possible, a complete detector is to be used.

47.2 Temperature test

47.2.1 There shall not be warping that impairs intended operation or exposes high-voltage uninsulated current-carrying parts when representative samples of a polymeric material are aged for 7 days in a circulating air-oven maintained at 194°F (90°C) or 28 days at 158°F (70°C) and in both cases at a relative humidity of 0 – 10 percent.

47.2.2 Three representative samples are to be mounted on supports as intended in service and placed in the oven. Following the aging period indicated in 47.2.1, the samples are to be viewed (while in the oven) for distortion, removed, permitted to cool to room temperature, and then reexamined for compliance with the requirements of 47.2.1. The detector cover may fall off provided that no high-voltage parts are exposed, operation is not affected, and the cover can be replaced as intended.

47.3 Flame test

47.3.1 When tested as specified in 47.3.3 – 47.3.6, a plastic material employed as parts of a detector for the sole support of current-carrying parts or as an enclosure shall not continue to burn for more than 1 minute after the fifth 5-second application of a test flame, with an interval of 5 seconds between applications of the test flame. There shall not be flaming or dripping particles or complete consumption of the sample during the test, and the material shall not be destroyed in the area of the test flame to such an extent that the integrity of the enclosure is affected. Three samples of the material or three test specimens consisting of a part or section of the enclosure are to be subjected to this test. Consideration may be given to leaving in place components and other parts that may influence the performance.

47.3.2 Prior to the flame test, the test samples are to be conditioned in a circulating air oven in accordance with either test condition described in 47.2.1. The samples are to be cooled to room temperature.

47.3.3 Two of the three test samples shall comply with the performance requirements. If one sample does not comply, the test shall be repeated on a new sample with the flame applied under the same conditions as for the noncomplying sample. If the new sample does not comply with the requirements, the construction tested does not comply with the flame test requirements.

47.3.4 The following test equipment is to be employed:

a) Test Chamber – The test chamber is to consist of a sheet metal cell 2 by 1 by 1 feet (0.6 by 0.3 by 0.3 m), open at the top and on one long side. The chamber is to be located so that an ample supply of air is provided, but the sample is not to be subjected to drafts. The chamber may be placed in a hood, provided that the fan is turned off during the test and allowed to run only between tests to remove fumes.

b) A ring stand with a clamp is to be used for supporting the specimens.

c) Burner and Mounting Block – The test flame is to be obtained by means of a Tirrill gas burner having a nominal bore of 3/8 inch (9.5 mm). The tube length above the primary air inlets is to be approximately 4 inches (102 mm). The burner is to be adjusted so that, while the burner is in a vertical position, the overall height of the flame is 5 inches (127 mm) and the height of the inner blue cone is 1-1/2 inches (38.1 mm). A mounting block is to be provided so that the burner may be positioned at an angle of 20 degrees from the vertical.

d) A stopwatch or clock.

e) A circulating-air oven.

47.3.5 The test samples are to be mounted as intended in service in the test chamber. The test flame is to be applied at an angle of 20 degrees from the vertical to any portion of the interior of the enclosure judged as likely to be ignited by proximity to live or arcing parts, coils, wiring, and the like.

47.3.6 The test flame is to be applied to a different location on each of the three samples tested.

47.4 Impact test

47.4.1 A thermoplastic enclosure shall withstand an impact of 7 J without permanent distortion to the extent that the spacings are reduced below acceptable values (see Section 14) or transient distortion which results in contact with live parts, and without causing openings which expose uninsulated high-voltage live parts.

Added 47.4.1 effective October 4, 2004

47.4.2 The impact is to be applied by means of a solid, smooth, steel sphere approximately 2 inches (50 mm) in diameter and weighing approximately 1.18 pounds (0.54 kg). The sphere is to fall freely from a position of rest through a vertical distance of approximately 51.5 inches (1310 mm) to apply an impact of 7 J.

Added 47.4.2 effective October 4, 2004

48 Strain Relief Test

48.1 Each lead employed for field connections or an internal lead or cord subjected to movement or handling during installation and servicing, including a battery clip lead assembly, shall withstand for 1 minute a force of 10 pounds (44.5 N) without any evidence of damage or of transmitting the stress to internal connections.

48.2 A strain relief test on a cord or leads that depend upon a thermoplastic enclosure or part is to be conducted following exposure to either temperature conditioning test described in 47.2.1. The test is to be performed after the sample has been placed in a room temperature environment for at least 3 hours.

49 Abnormal Operations Test

49.1 A detector with a polymeric enclosure shall be constructed such that the detector will initiate an alarm signal before being consumed by heat from a fire.

49.2 For this test four samples are to be mounted on a 4-foot (1.2 m) square board that is placed 5 feet (1.5 m) above the center of a 3-foot (0.9-m) square pan filled with denatured alcohol. The alcohol is to be ignited and the time and condition of the sample noted when an alarm is initiated.

MANUFACTURING AND PRODUCTION TESTS

50 General

50.1 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, Section 51, and the Sensitivity Calibration Tests, Section 52, except that other test arrangements may be considered and employed if determined to achieve the results contemplated. A record of complying heat detectors and the detector serial number or equivalent is to be maintained.

50.2 The sensitivity of a tested heat detector 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.

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51 Production Line Dielectric Voltage-Withstand Test for High-Voltage Products

51.1 Each heat detector rated at more than 30 volts ac rms (42.4 volts 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 hertz, 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 detector rated 250 volts ac rms or less – either 1000 volts (1414 volts, if a dc potential is used) applied for 60 seconds or 1200 volts (1697 volts, if a dc potential is used) applied for 1 second.

b) For a heat detector rated more than 250 volts – either 1000 volts plus twice the rated ac rms voltage (1414 volts plus 2.828 times the rated ac rms voltage, if a dc potential is used) applied for 60 seconds or 120 volts plus 2.4 times the rated voltage (1697 volts plus 3.394 times the rated ac rms voltage, if a dc potential is used) applied for 1 second.

51.2 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 detector.

51.3 A 500 volt-ampere or larger transformer, the output voltage of which can be varied, is to be used to determine compliance with 51.1. The requirement of a 500 volt-ampere or larger transformer can be waived if the high potential testing equipment used is such that it maintains the specified voltage at the heat detector during the test.

51.4 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.

52 Sensitivity Calibration Tests

52.1 Rate-of-rise heat detectors

52.1.1 Each production heat detector that operates on the rate-of-rise principle shall be subjected to calibration tests by the manufacturer before shipment to determine that:

a) The unit does not operate when the rate of temperature rise is 12°F (6.7°C) per minute or less, until a temperature of at least 130°F (54°C) is reached [starting from a temperature of 85 – 90°F (29.4 – 32.2°C)].

b) The unit functions at the rate of rise for which it was initially investigated.

52.2 Fixed-temperature heat detectors

52.2.1 Samples of each temperature rating of a fixed-temperature, self-restoring heat detector 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 22.

52.2.2 Samples of each temperature rating of a fixed-temperature, nonrestorable (spot-type) heat detector 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 22.

52.2.3 Samples of each temperature rating of a fixed-temperature, nonrestorable, heat-sensitive cable shall be subjected to a water bath test, oil bath test, or air oven test by the manufacturer to determine that the cable operates within the temperature range specified in the Operating Temperature Test, Section 22. A 3-foot (0.9-m) section of the heat sensitive cable is to be used.

MARKING

53 General

53.1 A heat detector shall be permanently marked, see the Marking Label Adhesion Tests, Section 35, with the information specified in (a) – (e). The marking in (f) shall also be provided as applicable. The marking shall be in a contrasting color, finish, or the equivalent. Markings described in (a) – (d) may appear on the inside of the device if it can be examined upon removal of not more than two mounting screws.

a) Name or identifying symbol of the manufacturer or private labeler.

b) Temperature rating in degrees Fahrenheit. For a line type of cable the temperature may be identified by colored threads woven in the braid.

c) Model number and date of manufacture or equivalent.

d) Electrical rating of contacts in volts, amperes or watts, and frequency.

e) The designation ″DO NOT PAINT,″ or the equivalent. The letters shall be not less than 1/8 inch (3 mm) high and shall be located so as to be clearly visible after the heat detector is mounted in its intended manner.

f) Two-wire electronic heat detectors shall include a compatibility identifier consisting of any six-digit or less alphanumeric combination.

53.2 Spot-type heat detectors shall bear distinctive color markings in accordance with Table 53.1.

53.3 Where the overall color of a heat detector is the same as the color marking required for that detector, either one of the following arrangements, applied in a contrasting color and visible after installation, shall be employed:

a) A ring on the surface of the detector or

b) The temperature rating in numerals at least 3/8 inch (9.5 mm) high.

53.4 If a manufacturer produces heat detectors at more than one factory, each device shall have a distinctive marking to identify it as the product of a particular factory.

Table 53.1
Marking

Revised Table 53.1 effective October 4, 2004

Temperature rating	Temperature rating range, °F	Temperature rating range, (°C)	Maximum installation temperature °F	Maximum installation temperature (°C)	Color code
Low	100 – 134	37.8 – 56.7	a		Yellow[b]
Ordinary	135 – 174	57.2 – 78.9	100	38	Uncolored
Intermediate	175 – 249	79.4 – 120.6	150	66	White
High	250 – 324	121 – 162.2	225	107	Blue
Extra High	325 – 399	163 – 203.8	300	149	Red
Very Extra High	400 – 499	204 – 259.4	375	191	Green
Ultra High	500 – 575	260 – 302	475	246	Orange

[a] 20°F (11.1°C) below rating.

[b] In addition to the color code marking, units shall also be marked to indicate the maximum ambient installation temperature.

53.5 A heat detector that may be used outdoors may additionally be marked with the designation ″OUTDOOR USE,″ or ″WEATHER RESISTANT USE,″ or the equivalent.

53.6 The markings for a heat-sensitive cable shall be indicated on a durable moisture-resistant tag that would require a cutting tool for removal.

53.7 Low-degree rated heat detectors shall be marked with the word ″CAUTION″ and the following or equivalent information, which may appear on the package, or on a ″stuffer″ or equivalent inside the package: ″To Avoid False Alarms Use Only In Controlled Ambient Temperatures At Least 20°F (11.1°C) Below Rating.″

54 Installation Instructions – Wiring Diagram

54.1 General

54.1.1 Installation instructions, including an installation wiring diagram, shall be packaged with each detector (head with integral base) illustrating the field connections to be made. For detectors that consist of separable heads and bases, the instructions and diagram shall be packaged with the base. It is not prohibited for the instructions to be attached to the detector (head with integral base) or separable base. When not attached, the instructions shall be referenced in the detector (head with integral base) or base marking.

Added 54.1.1 effective October 4, 2004

54.1.2 The installation wiring diagram shall show a pictorial view of the installation terminals or leads to which field connections are to be made as specified in (a) – (c):

a) Supervised connections (identified incoming and outgoing leads) to the initiating device circuit of a control unit and power supply circuit. See Figure 54.1 for examples.

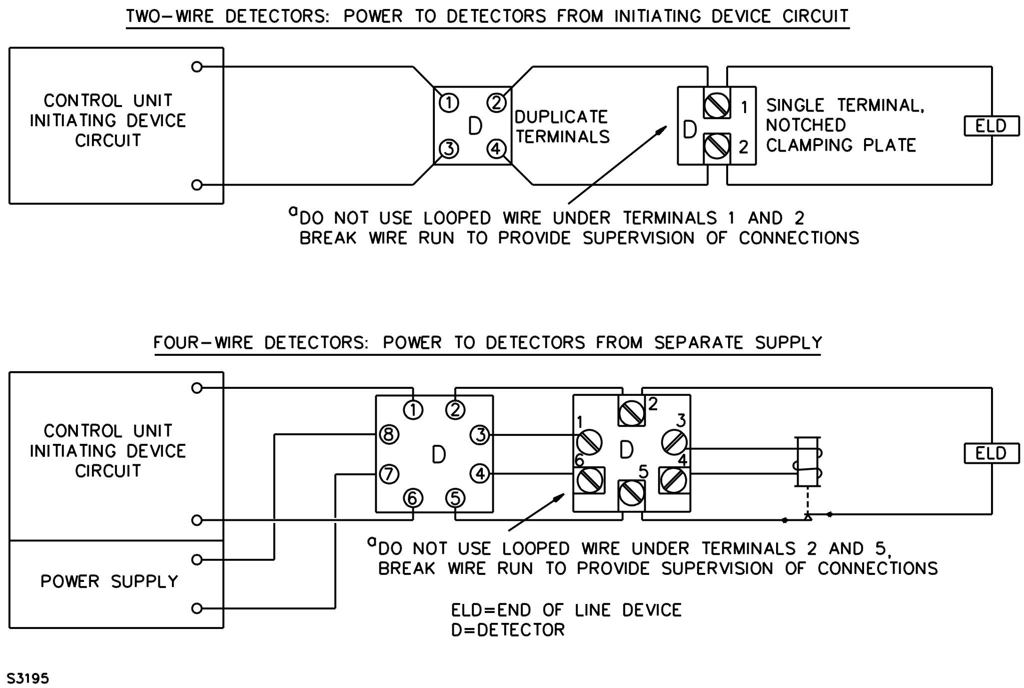
b) The terminal numbers or position (if distinctive) on the detector (head with integral base) or separable base shall agree with the numbers or position on the drawing.

c) When duplicate terminals are not provided to facilitate supervision of the installation wiring connections, and there is no provision to prevent looping an unbroken wire around or under a terminal, the word ″CAUTION″ and the following or equivalent text in letters not less than 3/32 inch (2.38 mm) high shall be included on the installation drawing: ″FOR SYSTEM SUPERVISION – FOR TERMINALS ___ AND ___, DO NOT USE LOOPED WIRE UNDER TERMINALS. BREAK WIRE RUN TO PROVIDE SUPERVISION OF CONNECTIONS″. The blanks shall contain the applicable terminal identification.

Added 54.1.2 effective October 4, 2004

Figure 54.1
Sample installation drawing for supervised connection of heat detectors

Added Figure 54.1 effective October 4, 2004



54.1.3 Instructions (diagram) not attached to the detector (head with integral base) or separable base shall be marked with the name or identifying symbol of the manufacturer or private labeler, detector or separable base model number, issue number and date, or equivalent.

Added 54.1.3 effective October 4, 2004

54.1.4 Installation instructions for a separable base shall include reference to all detector heads with which it is employed, by name of manufacturer and model number, or equivalent.

Added 54.1.4 effective October 4, 2004

54.1.5 When a technical bulletin or engineering drawing is separate from the installation instructions, the instructions shall reference the issue number or date of the bulletin.

Added 54.1.5 effective October 4, 2004

54.1.6 When other technical literature is required for installation or determination of compatibility between equipment, the instructions shall reference and identify the technical literature and its source. A copy of such literature shall be provided for review.

Added 54.1.6 effective October 4, 2004

54.2 Four-wire detectors

54.2.1 The marking information specified in (a) – (c) shall appear on the installation wiring diagram for the applicable circuit to which field connections are made:

a) Supply Circuit – Voltage, current or watts, and frequency;

b) Initiating Device Circuit – For open area detectors intended to be connected only to the initiating device circuit of a fire alarm system control unit, at least two detectors shall be shown connected to a typical initiating device circuit. For a detector intended only for releasing device service, a typical connection shall be shown. For a detector intended for both applications, typical connections representing both types of connections shall be shown; and

c) Supplementary Circuits – voltage, current or watts.

Added 54.2.1 effective October 4, 2004

54.2.2 Units rated in minimum and maximum voltage (or current) limits shall be marked with those ratings.

Added 54.2.2 effective October 4, 2004

54.3 Two-wire detectors

54.3.1 The instructions for two-wire detectors shall either include or provide reference to other identifiable literature and its source that contains the following information:

a) Name of manufacturer, model number(s) of compatible control unit(s), and compatibility identification marker;

b) Name or model number of any plug-in zone module, zone card, or zone panel, when more than one is available;

c) Identification of any other part of the control unit, such as specific wiring terminal numbers, or reference to the control unit installation wiring diagram by issue number and date, or any other variables requiring programming which are a factor in determining compatibility;

d) The maximum number of detectors that are intended to be connected to each initiating device circuit of the control unit. This includes any detectors that employ an integral component, such as a relay or sounder, that consumes power during an alarm condition;

e) Minimum and maximum rated operating voltage;

f) Maximum rated normal standby current;

g) Minimum and maximum rated alarm current and impedance; and

h) Minimum current and voltage required for intended operation of integral components, such as a relay or sounder.

Added 54.3.1 effective October 4, 2004

55 Technical Bulletin

55.1 A technical bulletin shall be provided by the manufacturer and is to be available for each installation for use as a reference by the installer. The bulletin shall include reference to the National Fire Alarm Code, NFPA 72, for the installation of detectors. The information in the bulletin shall include guidelines on detector location, spacings, maintenance, and servicing tests under various environmental conditions and physical configurations. The information shall be in accordance with NFPA 72.

Added 55.1 effective October 4, 2004

55.2 Information regarding locations where detectors are not to be installed shall also be provided to minimize the possibility of false alarms.

Added 55.2 effective October 4, 2004

55.3 Reference to the bulletin number and date shall be provided, either on the detector nameplate marking or on the installation drawing. When the installation drawing is included as part of the technical bulletin, reference to the bulletin is to be indicated on the detector.

Added 55.3 effective October 4, 2004

55.4 The technical bulletin, carton, or literature shipped with the detector shall not include manufacturer’s claims on the operation of the detector that have not been substantiated by the performance tests included in Sections 19 – 49, or that are not covered in the National Fire Alarm Code, NFPA 72, or other applicable standards of the National Fire Protection Association.

Added 55.4 effective October 4, 2004

55.5 The technical bulletin for heat detectors for special application shall specifically identify the environments within which the detectors are to be installed.

Added 55.5 effective October 4, 2004

SUPPLEMENT SA - INSTRUCTIONS FOR DETERMINING A RELIABILITY PREDICTION OF ELECTRONIC COMPONENTS AND MICROELECTRIC CIRCUITS

SA1 Methods of Determining Failure Rate

SA1.1 PARTS COUNT METHOD – For use only with low and ordinary rated heat detectors. Higher rated detectors must use the parts stress analysis method. When using this method the failure rate is to be determined as follows:

a) Select generic failure rate from the table among Tables SA1.1 – SA1.6 that most closely approximates the component employed.

b) Determine the quality factor multiplier for each component from Tables SA1.7– SA1.9.

c) Multiply the generic failure rate by its associated quality factor multiplier to obtain the final failure rate for the component. See sample calculation, Table SA1.10.

Note: Mil-specification numbers in Tables SA1.4 and SA1.5 are provided for reference only to determine general component type.

SA1.2 PARTS STRESS ANALYSIS METHOD[a] – The failure rate is calculated using the procedure in MIL-HDBK 217B, Section 2. Calculations and supporting data on rating of components for the determination will be required for review. See also Table SA1.11 and Figure SA1.1 for equations and tabulation sheets.

[a]If a MIL-Spec component is required in a detector but does not employ a specific marking to that effect, it will be necessary for the detector manufacturer to provide documentation to verify that the component is MIL-Spec graded. The documentation may be in the form of a shipping order, invoice, or equivalent, provided by the component supplier.

SA1.3 SCREENING BURN-IN METHOD – This method is required for the evaluation of custom integrated circuit ″chips″ although it may also be applied to any other component of a detector, including generic ″chips.″ The evaluation is to consist of a burn-in test program to determine the numerical failure rate coupled with a minimum quality assurance screening program for all production units. See Sections SB1 – SB3.

SA1.4 PUBLISHED RELIABILITY DATA – This method may be employed for the evaluation of generic integrated circuit ″chips″ as well as any other component of a detector, except for a custom ″chip.″ The evaluation is derived by the use of generic failure rate data from industry and military recognized publications on component reliability based on field accumulated data. Examples of such publications include Micro-Circuit Device Reliability, Linear/Interface Data and Micro-Circuit Device Reliability, and Digital Generic Data. Devices evaluated by this method shall comply with the identification program in SB1.3, and minimum screening program of Table SB2.1.

Table SA1.1
Generic failure rate for standard bipolar digital devices (TTL and DTL) in failures per million hours

Circuit complexity	Failure rate
1 to 20 Gates[a]	0.029
21 to 50 Gates	0.062
51 to 100 Gates	0.094
101 to 500 Gates	0.38
Greater than 500 Gates	6.0
Memories, less than or equal to 1000 Bits	0.30
Memories 1001 to 4000 Bits	0.70
Memories 4001 to 8000 Bits	1.2

[a] Assume 1 Gate is equivalent to four transistors.

Table SA1.2
Generic failure rate for standard bipolar beam lead and ECL, bipolar and MOS linear, and all other MOS devices in failures per million hours

Circuit complexity	Failure rate
1 to 20 Gates[a]	0.048
21 to 50 Gates	0.19
51 to 100 Gates	0.31
101 to 500 Gates	1.4
Greater than 500 Gates	23
Linear, less than or equal to 32 Transistors	0.052
Linear, 33 to 100 Transistors	0.12
Memories, less than or equal to 1000 Bits	1.2
Memories 1001 to 4000 Bits	2.7
Memories 4001 to 8000 Bits	4.5

[a] Assume 1 Gate is equivalent to four transistors.

Table SA1.3
Generic failure rate for discrete semiconductors in failures per million hours

Part type	Failure rate
Transistors:	
Silicon NPN	0.18
Silicon PNP	0.29
GePNP	0.41
GeNPN	1.1
FET	0.52
UJT, PUT[a]	1.7
Diodes:	
Silicon, General Purpose	0.12
Germanium, General Purpose	0.26
Zener and Avalanche	0.16
Thyrister	0.16
Silicon Microwave Detector	2.2
Ge Microwave Detector	5.6
Silicon Microwave Mixer	3.0
Ge Microwave Mixer	10.0
Varactor, Step	1.5

[a] A lower failure rate (0.16 failures/10^6 hrs) may be assigned provided the construction of the device is comparable to that of a thyrister.

Table SA1.4
Generic failure rate for resistors in failures per million hours

Resistors, fixed			Failure rate
Construction	**Style**	**Mil-R-Spec. (Ref. only)**	
Composition	RCR	39008	0.002
Composition	RC	11	0.01
Film	RLR	39017	0.015
Film	RL	22684	0.075
Film	RNR	55182	0.017
Film	RN	10509	0.017
Film, Power	RD	11804	0.96
Wire-Wound, Accurate	RBR	39005	0.056
Wire-Wound, Accurate	RB	93	0.28
Wire-Wound, Power	RWR	39007	0.033
Wire-Wound, Power	RW	26	0.17
Wire-Wound, Chassis Mount	RER	39009	0.062
Wire-Wound, Chassis Mount	RE	18546	0.31
Resistors, Variable			
Wire-Wound, Trimmer	RTR	39015	0.066
Wire-Wound, Trimmer	RT	27208	0.33
Wire-Wound, Precision	RR	12934	2.7
Wire-Wound, Semi-Precision	RA	19	2.3
Wire-Wound, Semi-Precision	RK	39002	2.3
Wire-Wound, Power	RP	22	2.3
Non-Wire-Wound, Trimmer	RJ	22097	4.6
Composition (Common Pot)	RV	94	
Factory Preset and Sealed			0.46
Field Variable			3.7

Table SA1.5
Generic failure rate for capacitors in failures per million hours

Dielectric	Style	Mil-C-Spec. (Ref. only)	Failure rate
Paper/Plastic	CHR	39022	0.0006
Paper/Plastic	CPV	14157	0.0006
Paper/Plastic	CQR	19978	0.0006
Paper/Plastic	CQ	19978	0.006
Mica	CMR	39001	0.0032
Mica	CM	5	0.032
Mica	CB	10950	0.58
Glass	CYR	23269	0.011
Ceramic	CKR	39014	0.022
Ceramic	CK	11015	0.22
Tantalum, Solid	CSR	39003	0.026
Tantalum, Nonsolid	CLR	39006	0.034
Tantalum, Nonsolid	CL	3965	0.34
Aluminum, Oxide	CU	39018	0.23
Aluminum,			
Dry Electrolyte	CE	62	0.41
Ceramic, Variable	CV	81	1.1
Piston, Variable	PC	14409	0.11

Table SA1.6
Generic failure rate for miscellaneous parts in failures per million hours

Part type	Failure rate
Pulse Transformer	0.0027
Audio Transformer	0.0066
Power Transformer and Filters	0.021
RF Transformers and Coils	0.022
Connectors	0.45
Connections	
Solder, Reflow Lap to Printed Circuit Boards	0.00012
Solder, Wave to Printed Circuit Boards	0.00044

Table SA1.6 Continued

Part type	Failure rate
Other Hand Solder Connections (e.g., Wire to Terminal Board)	0.0044
Crimp	0.0073
Weld	0.002
Wirewrap	0.0000037
Coaxial Connectors	0.63
Toggle Switches	0.57
Push-Button Switches	0.38
Sensitive Switches	0.90
Rotary Switches	1.4
General-Purpose Relays	0.30
High-Current Relay	1.0
Latching Relays	0.29
Reed Relays	0.26
Meters and Bimetal	5.7
Two-Sided Printed-Wiring Boards	0.0024
Multilayer Printed-Wiring Board	0.30
Quartz Crystals	0.20
Thermistor	
Bead	0.10
Disc	0.31
Fuses	0.10
Neon Lamps	0.20
Photocells	0.02
Light-Emitting Diodes (LED)	
General-Use (indicator light)	0.20
Light Source of Photoelectric Detectors	2.50[a]

[a] This is the maximum value permitted and is based on the failure rate of half light output. Selected LED's having projected lower failure rates at half light output are usually employed. The reliability is to be evaluated on data supplied by LED manufacturer.

Table SA1.7
Quality factors for Tables SA1.1 and SA1.2

Quality level or screen class	Description	Quality factor
A	Mil-M-38510, Class A	0.5
B	Mil-M-38510, Class B	1
B – 1	Mil-Std-883A, Method 5004, Class B	2.5
B – 2	Vendor Equivalent of Mil-Std-883A, Method 5004, Class B	5
C	Mil-M-38510, Class C	8
D	Commercial (or non-Mil Standard) Part with no screening beyond the manufacturer's regular quality assurance practices	75
E	Screening procedure per Table SB2.1	8

Table SA1.8
Quality factor for Table SA1.3

Part class	Quality factor
JANTXV	0.1
JANTX	0.2
JAN	1.0
Commercial Grade	1.0

Table SA1.9
Quality factor for Tables SA1.4 and SA1.5

Failure rate level (established reliability parts)	Quality factor
L	1.5
M	1.0
P	0.3
R	0.1
S	0.01

NOTE – For nonestablished reliability parts the quality factor equals 1.5. The quality factor for all miscellaneous parts equals 1.0.

Table SA1.10
Component reliability prediction

Component	Generic failure rate (A)	Quality factor multiplier (B)	Failure rate[a] failures/10^6 hrs, A times B
Composition Resistor	0.01	1	0.01
Composition Resistor	0.01	1	0.01
Composition Resistor	0.01	1	0.01
Film Resistor	0.075	1	0.075
Film Resistor	0.075	1	0.075
Wire-Wound Resistor, Power	0.17	1	0.17
Capacitor, Plastic	0.006	1	0.006
Capacitor, Plastic	0.006	1	0.006
Capacitor, Tantalum, Solid	0.026	1	0.026
Capacitor, Dry Electrolyte	0.41	1	0.41
Transistor, Silicon NPN	0.18	0.3	0.06
Transistor, Silicon NPN	0.18	0.3	0.06
Thyrister (SCR)	0.16	1	0.16
Diode, Silicon	0.12	1	0.12
Diode, Silicon	0.12	1	0.12
Relay, Reed	0.26	1	0.26
Relay, General Purpose	0.30	1	0.30
Connector	0.45	1	0.45
Printed-Wiring Board	0.0024	1	0.0024
Switch, Push Button	0.38	1	0.38
Potentiometer, Factory Preset	0.46	1	0.46
LED (Indicator Lamp)	0.20	1	0.20

[a] Failure rate for individual components shall not exceed 2.5 failures per million hours.

Table SA1.11
Parts stress analysis method references

Type device	Applicable equation	MIL-HDBK-217B 9/20/74 page reference
Monolithic Bipolar and MOS Digital SSI/MSI Devices < 100 Gates or 400 Transistors	$\lambda_p = \pi_L \pi_Q (C_1 \pi_T + C_2 \pi_E)$	2.1.1-1
Monolithic Bipolar and MOS Linear Devices	$\lambda_p = \pi_L \pi_Q (C_1 \pi_{T2} + C_2 \pi_E)$	2.1.2-1
Monolithic Bipolar and MOS Digital LSI Devices · 100 Gates or 400 Transistors	$\lambda_p = \pi_L \pi_Q (C_1 \pi_T + C_2 \pi_E)$	2.1.3-1
Monolithic MOS and Bipolar Memories	$\lambda_p = \pi_L \pi_Q (C_1 \pi_T + C_2 \pi_E)$	2.1.4-1
Hybrid Devices	$\lambda_p = \lambda_b (\pi_T \times \pi_E \times \pi_Q \times \pi_F)$	2.1.7-1
Transistors Group I General Purposes	$\lambda_p = \lambda_b (\pi_E \times \pi_A \times \pi_Q \times \pi_{S2} \times \pi_C)$	2.2.1-1
Transistors Group II Field Effect Transistors	$\lambda_p = \lambda_b (\pi_E \times \pi_A \times \pi_Q \times \pi_C)$	2.2.2-1
Transistors Group III Unijunction	$\lambda_p = \lambda_b \times \pi_E \times \pi_Q$	2.2.3-1
Diodes, Group IV General Purpose	$\lambda_p = \lambda_b (\pi_E \times \pi_Q \times \pi_A \times \pi_{S2} \times \pi_C)$	2.2.4-1
Diodes, Group V Zeners	$\lambda_p = \lambda_b (\pi_E \times \pi_A \times \pi_Q)$	2.2.5-1
Diodes, Group VI Thyristers	$\lambda_p = \lambda_b \times \pi_Q \times \pi_E$	2.2.6-1
Diodes, Group VII Microwave Detectors and Mixers	$\lambda_p = \lambda_b \times \pi_E \times \pi_Q$	2.2.7-1
Diodes, Group VIII Varactor Step Recovery Tunnel	$\lambda_p = \lambda_b \times \pi_E \times \pi_Q$	2.2.8-1
RCR and RC Insulated Fixed Composition	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.1-1
RLR, RL, RNR, RN Fixed Film Insulated	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.2-1
RD/P Power Film	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.2-5
RBR and RB Fixed Wire-Wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.3-1
RWR and RW Power Type Fixed Wire-Wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.3-3
RER and RE Power Type, Chassis Mounted Fixed Wire-Wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.3-5
RTH Bead and Disc Type Thermistors	Read Direct From Table	2.5.4-1
RTR and RT Variable Lead Screw Activated Wire-Wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q \times \pi_V)$	2.5.5-1
RR Precision Wire-Wound Potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS} \times \pi_Q (\pi_R \times \pi_V \times \pi_C \times \pi_E)$	2.5.5-3
RA and RK (Not ER) Semi-Precision Wire-Wound Potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS} (\pi_R \times \pi_V \times \pi_Q \times \pi_E)$	2.5.5-7

Table SA1.11 Continued

Type device	Applicable equation	MIL-HDBK-217B 9/20/74 page reference
RP High-Power, Wire-Wound Potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS} \times \pi_Q(\pi_R \times \pi_V \times \pi_C \times \pi_E)$	2.5.5-13
RJ Non-Wire-Wound Trimmers	$\lambda_p = \lambda_b \times \pi_{TAPS}(\pi_R \times \pi_V \times \pi_Q \times \pi_E)$	2.5.6-1
RV Composition Potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS}(\pi_R \times \pi_V \times \pi_Q \times \pi_E)$	2.5.6-5
CPV Paper and Plastic Film, Est. Rel. CHR Metalized Paper, Est. Rel. CQ & CQR Paper and Plastic Film, ER & NON-ER	$\lambda_p = \lambda_b(\pi_E \times \pi_Q)$	2.6.1-1
CM Mica Molded, CMR Mica Dipped, Est. Rel.	$\lambda_p = \lambda_b(\pi_E \times \pi_Q)$	2.6.2-1
CB Button Mica	$\lambda_p = \lambda_b\ (\pi_E)\ (\pi_Q)$	2.6.2-3
CYR Glass Capacitors, Est. Rel.	$\lambda_p = \lambda_b(\pi_E \times \pi_{CV} \times \pi_Q)$	2.6.3-1
CK Ceramic, General Purpose, CKR Ceramic, General Purpose, Est. Rel.	$\lambda_p = \lambda_b(\pi_E \times \pi_Q)$	2.6.4-1
CC Ceramic, Temperature Compensating	$\lambda_p = \lambda_b\ (\pi_E)\ (\pi_Q)$	2.6.4-5
CSR Solid Tantalum Electrolytic, Est. Rel.	$\lambda_p = \lambda_b(\pi_E \times \pi_{SR} \times \pi_Q)$	2.6.5-1
CLR Nonsolid Tantalum, Est. Rel., CL Nonsolid Tantalum, NON Est. Rel.	$\lambda_p = \lambda_b(\pi_E \times \pi_Q)$	2.6.5-3
CU Aluminum Oxide Electrolytic	$\lambda_p = \lambda_b(\pi_E) \times \pi_Q$	2.6.6-1
CE Aluminum, Dry Electrolyte	$\lambda_p = \lambda_b(\pi_E) \times \pi_Q$	2.6.6-3
CV Variable Ceramic Capacitors	$\lambda_p = \lambda_b(\pi_E) \times \pi_Q$	2.6.7-1
PC Variable, Piston-Type Tubular Trimmer	$\lambda_p = \lambda_b(\pi_E) \times \pi_Q$	2.6.8-1
Transformers	$\lambda_p = \lambda_b(\pi_E \times \pi_F)$	2.7-1
Motors, High-Speed	$\lambda_p =(\lambda_E + \lambda_W)\ \pi_E$	2.8.1-1
Blowers	$\lambda_p = \lambda_E + \lambda_W$	2.8.2-1
Relays	$\lambda_p = \lambda_b(\pi_E \times \pi_C \times \pi_{CYC} \times \pi_F)$	2.9-1
Switches, Snap-Action Toggle or Pushbutton	$\lambda_p = \lambda_b(\pi_E \times \pi_C \times \pi_{CYC})$	2.10-1
Basic Sensitive Switches	$\lambda_p = \lambda_b(\pi_E \times \pi_{CYC})$	2.10-2
Rotary, Ceramic or Glass Wafer Silver Alloy Contacts	$\lambda_p = \lambda_b(\pi_E \times \pi_{CYC})$	2.10-3
Connectors	$\lambda_p = \lambda_b(\pi_E \times \pi_p) + N\lambda_{CYC}$	2.11-1
NOTE: π_Q multiplier same as for JAN Class C if Table SB2.1 screening is conducted.		

Figure SA1.1
Tabulation sheet

DEVICE	EQUATION	λ_b	π_Q	π_E	π_A	π_{S2}	π_C	π_R	π_V	π_{TAPS}	π_{SR}	π_{CV}	π_F	π_N	π_{CYC}	π_L	π_P	λ_{CYC}	λ_P

λ_P = Failure rate for Component – Failures/10^6 hours
(Sum of numbers for that Component)

Overall System Failure Rate Failures/10^6 hours

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SUPPLEMENT SB - CRITERIA FOR ACCEPTANCE OF MICROELECTRONIC DEVICES

SB1 General

SB1.1 The evaluation and criteria for acceptance of microelectronic devices consists of a two part procedure:

a) Part I consists of a quality assurance screening program either by the component vendor or detector manufacturer, to assure uniformity of production.

b) Part II includes a determination of a failure rate for the device supplemented by a one time burn-in test.

SB1.2 Although this program is oriented primarily to custom integrated circuits (″chips″), it can also be applied for other microelectronic devices.

SB1.3 Components that comply with the requirements of this program shall be distinctively marked for identification purposes. The detector manufacturer shall maintain on file, accessible to an inspector, copies of the purchase and shipping orders for all detectors and ″chips″ so that a tally of detectors shipped can be compared to the quantity of screened devices procured from the component vendor.

SB2 Part I – Quality Assurance Screening Program

SB2.1 A minimum screening program (see Table SB2.1) is to be established by the component manufacturer (vendor).

SB2.2 The test methods and conditions referenced in Table SB2.1 are based on the most current revisions to MIL-STD-883B dated July 31, 1977.

Table SB2.1
Minimum screening programs

Hermetic packages	
1. Internal visual (Method 2010.1 condition B modified)	100 percent[a]
2. Bond strength (Method 2011)	Sample Basis[a]
3. Stabilization bake (Method 1008C, 150° C, 24 hours)	100 percent[b]
4. Temperature cycling (Method 1010C, -55°C to 150°C, 10 cycles)	100 percent[c]
5. Seal (Fine leak 1014B, 5×10^{-8} CC/Sec)	100 percent[d]
6. Seal (Gross leak – 1014B fluorocarbon)	100 percent
7. Functional electrical test, 25°C	100 percent
8. External visual, Method 2009	100 percent
9. Quality conformance	AQL 1.5 percent per MIL-STD 105 Level II
a) Functional electrical test, 25°C	
b) Temperature cycling (Method 1010C, -55°C to 150°C, 10 cycles)	
c) Seal (Fine lead, Method 1014B 5×10^{-8} CC/Sec)[e]	
d) External visual, Method 2009	
Plastic packages	
1. Internal visual (Method 2010.1 condition B modified)	100 percent[a]
2. Bond strength (Method 2011)	Sample Basis[a]

Table SB2.1 Continued on Next Page

Table SB2.1 Continued

Hermetic packages	
3. Temperature cycling (Method 1010C, -55°C to 150°C, 10 cycles)	100 percent[c,f]
4. Functional electrical test, 25°C	100 percent
5. External visual, Method 2009	100 percent
6. Quality conformance	AQL 1.5 percent per MIL-STD 105 Level II
a) Functional electrical test, 25°C	
b) Temperature cycling (Method 1010C, -55°C to 150°C, 10 cycles)	
c) External visual, Method 2009	

[a] Modified Procedures or sample lot sizes are to be submitted for review.

[b] Stabilization bake may be waived if production process includes equivalent conditioning.

[c] Thermal Shock Method 1011.1, Condition B or C, may be substituted.

[d] May be reduced to 1.5 percent AQL provided vendor's first lot of 25,000 units shows statistical justification.

[e] May be waived if justified by the reject rate in Item 5.

[f] May be waived if the sample lot used in the burn-in test is subjected to 100 cycles of the temperature cycling and no devices fail as a result of the temperature cycling. The manufacturer shall then perform an annual audit of the device package type. This audit may be in the form of selecting samples from the same package type and subjecting them to the Temperature Cycling or Thermal Shock (Method 1010C or 1011.1, Condition B or C, MIL-STD-883D, April 9, 1979). Records shall be maintained for inspection.

SB3 Part II – Determination of Failure Rate Number Supplemented by Burn-In Test

SB3.1 General

SB3.1.1 The objective of this part is to determine a numerical failure rate for the device. The method employs Arrhenius calculations and activation energy tables to correlate elevated temperature operation to a failure rate of 38°C (100°F) (maximum installation ambient temperature of the detector).

SB3.2 Determination sequence

SB3.2.1 The following step-by-step procedure is to be employed in determining the failure rate number:

a) Estimate numerical failure rate desired.

b) Select desired test temperature for acceptance test.

c) Using selected test temperature, refer to curves in Figure SB3.1 to determine related test time for initial conditional acceptance and final acceptance.

d) Using the equation in SB3.5.1 and the initial conditional test time determined in SB3.2.1(c), calculate the failure rate of the device for conditional acceptance.

e) Sample lot size to be used in temperature test is determined from Table SB3.1. This table lists initial sample lot sizes based on expected failure rates in percent per 1000 hours at a 60 percent confidence level and number of devices that fail during the test, the latter listed as accept numbers. If a different temperature is employed, lot sizes can be derived from a table of Summation of Terms of Poisson's Exponential Binomial Limit[b] at a 60 percent confidence level.

f) Using the Arrhenius equation and the final test time determined in SB3.2.1(c), calculate the failure rate of the device for final acceptance.

[b]Reliability Handbook by W. Grant Ireson

Figure SB3.1
Time-temperature regression and allowable time limits for test condition

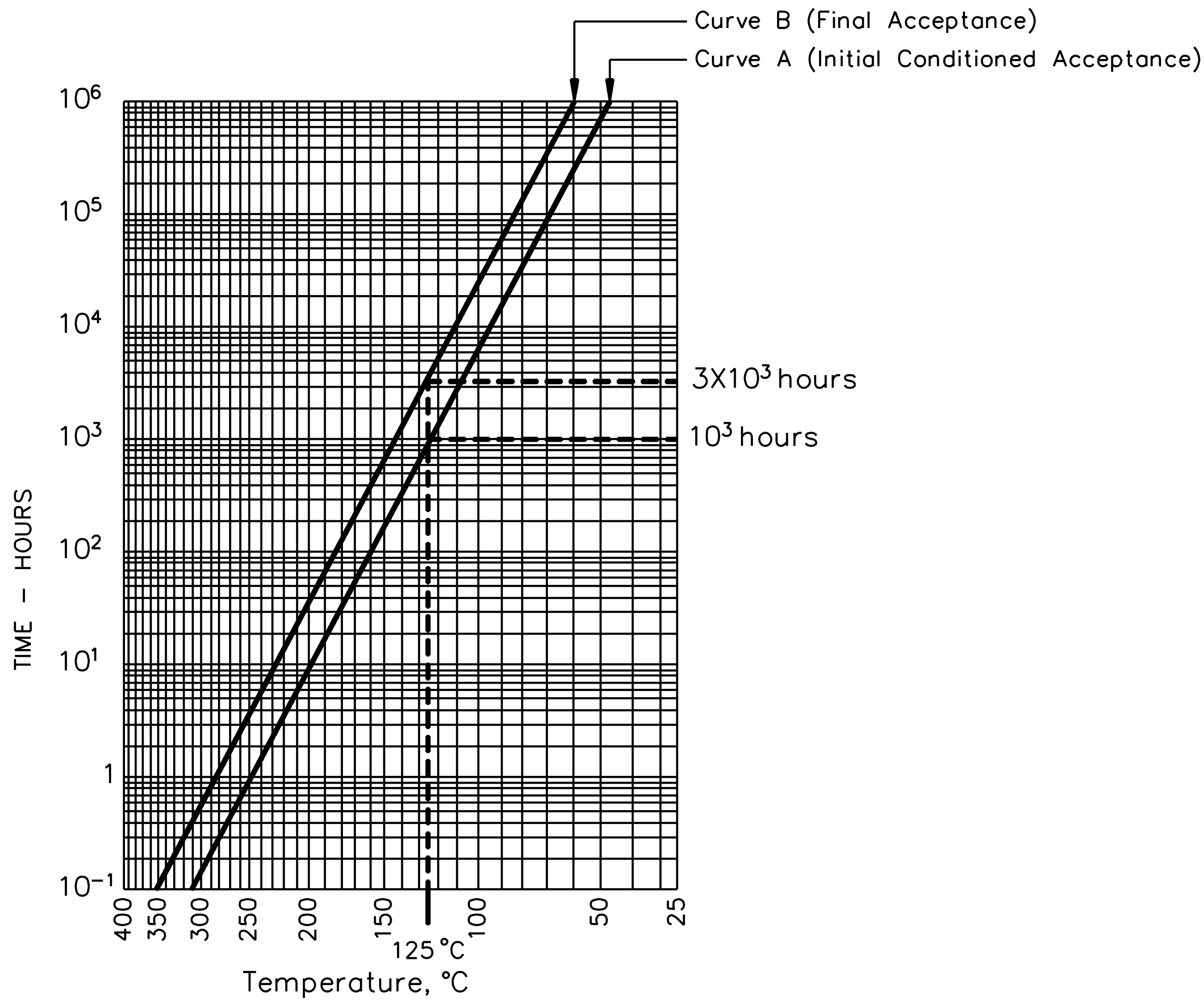

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Table SB3.1
Sample lot size for burn-in test

Accept number (C)	Failure rate – percent per 1000 hours																		
	20.00	18.00	15.00	12.00	10.00	8.00	7.00	6.00	5.00	4.00	3.00	2.00	1.50	1.00	0.70	0.30	0.20	0.15	0.10
0	5	5	6	8	9	12	13	16	19	23	31	47	62	93	133	311	466	622	933
1	11	12	15	18	22	27	31	36	44	54	73	109	145	218	311	725	1088	1451	2176
2	15	17	21	26	31	39	44	52	62	77	103	155	206	309	442	1031	1547	2062	3093
3	20	22	27	34	40	50	58	67	81	101	134	201	268	403	575	1342	2013	2684	4026
4	27	30	36	45	54	67	77	89	107	134	179	268	358	536	766	1788	2682	3576	5364
5	32	35	42	53	63	79	90	105	126	158	210	315	420	631	901	2102	3153	4204	6307
6	36	40	48	60	73	91	104	121	145	181	242	363	484	726	1037	2419	3629	4838	7257
7	41	45	54	68	81	101	116	135	162	203	270	405	540	810	1158	2701	4052	5403	8104
8	45	50	60	76	91	113	129	151	181	227	302	453	604	906	1295	3021	4531	6042	9063
9	50	56	67	84	100	125	143	167	200	251	334	501	668	1002	1432	3342	5012	6683	10025
10	60	67	80	100	120	150	171	200	240	300	399	599	799	1198	1712	3994	5991	7988	11982
11	65	72	86	108	129	162	185	216	259	324	431	647	863	1294	1849	4314	6472	8629	12943
12	70	77	93	116	139	174	199	232	278	348	464	696	927	1391	1987	4637	6956	9275	13912
13	74	83	99	124	149	186	212	248	297	372	496	744	991	1487	2124	4957	7435	9913	14870
14	77	85	102	128	153	192	219	255	307	383	511	766	1022	1533	2190	5109	7663	10218	15327
15	82	91	109	136	163	204	233	272	326	408	543	815	1087	1630	2329	5434	8151	10868	16302

SB3.3 Test calculations and procedures

SB3.3.1 Figure SB3.1 illustrates basic curves which represent burn-in test conditions of a device of 1000 hours for initial conditional acceptance and is continued to 3000 hours for final acceptance when tested at an elevated temperature of 125°C (257°F).

SB3.3.2 The elevated test temperature and related time periods (using the illustrated curves) may be increased or decreased except the minimum selected temperature for the burn-in test shall be not less than 100°C (212°F).

SB3.3.3 The following examples illustrate the use of the curves in Figure SB3.1 for calculations of final and initial conditional acceptance at temperatures other than 125°C (257°F):

a) Example 1 – Assuming a test temperature of 150°C (302°F):

1) Time for Initial Conditional Acceptance – 167 hours (using Curve A).

2) Time for Final Acceptance – 650 hours (using Curve B).

b) Example 2 – Assuming a test temperature of 100°C (212°F):

1) Time for Initial Conditional Acceptance – 5700 hours (using Curve A).

2) Time for Final Acceptance – 25,000 hours (using Curve B).

SB3.4 Test conditions

SB3.4.1 Acceptable sockets or other mounting means shall be provided to make firm electrical contact to the terminals of devices under test in the specified circuit configuration. The mounting means shall be constructed so that they will not remove internally dissipated heat from the device by conduction, other than that removed through the device terminals and the necessary electrical contacts, which shall be maintained at or above the specified ambient temperature. The apparatus shall provide for maintaining the specified biases at the terminal of the device under test and, when specified, monitoring of the input excitation.

SB3.4.2 Power supplies and current-setting resistors shall be capable of maintaining the specified operating conditions throughout the testing period with intended variations in their source voltages, ambient temperatures, and the like. The test equipment shall preferably be arranged so that only natural convection cooling of the devices occur. When test conditions result in significant power dissipation, the test apparatus shall be arranged so as to result in the approximate average power dissipation for each device whether devices are tested individually or in a group. The test circuits need not compensate for intended variations in individual device characteristics but shall be arranged so that the existence of failed or excessed (for example open, short, or the like) devices in a group does not negate the effect of the test for other devices in the group.

SB3.5 Failure rate number calculation

SB3.5.1 The following equation is to be used in determining the initial conditional and final failure rates for the device in concert with the burn-in test. Extrapolations are made from the selected elevated test temperature to the maximum installation temperature of the heat detector by use of the Arrhenius Equation.

$$\lambda = A_e^{\left(\frac{-E}{KT}\right)}$$

in which:

λ is the failure rate per million hours;

A is the constant;

E is the activation energy in electron volts (ev) (varies between 0.65 ev to 1.1 ev for a large number of integrated circuits) – a value of 0.65 ev is to be used unless documentation is provided that justifies using a different value;

K is Boltzman's constant (8.62 $\times$ 10^{-5} ev/°K); and

T is the absolute temperature in degrees Kelvin.

The following is an example of an ordinary degree heat detector with a maximum installation temperature of 38°C (100°F):

a) Desired numerical failure rate λ_2 = 0.1 Failure per 10^6 hours.

b) Desired test ambient temperature is 125°C.

c) Required test time from Figure SB3.1 for conditional acceptance is 1000 hours and for final acceptance is 3000 hours.

d) Using the equation in SB3.5.1 and assuming an Activation Energy (E) of 0.65 ev, the following calculations are performed:

$$\lambda_1 = A_e^{\left(\frac{-E}{KT}\right)} \quad for\ 125°C$$

$$\lambda_2 = A_e^{\left(\frac{-E}{KT}\right)} \quad for\ 38°C$$

Then:

$$\frac{\lambda_1}{\lambda_2} = \ln^{-1}\left[\frac{-E}{K}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right]$$

in which:

λ_2 is 0.1 Failure per 10^6 hours;

E is 0.65 ev;

T_1 is 398°K;

T_2 is 311°K; and

K is 8.62 × 10^{-5} ev/°K.

Then:

$$\lambda_1 = \lambda_2 \ \ln^{-1}\left[\frac{-0.65}{-8.62 \times 10^{-5}}\left(\frac{1}{348} - \frac{1}{311}\right)\right]$$

in which:

λ_1 is 20×10^{-6} Failures/hour.

λ_1 is 20 Failures/10^6 hours.

λ_1 is 0.02 Failure/1000 hours.

λ_1 is 2.0 percent/1000 hours.

e) Referring to Table SB3.1, the following sample lot size for the appropriate accept number (C – the number of failures or less) can be used at the conditional acceptance point (1000 hours). For 2.0 percent per 1000 hours:

C = 0 N = 47,

C = 1 N = 109,

C = 2 N = 155, and the like.

From the equation and Table SB3.1, with no failures from a sample lot size of 47 at a test ambient of 125°C, the failure rate is 0.1 Failure/10^6 hours at the conditional acceptance point of 1000 hours. The failure rate may be less at the final acceptance point of 3000 hours.

APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard − UL Standard Designation

Control Units for Fire-Protective Signaling Systems – UL 864
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Printed-Wiring Boards – UL 796
Switches, Snap, General-Use – UL 20
Tape, Polyvinyl Chloride, Polyethylene, and Rubber Insulating – UL 510
Transformers, Specialty – UL 506
Tubing, Extruded Insulating – UL 224
Wire Connectors and Soldering Lugs for Use With Copper Conductors – UL 486A
Wires and Cables, Thermoplastic-Insulated – UL 83
Wires and Cables, Thermoset-Insulated – UL 44

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Superseded requirements for
the Standard for
Heat Detectors for Fire Protective Signaling Systems

UL 521, Seventh Edition

The requirements shown are the current requirements that have been superseded by requirements in revisions issued for this Standard. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

29.1 General

29.1.1 An electronic heat detector:

a) Shall operate for its intended signaling performance; and

b) Shall not initiate a false alarm or a trouble signal;

The sensitivity shall not be adversely affected after being subjected to 500 internally induced transients, extraneous transients, 500 (high voltage) supply line transients, and 60 supply line (low-voltage) circuit transients, while energized from a source of supply as specified in Test Voltages, Section 16, and connected to the devices intended to be used with the detector.

29.3.2 To determine compliance with 29.3.1, two detectors are to be energized from a source of rated voltage and frequency and subjected to transients generated from the following devices located 1 foot (305 mm) from the detector, interconnecting wires, or both. The time of application for condition A is to be at least 2 minutes. Conditions (b), (c), (d), and (e) are to be applied for 10 cycles, each application of 2 seconds duration, except the last application shall be of a 2-minute duration. Near the end of the last cycle, the detector is to be subjected to an abnormal amount of heat to determine whether the unit is operational with the transient applied. For condition (b), the 1-foot distance is to be measured from the transmitter-receiver (walkie-talkie) antennae to the surface of the detector.

a) Sequential arc (Jacob’s ladder) generated between two 15 inch (381 mm) long, No. 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 separation of 1/8 inch (3.2 mm) at the bottom (adjacent to terminals) and extending to 1-1/4 inches (31.8 mm) at the top.

b) Energization and transmission of random voice message of three separate transmitter-receiver units (walkie-talkies) in turn, each having a 5 watt output and operating in the following nominal frequencies:

1) 27 megahertz,

2) 150 megahertz, and

3) 450 megahertz.

A total of six energizations are to be applied from each transmitter-receiver; five to consist of 5 seconds on and 5 seconds off, followed by one consisting of a single 15-second energization. For this test, the walkie-talkies are to be in the same room and on the same plane as the detector under test.

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 6-inch (152-mm) diameter solenoid-type vibrating bell[a] with no arc suppression and rated 24 volts dc.

[a] Edwards Model 439D-6AW vibrating bell rated 0.075 ampere, 20/24 volt dc or equivalent.

33.3 The test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 33.1. Spray heads are to be constructed in accordance with the details shown in Figure 33.2. The water pressure for all tests is to be maintained at 5 psig (34.4 kPa) at each spray head. The distance between the center nozzle and the unit is to be approximately 5 feet (1.52 m). The unit is to be brought into the focal area of the three spray heads in such a position and under such conditions that the greatest quantity of water will enter the unit while it is mounted on a vertical surface in a position of intended use. The spray is to be directed at an angle of 45 degrees to vertical toward the unit or openings closest to current-carrying parts. The total exposure is to be for 24 hours.

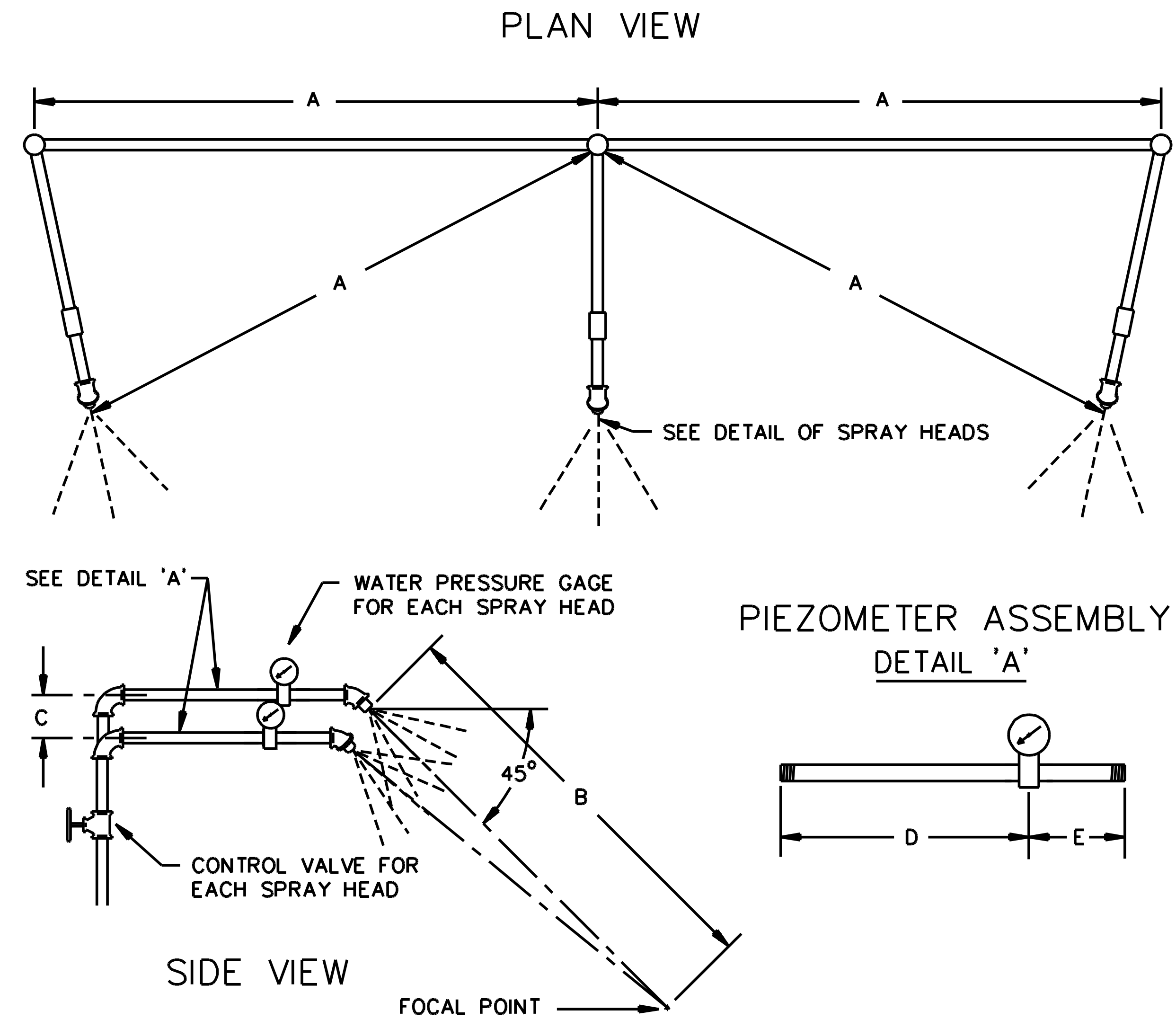
Table 53.1
Marking

Temperature rating	Temperature rating range, °F	Temperature rating range, (°C)	Maximum installation temperature °F	Maximum installation temperature (°C)	Color code
Low	100 – 134	37.8 – 56.7	a		b
Ordinary	135 – 174	57.2 – 78.9	100	38	Uncolored
Intermediate	175 – 249	79.4 – 120.6	150	66	White
High	250 – 324	121 – 162.2	225	107	Blue
Extra High	325 – 399	163 – 203.8	300	149	Red
Very Extra High	400 – 499	204 – 259.4	375	191	Green
Ultra High	500 – 575	260 – 302	475	246	Orange

[a] 20°F (11.1°C) below rating.

[b] Temperature rating (not a color code).

Figure 33.1
Rain-test spray-head piping



Item	inch	mm
A	28	710
B	55	1400
C	2−1/4	55
D	9	230
E	3	75

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