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Standard for Safety

UL 217

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Single and Multiple Station Smoke Detectors

Underwriters Laboratories Inc.®

Standard

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May 10, 1993

Standard for

Single and Multiple Station Smoke Detectors

UL 217, Fourth Edition

Accompanying this transmittal notice is a copy of the fourth edition of UL 217.

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UL 217

Standard for

Single and Multiple Station Smoke Detectors

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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 employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the 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 electrically operated single and multiple station smoke detectors intended for open area protection in ordinary indoor locations of residential units in accordance with the Standard for Household Fire Warning Equipment, NFPA 74, smoke detectors intended for use in recreational vehicles in accordance with the Standard for Recreational Vehicles, NFPA 501C, and portable smoke detectors used as "travel" alarms.

1.2 A single station smoke detector, as defined by these requirements, is a self-contained fire alarm device that consists of an assembly of electrical components including a smoke chamber, alarm sounding appliance, and provision for connection to a power supply source, either by splice leads or a cord and plug arrangement or containing integral batteries. A supplementary heat detector may be included as part of the appliance. Terminals may be included for connection to a remote audible signaling appliance or accessory. An integral transmitter may also be included to energize a remote audible signaling appliance.

1.3 Multiple station units are single station smoke detectors that may be either interconnected for common alarm annunciation or connected to remote thermostats.

1.4 These requirements, where applicable, also cover all remote accessories that may be connected to or are intended to be employed with a single or multiple station smoke detector. See 34.2.1.

1.5 This standard does not cover the following:

a) Smoke detectors of the nonself-contained type that are intended for connection to a household or industrial system control unit. These are included in the Standard for Smoke Detectors for Fire Protective Signaling Systems, UL 268.

b) Mechanically operated single and multiple station fire alarm devices that are specified in the Standard for Single and Multiple Station Heat Detectors, UL 539.

c) Heat detectors [except for the requirements in Optional Heat Detector, Section 32, and the Fire Test (Optional Heat Detector), Section 73] incorporated as part of a single station smoke detector assembly whose requirements are covered in the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521.

1.6 A product that contains features, characteristics, components, materials, or systems new or different from those in use when the standard was developed, and that involves a risk of fire, electrical shock, or injury to persons, shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the level of safety for the user of the product as originally anticipated by the intent of this standard.

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 B for a list of standards covering components generally used in the products covered by this standard.

2.1.2 A component need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed 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 recognized rating established for the intended conditions of use.

2.1.4 Specific components are recognized as being 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 for which they have been recognized.

2.2 Units of measurement

2.2.1 If a value for measurement as given in these requirements is followed by an equivalent value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

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.

3.2 ALARM SIGNAL — An audible signal intended to indicate an emergency fire condition.

3.3 ALARM VERIFICATION — The process that confirms the presence of an abnormal concentration of smoke particles in a detector for a predetermined period before an alarm signal is indicated.

3.4 COMBINATION SMOKE DETECTOR — A detector that employs more than one smoke detecting principle in one unit. To qualify as a combination smoke detector it is required that each principle contributes in response, either wholly or partially, to at least one of the Fire Tests (Section 45), or the Smoldering Smoke Test (Section 46).

3.5 COMPONENT, LIMITED LIFE — A component that is expected to fail and be periodically replaced and whose failure is supervised, if failure of the component affects normal operation or sensitivity. Typical examples of such components include incandescent lamps, electronic tube heaters, functional heating elements, and batteries. See also 37.4.2.

3.6 COMPONENT, RELIABLE — A component that is not expected to fail or be periodically replaced and is not supervised. A reliable component shall have a predicted failure rate of 2.5 or less failures per million hours.

3.7 SENSITIVITY — Relative degree of response of a detector. A high sensitivity denotes response to a lower concentration of smoke than a low sensitivity under identical smoke build-up conditions.

3.8 STORY — That portion of a building included between the upper surface of a floor and upper surface of the floor or roof next above.

3.9 TROUBLE LEVEL – Any combination of battery voltage and series resistance that results in an audible trouble signal from a battery-operated detector.

3.10 TROUBLE SIGNAL – A visual or audible signal intended to indicate a fault or trouble condition, such as an open or shorted condition of a component in the device or an open or ground in the connected wiring.

3.11 VOLTAGE CLASSIFICATION – Unless otherwise indicated, all voltage and current values mentioned in this standard are rms.

a) High-Voltage Circuit – A circuit classified as high-voltage is one having circuit characteristics in excess of those of a low-voltage circuit.

b) Low-Voltage Circuit – A circuit classified as low-voltage is one involving a potential of not more than 30 volts alternating current (42.4 volts peak or direct current), and supplied from a circuit whose power is limited to a maximum of 100 volt-amperes.

4 Detector Reliability Prediction

4.1 Detector units shall be designed to a maximum failure rate of 4.0 failures per million hours as calculated by a full part stress analysis prediction as described in Section 2.0 of MIL-HDBK 217B (20 September 1974) or 3.5 failures per million hours as calculated by a simplified parts count reliability prediction as described in Section 3.0 of MIL-HDBK 217B, or equivalent. A "Ground Fixed" (GF) environment is to be used for all calculations. If actual equivalent data is available from the manufacturer, it may be used in lieu of the projected data for the purpose of determining acceptable reliability.

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

a) Does not affect the normal operation, or

b) Is evaluated by specific performance tests included in this standard, need not be included in the failure rate calculation.

Examples include the audible signal appliance, optional thermostat, test switch, and battery contacts.

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

4.4 A reliable light emitting diode (LED) of a single station smoke detector employing a photocell-light assembly shall have a predicted failure rate of not greater than 2.5 failures per million hours. See 26.2.1 – 26.2.4 for LED operating conditions.

4.5 A custom integrated circuit (CHIP) employed in a detector shall have a predicted failure rate of not greater than 2.5 failures per million hours. The failure rate is to be determined through acceptable evaluation of data in a 3000 hour burn-in test, or equivalent.

5 Installation and Operating Instructions

5.1 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 homeowner's manual.

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

6 Nonfire Alarm Feature

6.1 A nonfire alarm feature, such as a burglar alarm, may be used in common with a single and/or multiple station smoke detector or accessory, provided it does not degrade or interfere with operation of the smoke detector or accessory and complies with all the requirements of this standard (see 4.3 and 35.1.9).

7 Alarm Silencing Means (Optional)

7.1 Each single and multiple station smoke detector may be provided with an automatically resettable alarm silencing means that has a fixed or variable time setting and that silences the detector alarm for a maximum of 15 minutes. Following the silenced period, the detector shall restore automatically to its intended operation. Silencing of one detector of a multiple station system shall not prevent an alarm operation from the other detectors in the system. See 35.2.1 and 35.2.2.

7.2 A variable adjustment may be provided on a detector to vary the silenced period. If included, the adjustment means shall be provided with a mechanical stop or the equivalent, so that the maximum 15-minute limitation cannot be exceeded.

8 Battery Removal Indicator

8.1 Removal of a battery from a battery-operated smoke detector shall result in a readily apparent and prominent visual indication. The visual indication shall consist of:

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

b) A hinged cover that cannot be closed with the battery removed; or

c) An equivalent arrangement.

8.2 If a warning flag, or equivalent, is employed to comply with the requirement of 8.1, it shall be marked as required in 88.6.

CONSTRUCTION

ASSEMBLY

9 General

9.1 Accessories

9.1.1 Unless specifically indicated otherwise, the construction requirements specified for a detector shall apply also for any remote accessories with which it is to be employed.

9.2 Sensitivity adjustment

9.2.1 If a field sensitivity adjustment is provided, it shall be accessible with the detector installed as intended, marked to indicate the direction of sensitivity (high or low), and shall employ a mechanical stop at both extremes. The sensitivity at the low sensitivity end shall be within the limits indicated in 38.1.1. Removal of a snap-on cover to gain access to the sensitivity control is permissible, if no high-voltage parts can be contacted by the user.

9.3 Radioactive materials

9.3.1 The manufacture, importation, distribution, and disposal of smoke detectors containing radioactive material are subject to the safety requirements of State radiation control agencies and/or the U. S. Nuclear Regulatory Commission.

9.3.2 Verification of the compliance of such detectors with the requirements of the regulating agency involved is required prior to or may be obtained concurrently with the establishment of compliance with the requirements of this standard.

9.4 Supplementary signaling feature

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

9.5 Insect guards

9.5.1 A detector shall be provided with a screen or equivalent protection (louvers, slots, holes) as a deterrent for entry of insects into the detecting chamber. The maximum opening size shall not be greater than 0.05 inch (1.27 mm).

9.5.2 To determine that the maximum opening size has not been exceeded, openings in rigid assemblies shall not permit passage of a 0.051 inch (1.30 mm) diameter rod. For nonrigid openings, such as a screen, ten measurements are to be made at different locations by an optical micrometer; five measurements are to be made in each direction (not on diagonal).

9.6 Supplementary heat detector

9.6.1 If a heat detector is provided integral with a smoke detector, the temperature rating of the heat detector shall not be less than 135°F (57°C). The heat detector may be either connected in the smoke detector circuit or intended for connection to a separate circuit.

9.7 Alarm verification feature (optional)

9.7.1 To reduce the effect of electrical and migratory smoke transients, a single and multiple station smoke detector may have provision for an alarm verification. The alarm verification time shall be 10 to 30 seconds. See 3.3, 35.2.1, 38.6.1, 45.1.3, 46.3, and 88.1(t).

9.7.2 If an alarm verification feature is incorporated in a detector, a bypass arrangement, readily accessible after installation, shall be provided. The bypass arrangement shall shunt out the alarm verification feature. The bypass may be included as part of the test feature described in 41.1.

Exception: The bypass is not required if the detector complies with the Fire Tests, Section 45, and the Smoldering Smoke Test, Section 46.

10 Servicing and Maintenance Protection

10.1 General

10.1.1 An uninsulated live part of a high-voltage circuit within the enclosure shall be located, guarded, or enclosed so as to minimize the likelihood of accidental contact by persons performing service functions which may be performed with the equipment energized.

10.1.2 An electrical component which may require examination, replacement, adjustment, servicing, or maintenance with the detector energized shall be located and mounted with respect to other components and with respect to grounded metal so that it is accessible for such service without subjecting the user to an electric shock from adjacent uninsulated high-voltage live parts.

10.1.3 The following are not considered to be uninsulated live parts:

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

b) Terminals and splices with insulation rated for the intended application; and

c) Insulated wire.

10.2 Sharp edges

10.2.1 An edge, projection, or corner of an enclosure, opening, frame, guard, knob, handle, or the like, of a smoke detector shall be smooth and rounded, so as not to cause a cut-type injury when contacted during use or user maintenance.

11 Enclosure

11.1 General

11.1.1 The enclosure 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 defects that, alone or in combination, may result in a risk of fire, electric shock, or injury to persons.

11.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two are to be considered in determining compliance with the requirement of 11.1.1.

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

11.1.4 There shall be no nonfunctional rear openings in a smoke detector intended for permanent wiring connection through which debris or air currents can pass that could affect detector response from smoke after the detector is installed as intended. A nonfunctional opening is one that is not required for operation or installation of a detector.

11.1.5 There shall be no openings between the mounting surface to which a detector is intended to be installed and the rear of the detector through which air can pass that could affect detector response from test smoke after the detector is installed as intended.

11.1.6 To comply with 11.1.4 and 11.1.5, one of the following methods, or its equivalent, may be used:

a) An elastomeric rubber or neoprene gasket, or the equivalent, may be interposed between the rear of the detector and the mounting surface to seal the rear openings and preclude the escape of air from around the edge of the detector; or

b) Instructions in the installation manual may be provided to describe the location and method(s) of applying a sealing compound that has been found acceptable for the intended use.

11.1.7 To determine compliance with the requirements of 11.1.4 and 11.1.5, representative detectors are to be subjected to the Smoke Entry (Stack Effect) Test, Section 42.

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

11.1.9 If the unit is intended for permanent connection, the enclosure shall either have provision for the connection of metal-clad cable, conduit, or nonmetallic sheathed cable, or have provision for mounting on an outlet box.

11.2 Cast metal enclosures

11.2.1 The thickness of cast metal for an enclosure shall be as indicated in Table 11.1. Cast metal having a thickness 1/32 inch (0.8 mm) less than that indicated in Table 11.1 may be employed if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape and/or size of the surface is such that equivalent mechanical strength is provided.

Table 11.1
Cast-metal enclosures

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

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

11.2.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, there shall not be less than 3-1/2 nor more than five threads in the metal, and the construction shall be such that a standard conduit bushing can be attached.

11.2.3 If threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall not be less than 3-1/2 full threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

11.3 Sheet metal enclosures

11.3.1 The thickness of sheet metal employed for the enclosure of a detector shall not be less than that indicated in Table 11.2, except that sheet metal of two gage sizes lesser thickness may be employed if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape and/or size of the surface is such that equivalent mechanical strength is provided.

Table 11.2
Sheet metal enclosures

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

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

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

11.3.4 A closure for a hole larger than 1-3/8 inch (34.9 mm) diameter shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used.

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

11.3.6 A knockout shall be provided with a surrounding surface for seating of a conduit bushing, and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those indicated in Spacings, General, Section 33.

11.4 Nonmetallic enclosures

11.4.1 An enclosure or parts of an enclosure of nonmetallic material shall have the mechanical strength and durability and be formed so that operating parts will be protected against damage. The mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 11.2. See also Tests of Thermoplastic Materials, Section 66.

11.4.2 The continuity of any grounding system to which a detector can be connected shall not rely on the dimensional integrity of the nonmetallic material.

11.5 Ventilating openings

11.5.1 Ventilating openings in an enclosure for high-voltage circuits including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening will permit passage of a rod having a diameter of 9/64 inch (3.6 mm). An enclosure for a fuse(s) or other overload protective device provided with ventilating openings shall afford protection against the emission of flame or molten metal. Openings provided to permit cleaning, or openings which may be used to clean internal parts, shall be designed to prevent damage to functional internal components during such cleaning operations.

11.5.2 Except as noted in 11.5.3, perforated sheet metal employed for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) in average thickness, 0.046 inch (1.17 mm) if zinc coated.

11.5.3 If the indentation of the guard or enclosure will not alter the clearance between uninsulated live parts and grounded metal so as to reduce spacings below the minimum values required, 0.021 inch (0.53 mm) expanded metal mesh or perforated sheet metal, 0.024 inch (0.61 mm) if zinc coated, may be employed under the following conditions.

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

b) The width of an opening so protected is not greater than 3-1/2 inches (88.9 mm).

11.5.4 The wires forming a screen protecting high-voltage current-carrying parts shall not be smaller than No. 16 AWG (1.3 mm^2) and the screen openings shall not be greater than 1/2 square inch (3.2 cm^2) in area.

11.6 Covers

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

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

b) It is necessary to open the cover periodically in connection with the intended operation of the detector.

For the purpose of this requirement, intended operation is considered to be operation of a switch for testing or operation of any other component of a detector that requires such action in connection with its intended performance. This requirement does not apply to a photoelectric type detector where the lamp is intended to be periodically replaced, or to the battery replacement aspect of a detector employing a battery as the main or standby supply.

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

11.6.3 If a detector cover is not intended to be removed for cleaning, maintenance, or both, and the detector is intended to be returned to the factory for servicing, the cover shall be secured so that it cannot be readily removed. Exposed screw slots or nuts, other than a tamperproof type, shall be sealed or covered. See 88.1(s) for supplementary marking.

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

11.6.4 A hinged cover is not required where the only fuse(s) enclosed is intended to provide protection to portions of internal circuits, such as may be employed on a separate printed wiring board or circuit subassembly, to prevent circuit damage resulting from a fault. The use of such a fuse(s) is acceptable if the word "CAUTION" and the following or equivalent marking is located on the cover of a detector employing high-voltage circuits: "Circuit Fuse(s) Inside – Disconnect Power Prior To Servicing."

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

11.7 Glass panels

11.7.1 Glass covering an enclosure opening shall be held securely in place so that it cannot be displaced in service and shall provide mechanical protection of the enclosed parts. The thickness of a glass cover shall not be less than that indicated in Table 11.3.

Table 11.3
Thickness of glass covers

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

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

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

a) Be mechanically equivalent to that of glass,

b) Not distort, or

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

11.7.3 A lens, light filter, or similar part of a smoke detector shall be constructed of a material whose transparency will not be diminished by the conditions to which it will be exposed in service, as represented by the Performance Tests (see Sections 35 – 76) of this standard.

12 Corrosion Protection

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

12.2 The requirement of 12.1 applies to all sheet steel or cast iron enclosures, and to all springs and other parts upon which mechanical operation may depend. It does not apply to minor parts, such as washers, screws, bolts, and the like, if the failure of such unprotected parts would not be likely to result in a risk of fire or electric shock or injury to persons or impair the operation of the detector. Parts made of stainless steel, polished or treated if necessary, do not require additional protection. Bearing surfaces shall be of materials that will prevent binding due to corrosion.

12.3 Metal shall not be used in combinations such as to cause galvanic action which will adversely affect cabinets or enclosures.

12.4 Hinges and other attachments shall be resistant to corrosion.

12.5 Nonferrous cabinets and enclosures may be employed without special corrosion protection.

POWER SUPPLY

13 Primary Power Supply

13.1 The primary power supply of a single station smoke detector shall be either a commercial light and power source available in a home or an integral battery or batteries. Connection to the commercial light and power source, if used, shall be in the form of permanent wiring to terminals or leads in a separate wiring compartment (see also 11.1.9) having provision for the connection of conduit, metal-clad or nonmetallic sheathed cable, by means of a power-supply cord and attachment-plug cap, or by means of a separate power supply.

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

14 Secondary Power Supply

14.1 The use of a secondary power supply is optional. If a secondary power supply, such as a battery is provided, it should have the capacity to supply the maximum intended power to the detector for 24 hours in the standby condition and thereafter be able to operate the detector for an alarm signal for at least 4 minutes continuously.

Exception: If the battery capacity is such that it cannot provide operation for 24 hours in the standby condition, followed by 4 minutes in alarm, it shall be capable of providing operation for at least 4 hours in the standby condition followed by 4 minutes of alarm. The marking on the unit shall include the following or equivalent wording:

"Battery capacity for emergency standby at least ___ hours."

The applicable time in hours is to be inserted.

14.2 If a battery is employed for the secondary power supply, it may be of a rechargeable or nonrechargeable type. For a rechargeable type battery, the maximum charging current, as well as the maximum trickle charging current available, shall not exceed the battery manufacturer's recommendations. For a nonrechargeable type battery, data on battery life, including discharge curves, shall be provided for the investigation to evaluate battery shelf aging and performance characteristics.

14.3 If a nonrechargeable or rechargeable type battery is employed as a secondary power supply, the marking on the unit shall include recommended periodic battery replacement instructions.

14.4 If the discharge condition of a nonrechargeable type battery cannot be discerned visually, some form of test means, or equivalent, shall be provided to determine battery capacity. Any of the following would be an acceptable means:

a) Battery test switch with related meter or equivalent means to indicate battery capacity.

b) Prominent marking on front of unit which has the following or equivalent wording: "Shut off A-C power. Push test switch. If sound of alarm has decreased below the level when AC was applied, replace battery."

c) Monitored battery where a trouble indication, as described in 37.1.3, is obtained.

15 Batteries

15.1 General

15.1.1 If a battery or set of batteries is employed as the main source of power of a single or multiple station smoke detector, it shall meet the requirements of the Battery Tests, Section 64.

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

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

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

15.1.5 Connections of external wiring to a battery-operated single- or multiple-station smoke detector, or to a portable accessory, shall not be subjected to stress or motion during battery replacement and/or servicing. Removal of the detector or accessory from the mounting support to replace a battery or to service the unit is permitted, provided the connected wiring is not subjected to flexing or stress.

15.2 Battery connections

15.2.1 Lead or terminal connections to batteries shall be identified with the proper polarity, (plus or minus signs), and provided with strain relief. The polarity may be indicated on the unit adjacent to the battery terminals or leads.

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

15.2.3 Each lead of a clip-lead assembly employed as part of a battery operated detector shall be a minimum of No. 26 AWG (0.21 mm^2) stranded wire with a minimum 1/64-inch (0.4-mm) insulation.

16 Supplementary Signaling Circuits

16.1 For a cord-connected or battery operated single station detector employing a supplementary signaling circuit which is energized from a separate source of supply, the source of energy shall not exceed the energy limits defined in 72.2.1 and 72.2.2.

16.2 For a detector intended to be connected to a fixed wiring system and employing a separately energized signaling circuit, the source of energy may exceed the limits in 72.2.1 if the connections are made as a Class 1 wiring system as defined in the National Electrical Code, NFPA 70.

FIELD WIRING

17 Permanent Connection

17.1 General

17.1.1 A single station or multiple station smoke detector intended for permanent connection shall be provided with wiring terminals or leads for the connection of conductors of at least the size required by the National Electrical Code, NFPA 70, corresponding to the rating of the unit.

17.2 Field-wiring compartment

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

17.2.2 Protection for internal components and wire insulation from sharp edges shall be provided by insulating barriers or metal barriers having smooth rounded edges, or the following or equivalent instructions shall be located in the wiring compartment: "When Installing, Route Wiring Away From Sharp Projections, Edges, And Internal Components."

17.3 Field-wiring terminals

17.3.1 Terminal parts to which field connections are to be made shall consist of binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position. Other terminal connections may be provided if found to be equivalent.

17.3.2 If a wiring-binding screw is employed at a field-wiring terminal, the screw shall not be smaller than a No. 6 (3.5 mm diameter).

17.3.3 Except as noted in 17.3.4, a terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick and shall not have less than two full threads in the metal.

17.3.4 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 security.

17.4 Field-wiring leads

17.4.1 Power supply leads provided for field connection shall not be less than 6 inches (152 mm) long, provided with strain relief, and shall not be smaller than No. 18 AWG (0.82 mm^2); and the insulation, if of rubber or thermoplastic, shall not be less than 1/32 inch (0.8 mm) in thickness.

17.4.2 Leads provided for field connection to power limited fire protective signaling circuits, such as may be employed for multiple station interconnection or for connection to remote signaling devices, shall not be smaller than No. 16 AWG (1.3 mm^2), for a single conductor, No. 19 AWG (0.65 mm^2) for two or more conductors, and No. 22 AWG (0.32 mm^2) for four or more conductors of a multiconductor cable. The conductor shall be solid, bunch tinned stranded, or stranded copper. Stranded copper wire, consisting of not more than seven strands, may be employed only for No. 18 AWG (0.82 mm^2) and larger conductors.

17.5 Grounded supply terminals and leads

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

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

17.5.3 A terminal or lead identified for the connection of the grounded supply conductor shall not be electrically connected to a single-pole manual switching device that has an OFF position or to a single-pole overcurrent (not thermal) protective device.

18 Power Supply Cord

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

18.2 The flexible cord shall be of Type SP-1, SPT-1, SP-2, SPT-2, SV, SVT, SJ, SJT, SPE, SVE, or equivalent, minimum No. 18 AWG (0.82 mm^2). It shall be rated for use at the voltage and ampacity rating of the detector, in accordance with the National Electrical Code, ANSI/NFPA 70.

18.3 Means shall be provided to prevent the flexible cord from being pushed into the enclosure through the cord-entry hole if such displacement can:

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

b) Reduce spacings below the minimum acceptable values, or

c) Result in damage in internal components.

18.4 A smoothly rounded restraining means shall be provided for securing the attachment plug to the receptacle. The means shall withstand for 1 minute a pull of 5 pounds force (22.25 N) while installed as intended in service without any evidence of damage to the connection.

19 Equipment Grounding

19.1 General

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

a) Is intended to be serviced internally and

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

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

a) A low-voltage detector;

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

c) A high-voltage detector provided with an overall nonmetallic enclosure and cover, that does not employ internal dead metal parts that:

1) May be energized under a fault condition and

2) Can be contacted during servicing.

19.2 Permanently connected units

19.2.1 The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green, with or without one or more yellow stripes. No other leads visible to the installer, other than grounding conductors, shall be so identified. A field-wiring terminal intended for connection of an equipment-grounding conductor shall be plainly identified, such as being marked "G," "GR," "Ground," "Grounding," or the equivalent, or by a marking on a wiring diagram provided on the detector. The field-wiring terminal shall be located so that it is unlikely to be removed during servicing of the detector.

19.3 Cord connected units

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

20 Remote Power Supply

20.1 For a detector that is intended to be connected to a separate remote power supply such as a transformer, the supply cord is not required to be factory wired to the detector, or to the transformer terminals or leads, if the installation instructions provided with the unit are explicit regarding the method of connection. The minimum size conductors between the detector and remote power supply shall be not less than No. 18 AWG (0.82 mm^2) and shall not be longer than 20 feet (6.1 m). The interconnecting wiring is to be provided with the detector and the transformer by the manufacturer.

20.2 Where longer runs of interconnecting wiring would be used in an installation, such as in a multiple station configuration, or where several detectors are supplied by a common power supply, the wiring need not be provided by the manufacturer. However, the installation wiring diagram or instructions shall be marked to specify that the wiring to be used shall be in accordance with the provisions of Article 760 of the National Electrical Code, ANSI/NFPA 70. In addition, the resistance of the interconnecting wiring shall be a maximum of 10 ohms, unless otherwise specified by the manufacturer.

INTERNAL WIRING

21 General

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

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

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

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

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

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

21.7 All splices and connections shall be mechanically secured to preclude shorting to adjacent uninsulated current carrying parts in the event that an improper connection, such as a cold solder joint, is made. Tack soldering is permitted where the design precludes mechanical security provided that five samples resist a pull force of 2 pounds (8.9 N) applied for 3 seconds and the connection is subjected to 100 percent inspection and testing with the same pull force by the manufacturer.

21.8 A splice shall be provided with insulation equivalent to that of the wires involved, if permanence of electrical spacing between the splice and uninsulated metal parts is not assured.

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

21.10 A metal barrier shall have a thickness at least equal to that required by Table 11.2, as determined by the size of the barrier. A barrier of insulating material shall not be less than 0.028 inch (0.71 mm) thick and shall be thicker if its deformation may be readily accomplished so as to defeat its purpose. Any clearance between the edge of a barrier and a compartment wall shall not be more than 1/16 inch (1.6 mm).

22 Bonding for Grounding

22.1 An exposed dead metal part of a high-voltage detector that is likely to become energized shall be bonded to the point of connection of the field-equipment grounding terminal or lead, if provided or required, and to the metal surrounding the knockout, hole, or bushing provided for field power-supply connections.

22.2 Uninsulated metal parts of electrical enclosures, transformer cores, mounting brackets, capacitors, and other electrical components are to be bonded for grounding if they may be contacted by the user or by a serviceman servicing or operating the equipment.

22.3 Metal parts as described below need not comply with the requirement of 22.2.

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

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

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

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

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

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

22.6 A bolted or screwed connection, that incorporates a star washer under the screwhead, is considered acceptable for penetrating nonconductive coatings.

22.7 If the bonding means depends upon screw threads, two or more screws, or two full threads of a single screw, engaging metal is considered acceptable.

22.8 Metal-to-metal hinge-bearing members for doors or covers may be considered as a means for bonding the door or cover for grounding provided a multiple bearing-pin type hinge is employed.

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

ELECTRICAL COMPONENTS

23 General

23.1 Mounting of components

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

Exception No. 1: The requirement that a switch be prevented from turning may be waived if all four of the following conditions are met:

> *a) The switch is to be of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during operation of the switch.*
>
> *b) The means for mounting the switch makes it unlikely that the operation of the switch will loosen it.*
>
> *c) The spacings are not to be reduced below the minimum required values if the switch rotates.*
>
> *d) The operation of the switch is to be by mechanical means rather than by direct contact by persons.*

Exception No. 2: A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the minimum values required. See Spacings, Section 33.

23.1.2 Uninsulated live parts shall be so secured to the base or mounting surface that they will be prevented from turning or shifting in position, if such motion may result in a reduction of spacings. Friction between surfaces is not acceptable as a means to prevent shifting or turning of live parts, but a properly applied lock washer may be accepted.

23.1.3 Uninsulated live parts, for example, field-wiring terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be prevented from turning or shifting in position if such motion may result in reduction of spacings below the minimum values required. 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 some other equivalent method.

23.2 Operating components

23.2.1 Operating components and assemblies, such as switches, relays, and similar devices, shall be protected by individual dust covers or dust tight cabinets, against fouling by dust or by other material which may impair their operation.

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

23.3 Current-carrying parts

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

23.3.2 Bearings, hinges, and the like are not acceptable for carrying current between fixed and moving parts.

23.4 Electrical insulating material

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

23.4.2 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated current-carrying parts of other than low-voltage circuits.

23.4.3 Polymeric materials may be used for the sole support of uninsulated live parts if found to be equivalent to the materials indicated in 23.4.1.

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

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

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

24 Bushings

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

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

24.3 Ceramic materials and some molded compositions are acceptable for insulating bushings, but separate bushings of wood and hot-molded shellac are not acceptable.

24.4 Fiber may be employed where:

a) It will not be subjected to a temperature higher than 90°C (194°F) under normal operating conditions,

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

c) It will not be affected adversely by ordinary ambient humidity conditions.

24.5 If a soft-rubber bushing or similar material that may deteriorate with age is employed in a hole in metal, the hole shall be free from sharp edges, burrs, projections, and the like, which would be likely to cut into the bushing and wire insulation.

24.6 An insulating metal grommet may be considered acceptable in lieu of an insulating bushing, provided that the insulating material used is not less than 1/32 inch (0.8 mm) in thickness and fills completely the space between the grommet and the metal in which it is mounted.

25 Lampholders and Lamps

25.1 A single station smoke detector intended to be connected to a commercial alternating current (ac) power source shall be provided with a "power-on" lamp to indicate energization of the unit.

25.2 If more than one lamp is provided on the detector, the "power-on" lamp shall be white or green, an alarm indicating lamp shall be red, and a trouble lamp shall be amber or yellow. The "power-on" lamp may be of a different color if marked to identify the function.

25.3 At least one spare lamp shall be provided in a single station smoke detector that employs photocell illuminating lamps that are likely to burn out during the service life of a detector.

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

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

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

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

26 Light Emitting Diode (LED) Source Lamps

26.1 General

26.1.1 A LED used as a light source of a single station smoke detector employing a photocell light assembly shall comply with electrical supervision requirements specified in 37.5.1 – 37.5.5, operating condition requirements specified in 26.2.1 – 26.2.4, and the reliability prediction specified in 4.1.

26.2 Operating conditions

26.2.1 For direct current operation, the drive current shall not exceed 75 percent of the dc forward current rating.

26.2.2 For pulsed operation, the average current shall not exceed 75 percent of the dc forward current rating.

26.2.3 For pulsed operation, where the pulse duration exceeds 1 millisecond or the duty factor is greater than 50 percent, the peak current shall not exceed 75 percent of the dc forward current rating.

26.2.4 For all applications, the LED shall be electrically protected from negative voltages, from transients or pulse undershoot exceeding 70 percent of the rated reverse voltage.

27 Protective Devices

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

28 Printed Wiring Boards

28.1 The components of a printed wiring board shall be secured in place and the spacings between circuits shall comply with the spacings requirements for rigidly clamped assemblies (Table 33.1). The board shall be mounted so that deflection of the board during servicing shall not result in damage to the board or risk of fire or electric shock.

29 Switches

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

29.2 If a reset switch is provided, it shall be of a self-restoring type.

29.3 An alarm silencing switch or equivalent means may be provided on a single or multiple station smoke detector if its "off normal" position is supervised.

30 Transformers and Coils

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

Exception: An autotransformer may be employed in a detector intended for permanent connection only, provided that the terminal or lead connected to the autotransformer winding which is common to both input and output circuits is identified, and that the output circuits are located only within the enclosure containing the autotransformer. See 17.5.1 and 17.5.2.

30.2 The insulation of coil windings of relays, transformers and the like shall be such as to resist the absorption of moisture.

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

31 Dropping Resistors

31.1 A carbon composition resistor shall not be used as a dropping resistor in the high-voltage circuit of a detector.

32 Optional Heat Detector

32.1 The temperature rating of an optional heat detector provided on a single or multiple station detector shall not be greater than 140°F (60°C).

SPACINGS

33 General

33.1 Spacings shall be maintained between uninsulated live parts and dead metal parts, and between uninsulated live parts of opposite polarity. The spacings shall not be less than those indicated in Table 33.1.

33.2 The spacings between an uninsulated live part and:

a) A wall or cover of a metal enclosure;

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

c) Any dead metal part

shall not be less than that indicated in Table 33.1.

33.3 The "Through Air" and "Over Surface" spacings of Table 33.1 measured at an individual component part are to be judged on the basis of the volt-amperes used and controlled by the individual component. However, the spacings from one component to another, and from any component to the enclosure or to other uninsulated dead metal parts, excluding the component mounting surface, shall be judged on the basis of the maximum voltage and total volt-amperes rating of all components in the enclosure.

33.4 The spacing requirements in Table 33.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component provided as part of the detector. Such spacings are judged on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete device, including clearances to dead metal or enclosures, shall be those indicated in Table 33.1.

33.5 The "To Wall of Enclosure" spacings of Table 33.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

33.6 Enameled or equivalently insulated wire is to be considered an uninsulated live part, but enamel is acceptable as turn-to-turn insulation in coils.

Table 33.1
Minimum spacings

Point of application	Voltage range	Minimum spacings[a,b] inch (mm)			
		Through air		Over surface	
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 employed where spacings would otherwise be insufficient, shall not be less than 0.028 inch (0.71 mm) in thickness; except that a liner or barrier not less than 0.013 inch (0.33 mm) in thickness 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 affected adversely by arcing. Insulating material having a thickness less than that specified may be used if it is 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

34 General

34.1 Test units and data

34.1.1 Detectors that are fully representative of production units are to be used for each of the following tests, unless otherwise specified. THE SENSITIVITY SETTING OR RANGE OF SENSITIVITIES PROVIDED ON THE SAMPLES FOR TEST WILL DEFINE THE PRODUCTION SENSITIVITY.

34.1.2 The devices employed for testing are to be those specified by the wiring diagram of the detector, except that substitute devices may be used if they produce functions and load conditions equivalent to those obtained with the devices intended to be used with the detector in service.

34.2 Accessories

34.2.1 Accessories for use with single and multiple station smoke detectors are to be subjected to the following tests as applicable:

a) Normal Operation, Section 35
b) Circuit Measurement, Section 36
c) Temperature, Section 48
d) Overload, Section 49
e) Endurance, Section 50
f) Variable Ambient Temperature, Section 51
g) Humidity, Section 52
h) Leakage Current, Section 53
i) Transient, Section 54
j) Dielectric Voltage-Withstand, Section 55
k) Overvoltage and Undervoltage, Section 57
l) Jarring, Section 61
m) Audibility, Section 65
n) Tests of Thermoplastic Materials, Section 66
o) Drop Test, Section 76 (portable appliance only)

34.3 Test voltages

34.3.1 Unless otherwise specified, the test voltage for each test shall be as follows, at rated frequency:

Detector rated voltage, nameplate	Test voltage
110 to 120	120
220 to 240	240
Other	Marked rating

34.3.2 The following samples are to be provided for testing:

a) At least 28 assembled detectors; 12 preset (as close as normal production calibration will permit) to the nominal maximum anticipated production sensitivity (most sensitive setting), and 16 preset (as close as normal production calibration will permit) to the nominal minimum anticipated production sensitivity (least sensitive setting). Four of the 12 units preset to the maximum sensitivity and four of the 16 units preset to the minimum sensitivity shall be calibrated so that the sensitivity of any individual unit does not vary more than 25 percent from any other unit in each setting and shall establish the maximum and minimum sensitivities to be employed in production. Combination smoke detectors are to be provided with means for monitoring each principle of operation during the Sensitivity Test, Section 38.

b) One additional unassembled detector.

c) Three additional samples of detectors that operate on the photoelectric principle provided with means to reduce the light output as described in 63.2.

d) Installation and Operating Instructions (see 5.1 and 5.2 and Instructions, General, Section 90).

34.3.3 For detectors employing a battery as the main operating supply, 24 additional battery operated detectors for long term battery tests or equivalent test circuit set ups with appropriate measuring facilities to monitor the battery voltage, standby current, and alarm current. (See Battery Tests, Section 64.)

34.3.4 Four battery test setups shall be provided for subjection to each of four environmental conditions. Each set up shall be representative of six detectors and shall include test terminals and switches, limiting resistors, the alarm horn, and batteries. The value of resistors shall represent the normal standby current which would be obtained from a complete detector.

34.3.5 The batteries shall be connected in the test circuit with the same terminal arrangement employed in the detector. Provision for connection of the actual sounding appliance used in the detector for novelty and weekly testing shall also be made. (See Battery Tests, Section 64.)

34.4 Component reliability data

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

34.4.2 The data required by 34.4.1 shall include the following or equivalent information:

a) Component and overall detector reliability analysis per Military Standard 217B, described in 4.1.

b) Component vendor's reliability and life expectancy data. This should include failure rate data at rated values and derated values. The latter data is required only where the derating values form the basis of reliability.

c) General description of the detector manufacturers quality assurance (QA) program. This data shall include incoming inspection, in-process QA, burn-in data and testing. This will apply to complete and partial assemblies as well as individual components.

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

e) Maximum vendor's ratings for each component as well as the actual maximum operating values (voltage and current) in the detectors.

f) A description of component screening and burn-in test data for solid-state devices or integrated circuits which operate at greater than the limits described in note b of Table 48.1.

g) For a detector using a reliable LED as the photocell illuminating light source, the data specified in 26.2.1 – 26.2.4.

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

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

j) A description of the smoke test chamber, including drawings and operation procedure, to be used by a manufacturer in conducting the factory smoke tests.

35 Normal Operation Test

35.1 General

35.1.1 A detector shall operate for all conditions of its intended performance, at all sensitivity settings, when energized from a source of rated voltage, under all conditions covered both in the installation instructions and in any supplementary information provided by the manufacturer.

35.1.2 The test voltage is to be in accordance with 34.3.1. The detector is to be in the standby condition and prepared for its intended signaling operation when it is connected to related devices and circuits.

35.1.3 The introduction of smoke into the detector chamber, such as from a smoldering cotton lamp wick, rope, or equivalent, shall result in the operation of the detector in its intended manner. See 38.1.1. The alarm signal shall persist for at least 4 minutes under an abnormal level of smoke.

35.1.4 A single station smoke detector that employs a secondary power supply shall operate for alarm signals with the main power de-energized.

35.1.5 If single station smoke detectors are also intended for multiple station connection, the operation for alarm of one detector shall result in the alarm signal of all connected detectors being energized and the detector that initiated the alarm signal shall be identified. See 25.7.

35.1.6 If a heat detector is provided integral with a single station smoke detector, or is intended to be connected to a remote initiating device circuit of a multiple station smoke detector, actuation of the heat detector shall result in the same type of alarm signal as when actuated by smoke.

35.1.7 Neither principle of operation of a combination smoke detector shall be rendered inoperative by any of the Performance Tests (Sections 35 – 76) of this standard. A circuit analysis shall be made, supplemented by electrical measurements if necessary, to determine that both principles of operation contribute to detector actuation.

35.1.8 Operation for alarm of a single-station smoke detector with integral transmitter that is energized by an initial pulse(s) shall result in an alarm signal being locked in for at least 4 minutes at a compatible receiving unit located at the maximum distance specified by the manufacturer, when tested under free-field conditions with no obstructions between the detector transmitter and receiver units. Refer to 90.1(m) for instructions to be provided. Lock-in of the receiver is not required if the receiving unit audible alarm signal is energized in time sequence and duration with the detector.

35.1.9 A detector or accessory that employs one or more nonfire-alarm features shall operate as follows:

a) The smoke detector fire alarm signal shall take precedence or be clearly recognizable over any other signal even when the nonfire alarm signal is initiated first.

b) Distinctive signals shall be obtained between the smoke detector fire alarm and other nonfire alarm functions. The use of a common sounding appliance for the fire alarm and nonfire alarm function(s) is acceptable if distinctive signals are obtained. A steady continuous sound for a fire alarm function and a pulsing sound for the nonfire-alarm (burglary) signaling function is acceptable. If an audible trouble signal is additionally provided it shall be distinctive from all alarm signals but may be common to all functions employed.

c) Any fault condition of limited life nonfire alarm components shall not interfere with the operation and supervision of the smoke detector. See 37.1.5.

35.2 Alarm silenced period

35.2.1 To determine the duration of the alarm silenced period each of four smoke detectors, in the normal standby condition, is to be placed in the sensitivity test chamber. See Sensitivity Test, Section 38. The smoke is to be increased until the detector goes into an alarm condition. The smoke is to be maintained at an abnormal amount for the duration of the test. After the detector has been in an alarm condition for approximately 1 minute, the silencing means is to be actuated and the time recorded between operation of the silencing means and reactivation of the detector alarm signal. The maximum time of silencing shall not exceed 15 minutes. See 7.1.

35.2.2 With the maximum number of detectors interconnected in a multiple station configuration as permitted by the installation instructions, one detector is to be placed into an alarm condition by permitting an abnormal amount of smoke to fill the sensitivity test chamber in accordance with the procedure described in 35.2.1. The alarm silencing means on that one unit is then to be actuated. The time is then to be recorded between operation of the silencing means and reactivation of the detector alarm. During the silenced period, the other detectors in the system are also to be subjected to an abnormal amount of smoke to determine that they are still operational for initiating an alarm. The maximum silenced period shall not exceed 15 minutes. See 7.1.

36 Circuit Measurement Test

36.1 Current input

36.1.1 Except for a battery operated detector, the input current of a single station smoke detector shall not exceed the marked rating by more than 10 percent when the detector is connected to a source of supply in accordance with 34.3.1 and operated under the conditions of intended use (standby and alarm).

36.2 Battery trouble voltage determination

36.2.1 An increase in the internal resistance, or a decrease in terminal voltage, of a battery employed as the primary source of power to a detector shall not impair operation for an alarm signal before a trouble signal is obtained. In addition, any combination of voltage and resistance at which a trouble signal is obtained shall be greater than the battery voltage and resistance combination measured over a 1 year period in the room ambient condition of the Battery Test, Section 64.

36.2.2 The trouble level of a battery operated smoke detector shall be determined (using the test circuit in Figure 36.1 and the voltage-resistance curves of Figure 36.2) for each of the following voltages:

a) Rated battery voltage.

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

c) Voltages between rated and trouble level voltage.

Figure 36.1
Test circuit

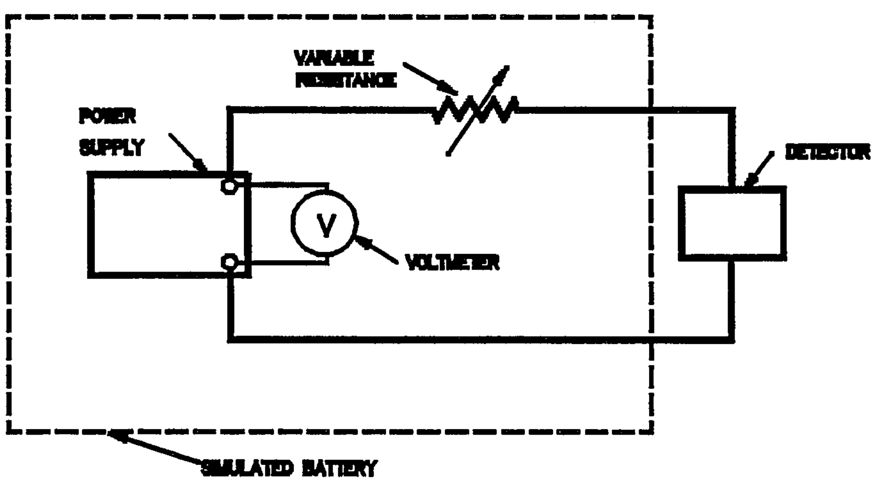

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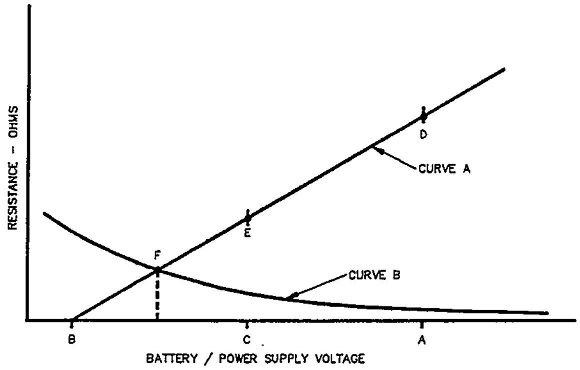
Figure 36.2
Trouble level determination



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A — Rated battery voltage.
B — Trouble level voltage (assuming minimal resistance).
C — Voltage value between rated and trouble level.
D — Trouble level resistance at rated battery voltage.
E — Trouble level resistance at voltage value C.
F — Maximum permissible battery resistance and minimum voltage after 1 year in long-term battery test.

Curve A — Sample plot of voltage vs. resistance (Detector Trouble Level Curve) at which a trouble signal in a detector is obtained. Audibility measurement is to be made at points between D and F.

Curve B — Sample plot of battery internal resistance vs. battery open circuit voltage derived from long term (minimum 1 year) battery test. Shape and slope of curve, as well as point of intersection with Curve A, will vary depending on battery used.

36.2.3 To determine compliance with 36.2.1 each of three detectors is to be connected in series with a variable regulated direct current power supply and a variable resistor as illustrated in Figure 36.1. The trouble level is to be determined by the following steps.

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

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

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

36.2.4 To determine that a battery is capable of supplying alarm and trouble signal power to the detector for at least 1 year under the room ambient condition described in Battery Tests, Section 64, Curve A of Figure 36.2 is to be plotted from the data obtained in the measurements described in 36.2.3 and compared to Curve B of Figure 36.2, which is plotted from data generated in the 1 year battery test. The intersection of Curves A and B shall not occur before 1 year and all points of Curve B to the right of point F (extended to the base line), shall be below Curve A.

37 Electrical Supervision Test

37.1 General

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

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

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

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

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

37.2 AC powered units

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

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

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

37.3 Battery powered units

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

37.3.2 To determine compliance with 37.3.1, three samples shall be equipped with batteries which have been depleted to the trouble signal level. The samples are then to be placed in alarm for 4 minutes. Following the 4 minutes of alarm the trouble signal shall persist for at least seven consecutive days. A fresh battery may be depleted by applying a 1 percent or smaller loading factor based on the ampere hour rating of the battery. For example, a 1000 milliampere-hour rated battery would be depleted by applying a 10 milliamperes (1 percent load) or less drain continuously until the battery voltage reaches the predetermined test level.

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

37.3.4 To determine compliance with 37.3.3, two samples of a detector that locks-in on alarm shall be equipped with batteries which have been depleted and stabilized at just above the trouble signal level. The samples are then to be placed in alarm and the battery voltage monitored. The samples shall automatically transfer to audible trouble when the battery trouble voltage is reached. The trouble signal shall persist for seven consecutive days. If the battery voltage recovers to a point where the trouble signal is no longer emitted, the unit shall be placed into alarm again until the trouble signal is reinstituted.

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

37.4 Component failure

37.4.1 Failure of a limited life electronic component, such as opening or shorting of electrolytic capacitors, shall be indicated by an audible trouble or alarm signal or a reliable component shall be used. The reliable component shall fall within the reliability prediction described in 3.6.

37.4.2 Internal shorts between any two elements of an electronic tube shall be indicated by either an audible trouble signal or an alarm signal if such failure prevents operation of the unit. Such a failure shall not result in a risk of fire.

37.4.3 The heaters of all electronic tubes or other functional heating elements employed in a detector shall be electrically supervised to indicate an open circuit fault by an audible trouble signal if the fault prevents operation of the unit or results in loss of sensitivity or response to the Fire Tests, Section 45, and the Smoldering Smoke Test, Section 46.

37.5 Photocell illuminating lamps

37.5.1 The filament(s) of a photocell illuminating lamp(s), which is likely to burn out periodically, shall be electrically supervised to indicate an open circuit fault by an audible trouble signal.

37.5.2 A limited life LED employed as the light source of a detector shall be electrically supervised to indicate an audible trouble signal in the event of an open, short, or, except as exempted in 37.5.3, 50 percent or greater light degradation. Energization of the alarm signal for a maximum of 5 seconds prior to the trouble signal would be acceptable.

37.5.3 An audible trouble signal for greater than 50 percent light degradation of a limited life LED is not required if light degradation data is supplied by the LED manufacturer to show that, for the conditions under which it is to be operated, the LED will not reach 50 percent light output at the end of the reliability prediction period. See 3.6.

37.5.4 When the light output of an LED source lamp is reduced to the 50 percent level, or the light level anticipated at the end of the reliability prediction is less than 50 percent, the sensitivity of the detector shall not be reduced by more than 50 percent of the value at full output, and in no case shall it exceed 4 percent per foot (12.5 percent/m) for gray smoke and 10 percent per foot (29.2 percent/m) for black smoke. (See Reduction in Light Output Test, Section 63.)

37.5.5 An LED employed as the light source of a photoelectric detector is not required to be electrically supervised by means of an audible trouble signal if it is considered to be reliable based on its use in the detector and supporting reliability data provided by the component manufacturer. Failure of the reliable LED at the end of the failure rate prediction described in 3.6, may result in an alarm signal.

37.6 External wiring

37.6.1 An open or ground fault in the loop wiring connected from a single station smoke detector to additional remote heat detectors that prevent operation for alarm signals from any of the interconnected detectors, shall not cause an alarm signal but shall result in an audible trouble signal. A short or double ground fault in the leads may result in an alarm.

37.6.2 An open, ground fault, or short in any power limited fire protective circuit wiring among multiple station interconnected detectors or any wiring extending to a remote signaling device is not required to be indicated by a trouble signal if the fault does not prevent operation of any of the interconnected units as a single station detector. A ground fault is permitted to prevent operation for alarm if the interconnected wiring is to be made in accordance with Class 1 requirements of the National Electrical Code, ANSI/NFPA 70. The installation wiring diagram shall indicate the type of connections to be employed.

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

38 Sensitivity Test

38.1 General

38.1.1 A smoke detector when calibrated to each end of its production window shall operate within the limits specified below when subjected to a smoldering smoke condition using the test equipment described in 38.3.1 — 38.3.3, and when subjected to a range of air velocities. If the detector employs a variable sensitivity setting, test measurements are to be made at maximum and minimum settings. The sensitivity measurement is to be made with the detector located in the air stream in the least and most favorable horizontal positions for smoke entry as determined in the Directionality Test, Section 40. If a detector employs alarm verification [see 88.1(m)], the sensitivity measurements are to be made with and without the alarm verification bypass applied.

a) Visible Smoke Obscuration Limits (Gray Smoke):

Percent per foot	Percent per meter	OD per foot	OD per meter
4.0 0.5	12.5 1.6	0.0177 0.0022	0.0581 maximum 0.0072 minimum

b) Visible Smoke Obscuration Limits (Black Smoke):

Percent per foot	Percent per meter	OD per foot	OD per meter
13.0 0.5	36.71 1.6	0.060 0.0022	0.198 maximum 0.0072 minimum

c) Measuring Ionization Chamber (MIC) Measurement:

93 *pA* (*minimum*) - 37.5 *pA* (*maximum*)

38.1.2 A single station smoke detector employing a secondary power supply shall operate within the limits specified in 38.1.1 when operating from the secondary power supply.

38.2 Combustibles

38.2.1 A cotton lamp wick, nominally 1/8 inch (3.2 mm) in diameter, a minimum of 5 inches (127 mm) in length, and secured by a thin wire inserted through one end, is to be employed as the source of smoke. Prior to use, the wick is to be conditioned at least 72 hours at 45°C (113°F) and at 10 percent relative humidity. It is then to be stored in a desiccator at room temperature at 10 percent or less relative humidity. The wick end is to be cut square and smoldering initiated by momentarily placing the wick end over a horizontally mounted resistive heater element energized to a dull red color. Upon ignition, momentary flaming may occur for approximately 1 second, after which the flame is to be extinguished. The wick is then permitted to smolder a minimum of 30 seconds before being placed in the chamber. The smoldering rate of the wick is to be such that the relationship between the MIC output and the percent light transmission remains within the curves illustrated in Figure 38.1. The visible smoke buildup rate is to be maintained within the limits illustrated in Figure 38.2. For black smoke, a small kerosene lamp with a 1/4 inch (6.4 mm) wide wick [the flame shielded with 38.3.3(p)] is to be placed outside the test compartment and the smoke permitted to enter through an inverted funnel-pipe arrangement. The wick is to be adjusted so that the relationship between the MIC output and the percent light transmission remains within the curves of Figure 38.3. The visible smoke buildup rate is to be maintained within the limits illustrated in Figure 38.4.

Figure 38.1
Sensitivity test limits – gray smoke – cotton wick – 30 fpm

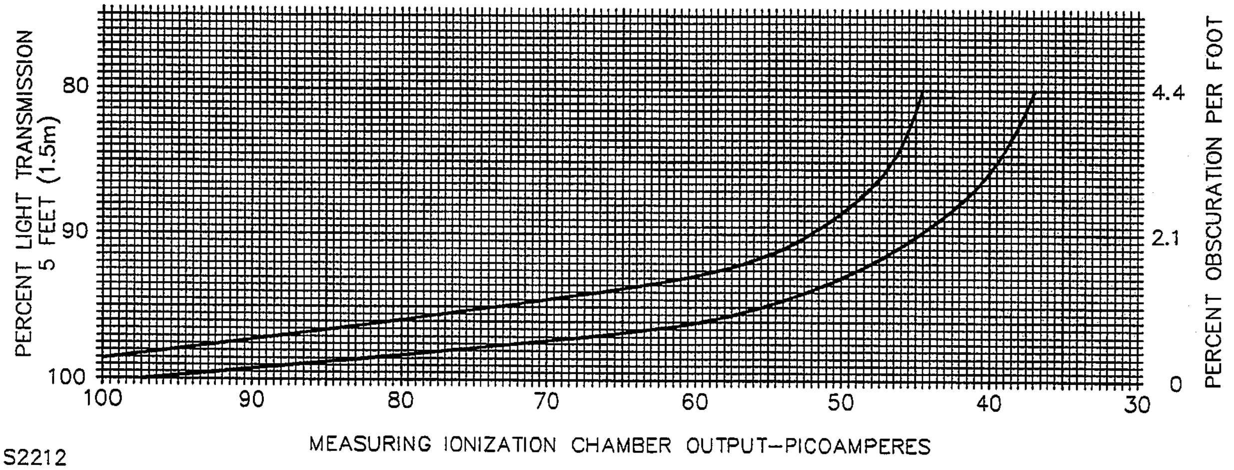

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Figure 38.2
Smoke build-up rate – sensitivity test – gray smoke – cotton wick – 30 fpm

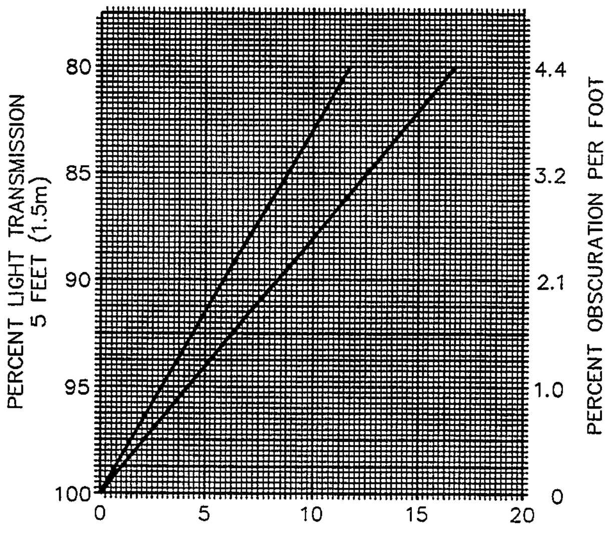

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Figure 38.3
Sensitivity test limits (black smoke)

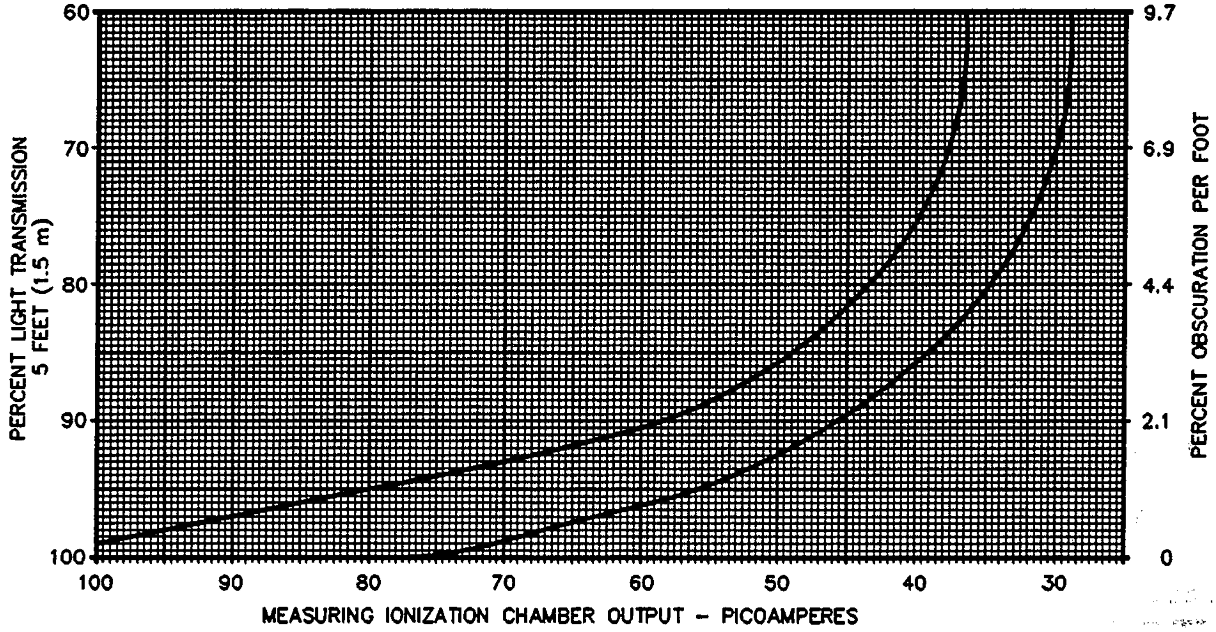

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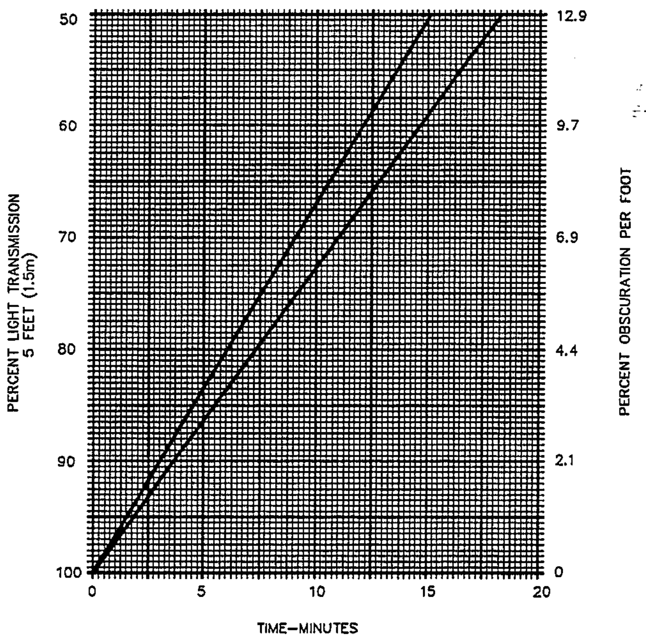
Figure 38.4
Smoke build-up rate – sensitivity test (black smoke)



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38.3 Test equipment

38.3.1 The visible smoke obscuration (optical density) in the test compartment is to be measured by means of a dc type microammeter having a maximum internal resistance of 100 ohms and full scale reading of 100 μA used with a barrier type selenium photovoltaic cell, enclosed in a hermetically sealed case.[a] An equivalent meter consists of a digital voltmeter having a minimum input impedance of 10 megohms in parallel with a 100 ohms resistance, and a 500 ohms potentiometer. The meter and cell are to be used in conjunction with the light produced by a tungsten filament automotive type lamp (such as a prefocused spotlight bulb) energized from a constant current source at approximately half rated voltage to provide a light beam of uniform flux density. The photoelectric cell and lamp are to be spaced 5 feet (1.5 m) apart. The following equations are to be used:

[a] A meter acceptable for this purpose is Weston Instrument Model 622 in conjunction with a Weston Instrument Model 594 RR Photronic Cell.

a) At any distance, the percent obscuration per foot (or per meter) will be:

$$O_u = \left[1 - \left(\frac{T_s}{T_c}\right)^{\frac{1}{d}}\right] 100$$

In which:

O_u is the percent obscuration per foot (or per meter).

T_s is the smoke density meter reading with smoke.

T_c is the smoke density meter reading with clear air.

d is the distance in feet (or meters).

b) The percent obscuration of light for the full length beam at any distance will be:

$$O_d = \left[1 - \frac{T_s}{T_c}\right] 100$$

In which:

O_d is the percent obscuration at distance d.

T_s is the smoke density meter reading with smoke.

T_c is the smoke density meter reading with clear air.

c) The percent transmission of light for the full length beam at any distance will be:

$$T_d = \left[\frac{T_s}{T_c} \right] 100$$

In which:

T_d is the percent transmission at distance d.

T_s is the smoke density meter reading with smoke.

T_c is the smoke density meter reading with clear air.

d) When the percent obscuration per foot (or per meter) is known, the percent obscuration for the full length of any longer beam can be determined by the following:

$$O_d = \left[1 - \left(1 - \frac{O_u}{100} \right)^d \right] 100$$

In which:

O_d is the percent obscuration at distance d.

O_u is the percent obscuration per foot (or per meter).

d is the distance in feet (or meters).

e) At any distance the total optical density will be:

$$OD_t = Log_{10} \left(\frac{T_c}{T_s} \right)$$

In which:

OD_t is the Optical Density.

T_c is the smoke density meter reading with clear air.

T_s is the smoke density meter reading with smoke.

f) At any distance, the optical density per foot (or per meter) will be:

$$OD = \frac{Log_{10}\left(\frac{T_c}{T_s}\right)}{d}$$

In which:

OD is the Optical Density per foot (or per meter).

T_c is the smoke density meter reading with clear air.

T_s is the smoke density meter reading with smoke.

d is the distance in feet (or meters).

38.3.2 A Measuring Ionization Chamber (MIC)[b] is to be used to measure the relative buildup of particles of combustion during each trial. The MIC utilizes the ionization principle with air drawn through the chamber at a rate of 25 ±5 liters per minute by a regulated vacuum pump.

[b] Electronikcentralen, Horsholm Denmark, Measuring Ionization Chamber (MIC), Type EC 23095.

38.3.3 A typical test chamber consists of the following items. Different chamber configurations may be used as long as they provide a homogeneous smoke mix and a laminar air flow across the detector, adjustable from 30 to 150 feet per minute (0.16 to 0.76 m/s).

a) Outer Cabinet – Constructed of 3/4 inch (19.1 mm) exterior grade plywood, has overall inside dimensions of approximately 65-3/4 inches (1.67 m) long by 19-1/4 inches (490 mm) deep by 18-1/8 inches (460 mm) wide. Has a centrally located gasketed hinged top door approximately 33-7/8 inches (860 mm) wide in the top with a 12 by 24 inch (305 by 610 mm) clear plastic window. A 1/4 inch (6.4 mm) diameter hole is located in the window center for air flow measurement. Box is provided with a 7 inch (178 mm) diameter exhaust port in the right end centered 4-1/2 inches (114 mm) above the bottom and employed with a sliding or hinged wooden cover.

b) Inner Compartment – Constructed of 3/4 inch exterior grade plywood, approximately inside dimension 41-3/4 inches (1.06 m) long by 11-1/2 inches (292 mm) high covering the entire width of the inside of the outer cabinet. The left end has a 5-3/4 inch (146 mm) diameter hole for the circulating fan centered 3-7/8 inches (96.1 mm) above the bottom and a 4 inch (102 mm) diameter hole for the light beam centered 3 inches (76.2 mm) in either direction from the top back corner. The right end is the same as the left end except it has one additional 4 inch diameter hole centered 3 inches in either direction from the top front corner. Molding strips nominal 5/8 inch (15.9 mm) are used to secure the end pieces and the top. All interior surfaces are painted with a flat black paint.

c) Circulating Fan[c] – 250 cubic feet per minute (cfm) (0.12 m^3/s) rated 115 volts, 60 hertz, 5-3/4-inch (146-mm) diameter. The fan may be located on either side of the opening. The fan is connected to a motor controller (r) for variable speed adjustment.

Alternate Fan[d] – 550 cfm (0.26 m^3/s), rated 115 volts, 50/60 hertz, 10-inch (254-mm) diameter.

[c] A fan acceptable for this purpose is a Model 7600 rated 115 volts, 60 hertz by Pamoter, Inc. or equivalent.

[d] E. G. & G. Rotron, Model CL2L2, or equivalent.

d) Exhaust Fan – Same as (c), except speed not adjustable.

e) Photocell[e] – Selenium barrier layer type, approximately 1.5 inch (38 mm) diameter for active area. Photovoltaic cell active material is sealed against environment and mounted on a 3/4 inch (19.1 mm) plywood bracket approximately 5 inches (127 mm) behind a panel that has a 2-1/2 inch (63.1 mm) diameter hole to limit the detection of forward-scattered light. Photocell has a 25 percent maximum deviation from true linearity at 200 foot-candles (2152 lm/m^2) with a 200 ohm load resistance, and has a sensitivity of 4.4 ±0.3 microamperes per foot-candle (0.416 ±0.046 microamperes per lm/m^2) flowing through a 200 ohm load (meter resistance or other). The photocell (in use) is loaded with a nominal 100 ohm, 1 percent load, trimmed with a 5000 ohm, ten turn potentiometer, and is nominally illuminated at 22 foot-candles (236.7 lm/m^2). Spectral response peak is between 530 and 580 nanometer with 30 percent sensitivity response at approximately 350 and 660 nanometer.

[e] A photocell acceptable for this purpose is the Weston Instruments Model 594 RR.

f) Airstream Deflector – Sheet aluminum, approximately 18 inches (457 mm) wide by 15-1/2 inches (394 mm) long secured at each end by screws to two 3/4 inch (19.1 mm) thick plywood sections; each section is to be approximately 8-5/8 inches (219 mm) high, 9-1/4 inches (235 mm) long (adjacent to top of test box), and a 10 inch (254 mm) radius curved section to which the deflecting plate is to be attached. The plate is to extend approximately 1 inch (254.4 mm) beyond the upper edge and 5/8 inch (15.9 mm) beyond the lower edge. Each plywood cutout is to be secured to the side wall of the test compartment.

g) Airstream Straightener[f] – Aluminum honeycomb nominal 1/4 inch (6.4 mm) cell size; overall dimensions are to be approximately 7 by 18 by 3 inches (178 by 457 by 76 mm). An equivalent honeycomb may be employed, provided that the cell size length to diameter ratio is greater than 10.

[f] Expanded Commercial Grade Honeycomb 1/4 CGH – 5.2 N American Cyanamid Company is acceptable for this purpose.

h) Screen – Screening material of aluminum wire approximately 0.01 inch (0.3 mm) diameter, having nominal 1/16 inch (1.6 mm) square openings approximately 18-1/8 inches (464 mm) long by 7 inches (178 mm) wide. To be wedged adjacent to airstream straightener.

i) Monitoring Head[g] – Measuring Ionization Chamber mounted on backwall adjacent to test sample area 1 inch (25 mm) above test platform. Employed with (s).

[g] An instrument acceptable for this application is a Measuring Ionization Chamber (MIC) Type EC 23095 and control equipment manufactured by Electronikcentralen, Horsholm Denmark.

j) Detector Under Test – Located in center on inner compartment top. Positioned to rest on back (as illustrated) or may be inverted and suspended from the box cover. Samples spaced at least 2 inches (51 mm) from the nearest edge of the monitoring head. Located so that least favorable position for smoke entry faces oncoming air flow.

k) Outlets – 120 volt receptacles for test samples, controlled by a variable autotransformer on the control cabinet.

l) Lamp — Low-voltage automotive spot-light type 4515 or equivalent rated at 6 volts dc, and mounted on 3/4 inch (19.1 mm) plywood bracket approximately 4 inches (102 mm) from the side wall in-line with the photocell. The distance from the lamp (lens face) to photocell is to be exactly 5 feet (1.52 m). The lamp is to be operated from a regulated voltage supply at 2.40 volts which yields a lamp color temperature of 2373 $\pm 50°K$. At that level, the photocell current is to be 100 ± 25 microamperes into 100 ohms. The lamp is not to cause random meter fluctuations.

m) Smoke Generator Access Assembly — Constructed of 3/4 inch (19.1 mm) plywood approximately 9 inches (229 mm) high by 7 inches (178 mm) wide with a 4-7/8 by 6-3/4 inch (124 by 172 mm) panel on the inside so as to be flush on the inside of the compartment when closed. Has a semicircular shaped shelf of approximately 3-5/8 inch (92.1 mm) radius mounted 2-5/8 inches (66.7 mm) above the bottom to support the combustible holder and screen.

n) Wick Igniter — Cone resistor, rated 1000 watts, wire guard. Energized through output of variable autotransformer to provide dull red head (approximately 75 — 80 volts).

o) Kerosene Lamp — Employed to generate black smoke. Approximately 4 inches (102 mm) high, 1/2 inch (12.7 mm) cotton wick, perforated metal shroud used as shield for wick, approximately 3-1/2 inches (88.9 mm) high, 2-3/4 inches (70 mm) diameter.

p) Combustible Holder and Screen (32 FPM Velocity) — Steel cylinder open on both ends, approximately 3 inches (76.2 mm) diameter by 6 inches (152 mm) long with 1/8 inch (3.2 mm) diameter holes on 9/32 inch (7.1 mm) centers. Smaller, 1/32 inch (0.8 mm) diameter holes spaced 3/32 inch (2.4 mm) on centers are arranged in 9/32 inch squares around each larger hole. Combustible is cotton lamp wick 1/8 inch in diameter with the smoldering end pointing downward so as to extend approximately 5 inches (127 mm) into screen. Wick is held vertically by a wire in the center of and supported by the screen.

Combustible Holder and Screen (150 FPM Velocity) — Same overall dimensions as holder for 32 fpm velocity except 5-3/4 inches high, fabricated from solid sheet metal with a 1/2- by 1-7/8 inch (13- by 48-mm) rectangular opening at top for insertion of wick and a 3/16 inch (5 mm) diameter hole on side approximately 1 inch (25 mm) from bottom. See Figure 38.5.

q) METER ASSEMBLY — Digital microammeter assembly consisting of a voltmeter having a minimum impedance of 10 megohms (clear air condition is indicated as 10 millivolts), and a trim potentiometer for adjustment of the meter. Connected directly to photocell (item 5). An analog direct current microammeter, having a maximum impedance of 100 ohms and a linearity of 1 percent or better over a range of 50 — 100 microamperes, may also be used.

r) CONTROL CABINET — Cabinet for mounting timers, switches, variable autotransformer for varying supply voltage to outlets (k), and potentiometer for speed control of circulating fan (item 3).

s) MONITOR HEAD METER[h] — High impedance meter 100 picoamperes full scale. Employed with (i) and (u).

[h] Fluke Model 8022A multimeter, or equivalent.

t) AIR DIFFUSER — Same type of screening material as described in (h). To be wedged between the underside of the air stream straightener and the deflector at approximately a 45 degree angle with the horizontal.

u) CONTROL EQUIPMENT (MONITORING HEAD) — Consists of a suction control unit employed with a vacuum pump and an amplifier with power supply. Employed with (i) and (s).

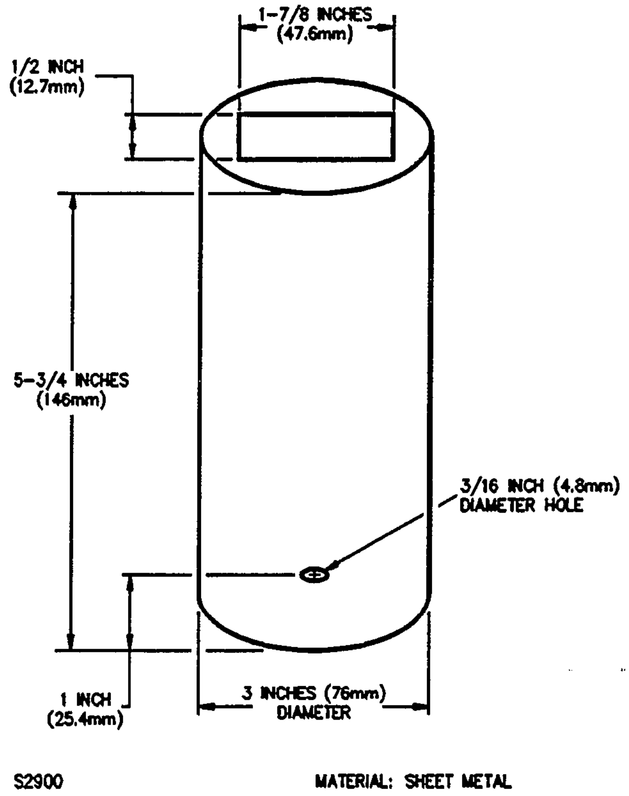
v) RECORDER[i] – X–Y plotter. Records buildup of visible smoke versus MIC output.

[i] Heath Model SR-207 rated 120 volts, 50/60 cycles, 35 watts, or equivalent.

w) VELOMETER[j] — Velocity measuring instrument with probe sensor. Probe inserted through hole in plastic window to measure air flow 1 inch (25.4 mm) above platform.

[j] Alnor Instrument Co. Type 8500, or equivalent.

Figure 38.5
Wick holder (150 fpm)



38.4 Test method

38.4.1 The test is to be conducted in an ambient temperature of 23 ±3°C (73.4 ±5°F) at a relative humidity between 50 ±20 percent and a barometric pressure of 760 ±30 mm of mercury.

38.4.2 A minimum of 12 samples of the detector, previously energized from a source of supply in accordance with 34.3.1 for at least 16 hours or for a time interval as recommended by the manufacturer, are to be subjected to this test. The detector under test is to be tested in the least and most favorable horizontal positions of smoke entry. See 40.1.

38.4.3 The air velocity in the test compartment is to be maintained at 32 ±2 fpm (0.16 ±0.001 m/s), as measured 1 inch (25.4 mm) in front (upstream) of the middle section of the detector with a hot wire anemometer, or equivalent air velocity measuring instrument. The velocity measurement is to be made with the detector removed.

38.4.4 The combustible is to be inserted into the test chamber and operation is to be continued until the detector is actuated in a continuous (steady or pulsing) alarm condition. For detectors whose alarm is nonpulsing but which emit alarm pulses with the initial entry of smoke, a continuous alarm condition is one that is continuous (nonpulsing) for not less than 5 seconds. The MIC/light relationship and the visible smoke build-up rate is to remain within the limits represented by the curves illustrated in Figures 38.1 and 38.2. If the trial-to-trial variation in percent light transmission at alarm is ±0.2 or less, only three trials need be conducted on each sample. If the variation is greater than ±0.2, five trials are to be performed. The test chamber is to be exhausted between each trial until the MIC and light beam indicate a clear condition. The airflow is to be allowed to stabilize for at least 30 seconds before each test trial.

38.4.5 The final value used for the sensitivity shall be the average of the total number of readings. The following readings are to be recorded for each trial at the moment of actuation:

a) Visible Smoke Obscuration (percent light transmission),

b) Measuring Ionization Chamber (MIC) Meter Reading, and

c) Time of test trial.

For combination smoke detectors, the sensitivity of each principle of operation is to be recorded. If a detector has a variable sensitivity setting, test trials are to be made at the maximum and minimum sensitivity settings.

38.5 Uniformity of operation

38.5.1 The detector shall be uniform in operation so that the readings of the smoke density and monitoring head meter of one detector shall be within 50 percent of the overall average of all 12 detectors tested in 38.4.2. If a detector has a variable sensitivity setting, the requirement applies to each setting tested.

38.6 Alarm verification

38.6.1 This test is to be conducted only on detectors that employ an alarm verification circuit that is bypassed in order to comply with the Fire Tests, Section 45, and the Smoldering Smoke Test, Section 46. To determine the delay time of an alarm verification circuit, sensitivity measurements are to be made on each of 10 samples; 5 preset to the maximum anticipated production sensitivity and 5 preset to the minimum anticipated production sensitivity. With the alarm verification bypassed, each detector is to be subjected to an increase in smoke until the alarm sounder is energized at which point the bypass is immediately removed (the unit is now out of alarm) and the test continued until the detector realarms. The sensitivity measurement is to be recorded at each alarm point and the time differential noted between the two alarm points. The measured time differential shall be between 10 and 30 seconds. If the alarm verification delay time cannot be obtained using the method described, an equivalent procedure is to be employed.

39 Velocity-Sensitivity Test

39.1 The sensitivity of a detector shall not vary more than 1 percent per foot obscuration outside of the production window limits, using gray smoke, when tested in accordance with the sensitivity test at air velocities of 32 and 150 fpm (0.16 and 0.76 m/s) ±10 percent. In no case shall the sensitivity exceed the limits specified in 38.1.1 for gray smoke.

39.2 Two detectors, one at maximum and one at minimum sensitivity are to be subjected, in turn, to the sensitivity test; first at a velocity of 32 fpm (0.16 m/s), and then at a velocity of 150 fpm (0.76 m/s). At 150 fpm, the smoldering rate of the wick is to be such that the relationship between the MIC output and the percent light transmission remains within the limits represented by the curve illustrated in Figure 39.1. The visible smoke buildup rate is to be maintained within the limits of Figure 39.2.

Figure 39.1
Smoke entry test limits – gray smoke – cotton wick – 150 fpm

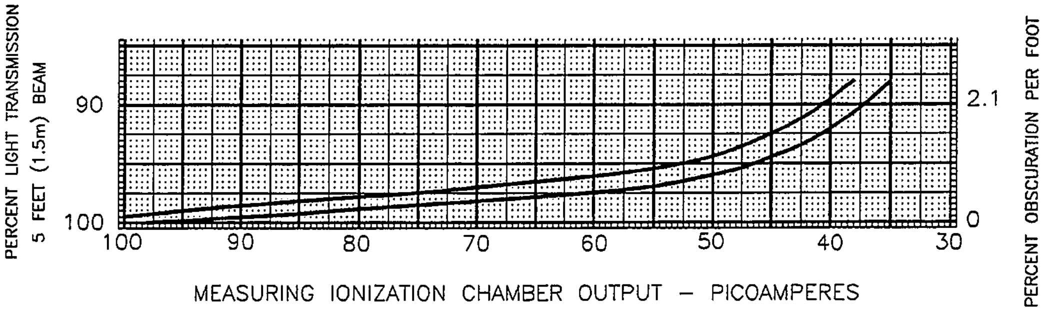


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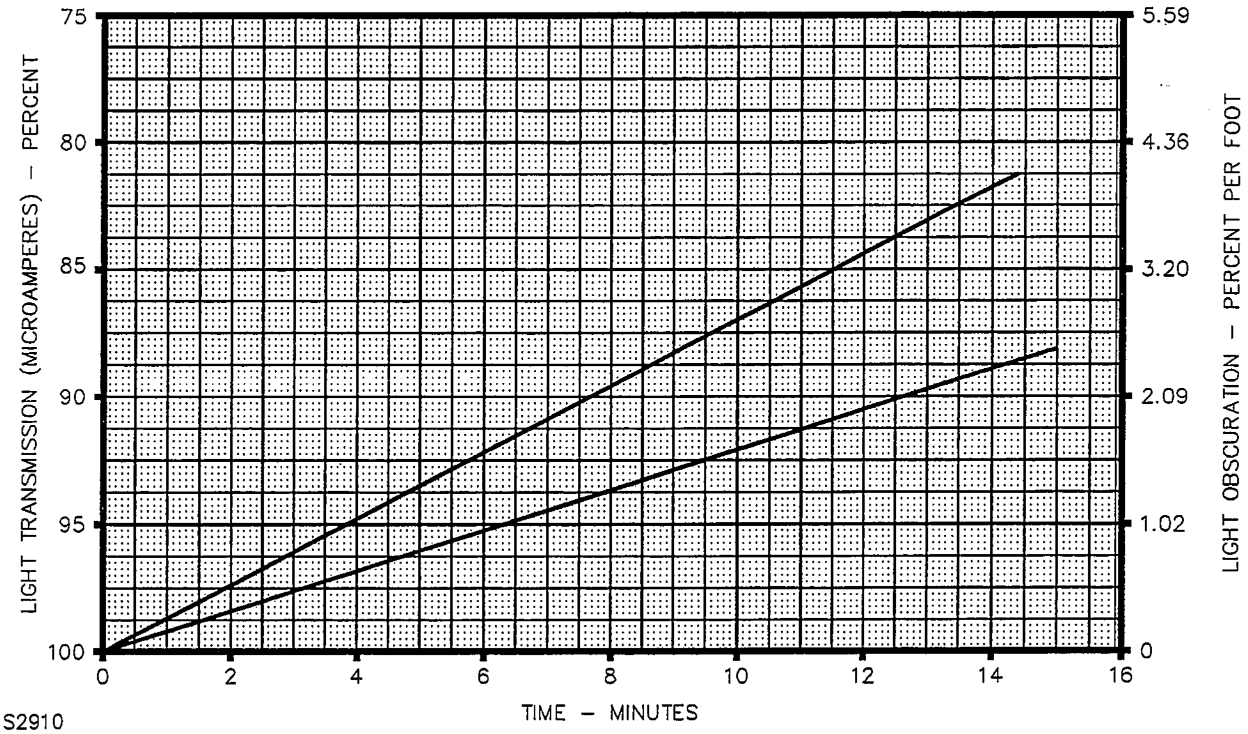
Figure 39.2
Smoke build-up rate – velocity-sensitivity test – gray smoke – cotton wick – 150 fpm



S2910

39.3 For this test the detectors are to be oriented, in turn, in the least favorable and then the most favorable position for smoke entry.

40 Directionality Test

40.1 The sensitivity of the detector shall comply with the requirements of 38.1.1 for gray smoke, in any orientation with the air flow in the chamber. The detector shall be tested at a 30 — 35 fpm (0.15 — 0.18 m/s) air velocity in its least favorable position and at each 90 degree angle from the position. The positions would include all four compass points with the detector in a horizontal position with the oncoming air directed to each of four sides and with the detector positioned on edge with the detector front facing the oncoming air. The locations of the least and most favorable smoke entry positions are to be marked on all detectors to be used in subsequent Sensitivity Tests, see 38.1.1, the Fire Test, Section 45, and the Smoldering Smoke Test, Section 46.

40.2 Two samples, one employing a maximum sensitivity, and one employing a minimum sensitivity, are to be employed for this test. A detector positioned on edge is to be mounted on a wooden board so that the edge of the detector rests on the mounting platform. The mounting board is to extend a maximum of 2 inches (50.8 mm) beyond the vertical sides of a detector and no extension beyond the top edge.

40.3 If the height of a detector is too great to be accommodated in the platform test area, it is to be located adjacent to the left edge of the mounting platform with the top edge touching the roof of the test compartment and corresponding adjustments made in the location of the velocity measurement. See 38.4.3.

41 Sensitivity Test Feature

41.1 A sensitivity test feature shall be provided on a smoke detector, to simulate either mechanically or electrically a specified level of smoke in the sensing chamber. The test feature shall be accessible from outside the detector, with the detector installed as intended. The maximum permissible measured level shall not exceed 6 percent per foot [0.027 OD/foot (0.088 OD/m)] obscuration using gray smoke.

41.2 Four samples, two at maximum and two at minimum sensitivity, shall be subjected to this test. Each sample is to be connected to a rated supply voltage, except that a detector employing a battery as the main supply shall be tested at the test voltage level (rated or trouble level voltage) that results in the lowest sensitivity measurement. The sensitivity is to be determined by conducting a curve plot of smoke obscuration versus an instrument (meter) reading, or equivalent.

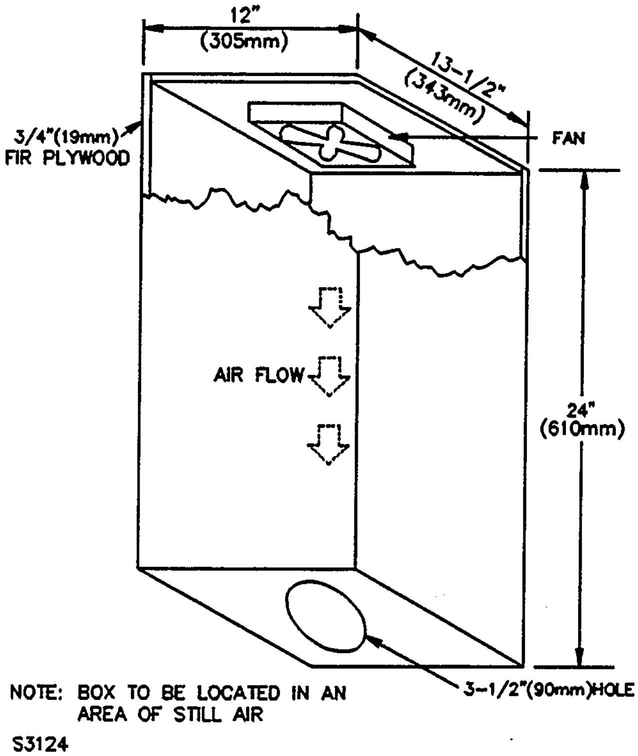
42 Smoke Entry (Stack Effect) Test

42.1 A smoke detector shall alarm within 2 minutes under the test conditions described in 42.2 — 42.4, which simulate air passing through an electrical conduit system that is connected to a smoke detector.

42.2 The test box shown in Figure 42.1 is to be employed. Fan operation is to be adjusted so that the free flow air velocity at the center of the hole in the base is 300 feet per minute and with the hole covered, the fan shall produce a back pressure measuring between 0.012 — 0.015 inches of water. The fan is then to be turned off. A smoke detector is to be installed in accordance with the manufacturer's installation instructions, facing downward and covering the hole in the base of the test box, to simulate installation in a ceiling.

42.3 The upper, smoldering end of 1/8 inch (3.2 mm) diameter vertical cotton wick is to be positioned 3 inches (76 mm) below the lowest surface of the detector, in turn, below the center of the detector, and below the detector at four equally spaced locations about the outer rim of the detector. The time until the detector alarms is to be recorded at each of the five wick positions, beginning when the wick is first positioned. Two detectors are to be tested.

Figure 42.1
Test apparatus – smoke entry (stack effect) test



Note: The box should be located in an area having still air.

42.4 The procedure described in 42.2 and 42.3 is to be repeated on both detectors, except the fan is to be turned on.

43 Lamp Interchangeability Test (Photoelectric)

43.1 The sensitivity of a detector employing a replaceable light source shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) using gray smoke and 4 percent per foot obscuration (0.058 optical density per meter) using black smoke, and shall comply with the requirements of the Sensitivity Test, Section 38, when tested with the intended replacement lamps.

43.2 Three samples, set at the minimum sensitivity setting are to be subjected to the Sensitivity Test, Section 38. The detectors then are to be de-energized, the photocell illuminating lamp replaced, reenergized, and again subjected to the Sensitivity Test.

44 Stability Tests

44.1 There shall be no false alarms of a detector set at the maximum sensitivity setting when two representative samples are subjected to the following test conditions. Different detectors are to be employed for each test. A test need not be conducted if the principle of operation is such that conducting the test would have no possible effect. Detectors whose sensitivity may be affected by air velocity are to be tested in the horizontal position in which a false alarm is most likely to occur. Momentary energization of the alarm (maximum of 1 second) is permitted during this test.

a) Operation for 90 days in an ambient room temperature of approximately 23 ±2°C (73.4 ±3°F) 30 to 50 percent relative humidity, and having a relatively clean atmosphere with air movement of 0 — 10 fpm (0 — 0.05 m/s).

b) Operation for 90 days in a relatively clean atmosphere in an air stream having a velocity of 300 ±25 fpm (1.5 ±0.13 m/s) in an ambient as specified in (a).

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°F).

d) Ten cycles of temperature variation between 0 and 49°C (32 and 120°F).

e) Ten cycles of change of air velocity from 0 to 300 ±25 fpm (0 to 1.5 ±0.13 m/s).

f) Ten cycles of a 2 inch (50.8 mm) change of air pressure starting from 31 to 29 ±0.5 inches (787 to 737 ±12.7 mm) of mercury.

g) 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 followed by 10 cycles of very rapid OFF-ON switching (each consisting of 3 OFF-3 ON sequences in 1-1/2 seconds) to simulate a loose wire connection in the home or an automatic reclosing circuit in the distribution line, at not more than 1 cycle per minute. Battery operated detectors may be tested in conjunction with the Battery Replacement Test, Section 69.

h) Twenty cycles subjected to high light intensity from a distance of 1 foot (0.3 m), 10 cycles using a 150 watt incandescent lamp, 10 cycles using a 4 light fluorescent fixture with 40 watt daylight lamps at a rate of 4 cycles per minute. Each cycle is to consist of 10 seconds ON and 5 seconds OFF.

i) Ten cycles exposed to direct sunlight at a rate of 4 cycles per minute. Each cycle is to consist of 10 seconds of exposure and 5 seconds not exposed.

44.2 Two detectors, employing a maximum sensitivity setting, are to be mounted in a position of normal use, energized from a source of supply in accordance with 34.3.1 and subjected to each of the above test conditions.

44.3 For 44.1(a) the detectors are to be mounted on wooden supports simulating normal installation and are to be connected to indicating lamps or equivalent means to indicate a false alarm.

44.4 For 44.1(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.

44.5 For 44.1(d), the time of cycling from one extreme to the other shall be a maximum of 1 hour and a minimum of 5 minutes and not less than 15 minutes at each temperature level. For (e) the air velocity is to be turned on and off abruptly with a maximum of 1 hour between applications. For (f), the time of change from one pressure to the other is to be approximately 30 seconds. For (h) and (i), the detector is to be positioned in a plane to permit the maximum entry of light into the chamber. Each cycle is to start at one test condition, changing to the other extreme, and returning to the original test condition.

44.6 The test samples subjected to (a) — (i) of 44.1 are to be tested for sensitivity, using gray smoke (see Sensitivity Test, Section 38), following the completion of each test. The response of any detector, when tested in accordance with the Sensitivity Test, shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the value obtained prior to the test, and shall not, in any case, exceed the limits of 38.1.1.

45 Fire Tests

45.1 General

45.1.1 Each detector subjected to the tests specified in 45.2.1 — 45.4.1 shall operate for alarm when installed as intended in service and exposed to the following four types of controlled test fires. The maximum response time shall be 4 minutes for Tests A and B, 3 minutes for Test C, and 2 minutes for Test D. All combustibles shall be ignited with the device as described. The bottom of the container for all combustibles is to be 3 feet (0.9 m) above the floor. Both the paper and wood brand are to be preconditioned in a relative humidity of 50 ±5 percent at a temperature of 23 ±2°C (73.4 ±3°F) for at least 48 hours prior to the test.

45.1.2 With reference to the requirements of 45.1.1, in lieu of employing detectors with a precalibrated alarm setting, detectors may be employed that will not alarm at a precalibrated setting but are equipped with means to provide an analog output (electrical measurement) of the detector sensitivity during the course of the test trials. The detectors then are to be subjected to the Sensitivity Test, Section 38, in the smoke box with the analog output recorded to translate the electrical reading into an obscuration measurement. With this type of arrangement the minimum production sensitivity setting may be obtained without the need of conducting repeat tests after recalibration. This method may also be used in the Soldering Smoke Test, Section 46.

45.1.3 The alarm verification feature (circuit) of a detector may be bypassed during the Fire Tests, provided the detector is marked in accordance with 88.1(t).

45.2 Paper fire — Test A

45.2.1 The following materials and procedures shall be used for the paper fire test.

a) Combustible — Shredded newsprint (black printing only) is to be cut in strips 1/4 to 3/8 inch (6 to 10 mm) wide, 1 to 4 inches (25.4 to 102 mm) long, total weight 1-1/2 oz (42.6 g). The paper is to be poured into the receptacle, see (b), with the bottom covered temporarily by a flat plate. The receptacle is to be tamped periodically during the pouring operation until the paper contents are even with the top of the receptacle. The paper is then to be further tamped by hand or by a rod approximately 1 inch in diameter until the paper level is approximately 4 inches below the top edge of the receptacle. A hole approximately 1 inch diameter is to be formed through the center from top to bottom of the paper. The temporary bottom plate is then to be removed and the assembly mounted 3 feet (0.9 m) above the floor on a 5 inch (127 mm) diameter ring support.

b) Receptacle – To be formed of 1/32 inch (0.79 mm) thick sheet metal, 4 inches in diameter and 12 inches (0.3 m) high and seamed together, with no air gap at the seam, with support rods at the bottom.

c) Point of Ignition – The probe tips of the igniter are to be placed at the bottom center of the receptacle touching the paper and arcing sustained for up to 5 seconds.

d) Smoke Profile – For this test the following conditions apply:

1) Flame breakthrough shall occur between 1 and 3 minutes.

2) The first principal peak of light obscuration shall occur between 1 and 3 minutes.

3) Smoke shall peak between 27 and 37 percent per foot obscuration [0.137 and 0.2 OD/foot (0.45 and 0.66 OD/m)] at the ceiling detector location; and between 21.5 and 37 percent per foot [0.105 and 0.2 OD/foot (0.345 and 0.66 OD/m)] at each sidewall detector location.

4) There shall be between 20 and 40 seconds of 4 percent per foot [0.018 OD/foot (0.058 OD/m)] or higher obscuration at the ceiling detector location; and between 10 and 30 seconds of 10 percent per foot [0.045 OD/foot (0.15 OD/m)] or higher obscuration at the sidewall detector locations.

5) The secondary peak shall not exceed 13 percent per foot obscuration [0.061 OD/foot (0.2 OD/m)] at any detector location.

6) Length of test shall be 4 minutes.

45.3 Wood fire – Test B

45.3.1 The following materials and procedures shall be used for the wood fire test.

a) Combustible[k] – A wood brand formed of three layers of kiln dried fir strips, each strip 3/4 inch (19.1 mm) square in cross section, 6 inches (152 mm) long with six strips in each layer, is to be used. Wood strips are to be nailed or stapled together with adjacent layers at right angles to each other. Overall dimensions of the wood brand are to be approximately 6 by 6 by 2-1/2 inches (152 by 152 by 64 mm). The brand is to be supported on a 5 inch (127 mm) diameter ring support 3 feet (0.9 m) above the test room floor.

[k] Douglas Fir, S4 (smooth on all sides), clear of knots and holes, weight — 1.05 — 1.32 pounds per 10 foot length.

b) Promoter – The wood brand is to be ignited by burning 4 milliliters of denatured alcohol consisting of 190 proof (95 percent) ethanol to which 5 percent methanol is added as a denaturant. The alcohol is to be placed in a 1-1/2 inch (38 mm) diameter, 1 inch (25.4 mm) deep metal container, the bottom of which is to be 3-1/2 inches (89 mm) below the bottom of the wood brand and centered so that the flame will not break through the top of the wood brand. The container is to be supported by a 1/4 inch (6.4 mm) hardware cloth. The alcohol is to be placed in the container no earlier than 30 seconds prior to ignition.

c) Point of Ignition – Ignition is to be by probes in alcohol. Probe tips of the igniter are to be placed as near the container lip as possible without arcing to the sides.

d) Smoke Profile — For this test the following conditions apply.

1) Smoke buildup shall begin between 80 and 120 seconds at the ceiling detector location; and between 60 and 120 seconds at each sidewall detector location.

2) There shall be at least 60 seconds of 4 percent per foot obscuration [0.018 OD/foot (0.058 OD/m)] at all detector locations.

3) Maximum obscuration shall not exceed 17 percent per foot [0.081 OD/foot (0.265 OD/m)] at the ceiling detector location; and 27.5 percent per foot [0.14 OD/foot (0.46 OD/m)] at either sidewall detector location.

4) Flame breakthrough shall occur between 150 and 190 seconds.

5) Length of test shall be 4 minutes.

45.4 Gasoline fire — Test C

45.4.1 The following materials and procedures shall be used for the gasoline fire test.

a) Combustible — Consists of 30 milliliters of regular leaded gasoline which is to be burned in a metal receptacle.

b) Receptacle — To be formed of 0.025 inch (0.635 mm) stainless steel, 6-1/4 inches (158 mm) in diameter and 1-1/4 inches (32 mm) deep, the bottom having 1/2 inch (12.7 mm) rounded base, located 3 feet (0.9 m) above the test room floor and centered with a ring support. The gasoline is to be poured into the receptacle approximately 30 seconds prior to ignition.

c) Point of Ignition — The probe tips of the igniter are to be placed so that they are above the lip of the pan and not extending into the pan. This results in ignition of the vapors above the gasoline.

d) Smoke Profiles — For this test the following conditions apply:

1) Smoke buildup shall begin between 20 and 30 seconds at all detector locations.

2) The flame shall not extinguish before 120 seconds.

3) Ten percent per foot obscuration [0.046 OD/foot (0.15 OD/m)] shall occur between 90 and 130 seconds at the ceiling detector location; and between 60 and 100 seconds at each sidewall detector location.

4) Maximum obscuration shall not exceed 17 percent per foot [0.081 OD/foot (0.265 OD/m)] at the ceiling detector location; or 21.5 percent per foot [0.105 OD/foot (0.345 OD/m)] at either sidewall detector location.

5) Length of test shall be 3 minutes.

6) At the termination of the test (180 seconds) smoke buildup shall be between 11 and 15 percent per foot obscuration [0.051 and 0.071 OD/foot (0.166 and 0.232 OD/m)] at the ceiling detector location; and between 13 and 21.5 percent per foot [0.061 and 0.105 OD/foot (0.2 and 0.345 OD/m)] at each sidewall detector location.

45.5 Polystyrene fire — Test D

45.5.1 The following materials and procedures shall be used for the polystyrene fire test.

a) Combustible — Consists of 1 ounce (28.4 g) of foam polystyrene type packing material, density between 1.5 — 2.0 lb/ft^3 (24 — 32 kg/m^3), with no flame inhibitor, each piece being a truncated prism approximately 1 inch (25.4 mm) on each side and 1/2 inch (12.7 mm) high.

b) Receptacle — To be formed of 1/4 inch (6.4 mm) mesh hardware cloth, approximately 18 inches (457 mm) high by 6 inches (152 mm) in diameter with a hardware cloth bottom, centered on a ring support. The combustible is to be poured into the receptacle and leveled out.

c) Promotor — The combustible is to be ignited with 5 milliliters denatured alcohol placed in a 4 inch (102 mm) diameter 1-1/2 inch (38.1 mm) deep metal container under the wire basket. The 4 inch container shall be placed in a larger, approximately 9 inch (230 mm) diameter container. The containers are to be centered on the support ring upon which the wire mesh basket rests and placed as close to the bottom of the wire mesh basket as possible allowing for probe placement.

d) Point of Ignition — Alcohol is to be poured over one piece of polystyrene and placed between the probe tips of the igniter in the smaller container approximately 30 seconds prior to ignition. Ignition is to be by a 2 second arc.

e) Smoke Profile — For this test the following conditions apply:

1) Smoke buildup shall occur between 35 and 45 seconds at the ceiling detector location; and between 25 and 35 seconds at each sidewall detector location.

2) Ten percent per foot obscuration [0.046 OD/foot (0.15 OD mm)] shall occur between 70 and 90 seconds at the ceiling detector location; and between 60 and 80 seconds at each sidewall detector location.

3) After obtaining the 10 percent obscuration, and buildup shall remain between 10 and 13 percent per foot [0.046 and 0.061 OD/foot (0.15 and 0.2 OD/m)] at the ceiling detector location; and between 10 and 17 percent per foot [0.026 and 0.08 OD/foot (0.15 and 0.265 OD/m)] at each sidewall detector location.

4) Length of test shall be 2 minutes.

45.6 Igniter Assembly

45.6.1 The igniter assembly is to consist of the following or equivalent components:

a) Igniter Probes — The metal probes, approximately 1/4 inch (6.4 mm) diameter and tapered at the ends to form a point and maintained approximately 1/2 inch (12.7 mm) apart, are to be connected to the high-voltage insulated output leads of an oil burner ignition transformer, see (c). Adjustment and support for the probes is to be provided by metal clamps affixed to a vertical steel bar integral with the igniter assembly.

b) Support — A ring clamp, approximately 5 inches (127 mm) in diameter is clamped to a ring stand to support the container holding the combustible.

c) Ignition Source — Consists of a 120 volt, 60 hertz primary, 10,000 volt, 23 milliamperes secondary oil burner ignition transformer, the output of which is to be connected to the igniter probes. The arc used for ignition is to be obtained by the closure of a remote, low-voltage, momentary contact switch which energizes a relay whose contacts control the transformer primary.

45.7 Test conditions

45.7.1 The fire tests are to be conducted in a 36 foot long by 22 foot wide by 10 foot high (10.9 by 6.7 by 3.1 m) room having a smooth ceiling with no physical obstructions. Air movement in the test room shall be essentially zero. The distance from the base of the combustible to the ceiling is to be 7 feet (2.1 m). The room is to be provided with a means for the removal of smoke. Heating, humidity, and air conditioning are to be provided for maintaining the room ambient, if necessary, but are to be shut down during the test trial. See Figure 45.1.

45.7.2 The tests are to be conducted in an ambient temperature between 20.0 and 25.5°C (68 and 78°F) and a relative humidity of 50 ±10 percent. The detector samples are to be energized from a source of supply in accordance with 34.3.1 except that detectors powered from a battery shall be energized by batteries depleted to their trouble signal voltage levels unless the minimum sensitivity is measured at rated voltage.

45.7.3 If intended for ceiling mounting only, two detectors are to be tested on a ceiling panel. See Figure 45.2. If intended for wall mounting only, two detectors are to be tested, one on each sidewall. See Figure 45.3. For detectors intended for both wall and ceiling mounting, four detectors are to be tested: two on the ceiling and one on each side wall. See Figure 45.4. For detectors intended as portable (travel) alarms, two units are to be mounted, one on each side wall, 16 inches (406 mm) from the ceiling to the top of the detector.

45.7.4 All detector samples, each adjusted to its minimum sensitivity setting, shall respond to each combustible. The test time is to start at ignition. Each detector shall operate for continuous (steady or pulsing) alarm. For detectors whose alarm is nonpulsing but that emit alarm pulses with the initial entry of smoke, a continuous alarm is one that is continuous (nonpulsing) for not less than 5 seconds. The smoke obscuration level at each of three detector locations (ceiling and each side wall) is to be monitored by a photocell-light-beam assembly, mounted directly on the ceiling and spaced 5 feet (1.52 m) apart. See 38.3.3 (e) and (l) for a description of this assembly. Combination smoke detectors are to be provided with means for monitoring each principle of operation during testing. Each principle shall contribute in response, either wholly or partially, to at least one of the test fires, or the Smoldering Smoke Test, Section 46, or to both.

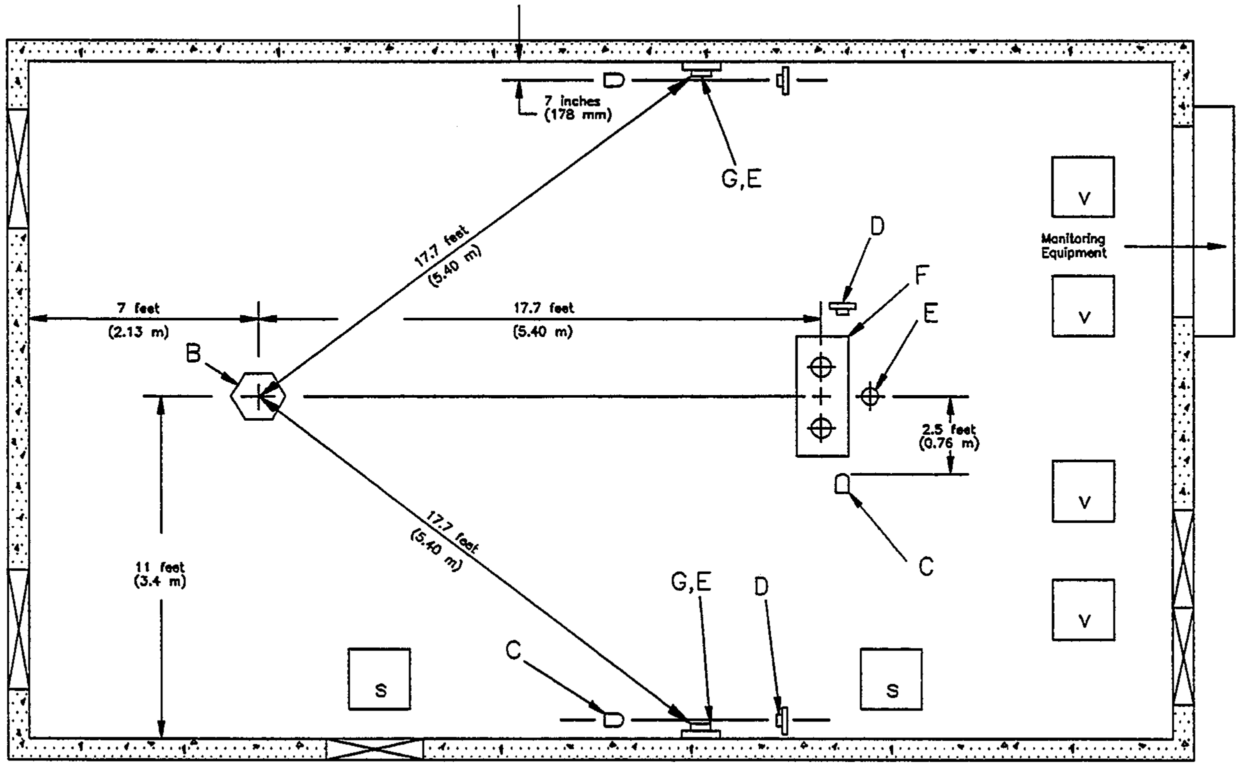
45.7.5 A detector intended for flush mounting is to be mounted flush with the mounting base. Both wall and ceiling mounted detectors are to be placed in the least favorable position of smoke entry with respect to the oncoming smoke flow unless the manufacturer's installation instructions indicate a specific mounting arrangement, or the mounting position is obvious.

45.7.6 To determine the acceptability of each test fire, the smoke profile curves as described in each fire test shall be obtained for the application combustible. See Figures 45.5 — 45.8.

45.7.7 Measuring Ionization Chambers (MICs are to be used to measure the relative buildup of particles of combustion during each trial at each detector location. The MIC utilizes the ionization principle with air drawn through the chamber at a rate of 25 ±5 liters per minute by a regulated vacuum pump. A monitoring head is to be located at each detector location as shown in Figure 45.1.

45.7.8 Prior to each test, each MIC is to be calibrated in clean air for a value of 100 picoamperes. As the smoke level increases during the test, the meter reading will decrease.

Figure 45.1
Fire test room



S2300

A. Fire Test Room Dimensions
   1. Length — 36 feet (11 m)
   2. Width — 22 feet (6.7 m)
   3. Ceiling — height 10 feet (3.0 m) suspended type. Consists of 2 by 4 feet (0.6 by 1.2 m) by 5/8 inch (15.9 mm) thick incombustible fissured mineral fiber layer in panels.

B. Test Fire
   1. 3 feet (0.91 m) above floor for Fire Tests
   2. 8 inches (203 mm) above floor for Smoldering Smoke Test

C. Lamp Assembly — 4 inches (102 mm) below ceiling, 7 inches (178 mm) from each side wall.

D. Photocell Assembly — Spaced 5 feet (1.5 m) from lamp, photocell center 4 inches (102 mm) below ceiling, 7 inches (178 mm) from each side wall.

E. Measuring Ionization Chamber (MIC) — See 46.9.

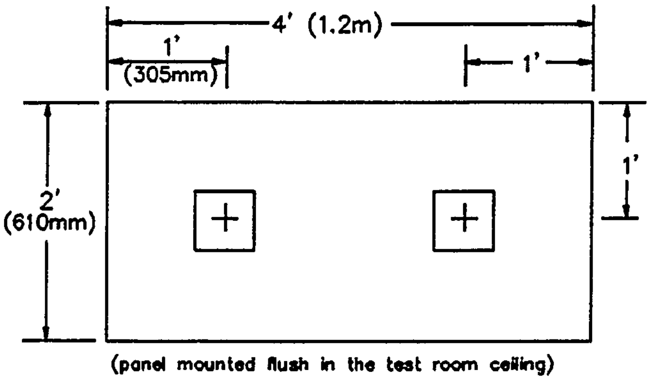
F. Test Panel, ceiling mounted detectors — see Figures 45.2 and 45.4.

G. Test Panel, sidewall mounted detectors — see Figures 45.3 and 45.4.

S. Air Supply

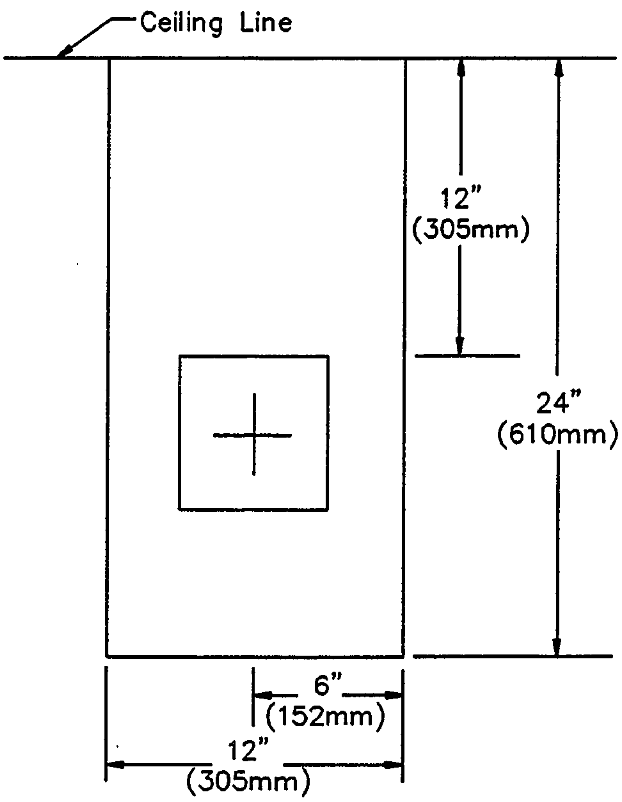
V. Exhaust Vents

Figure 45.2
Ceiling panel size and sample location for ceiling mounting of detectors



S2482

Figure 45.3
Sidewall panel size and sample location for wall mounting of detectors



S2483 (Two Required)

NOTE — Distance may be less than 12 inches but not less than 4 inches to the top of the detector if so specified in the installation instructions.

Figure 45.4
Panel mounting for fire tests

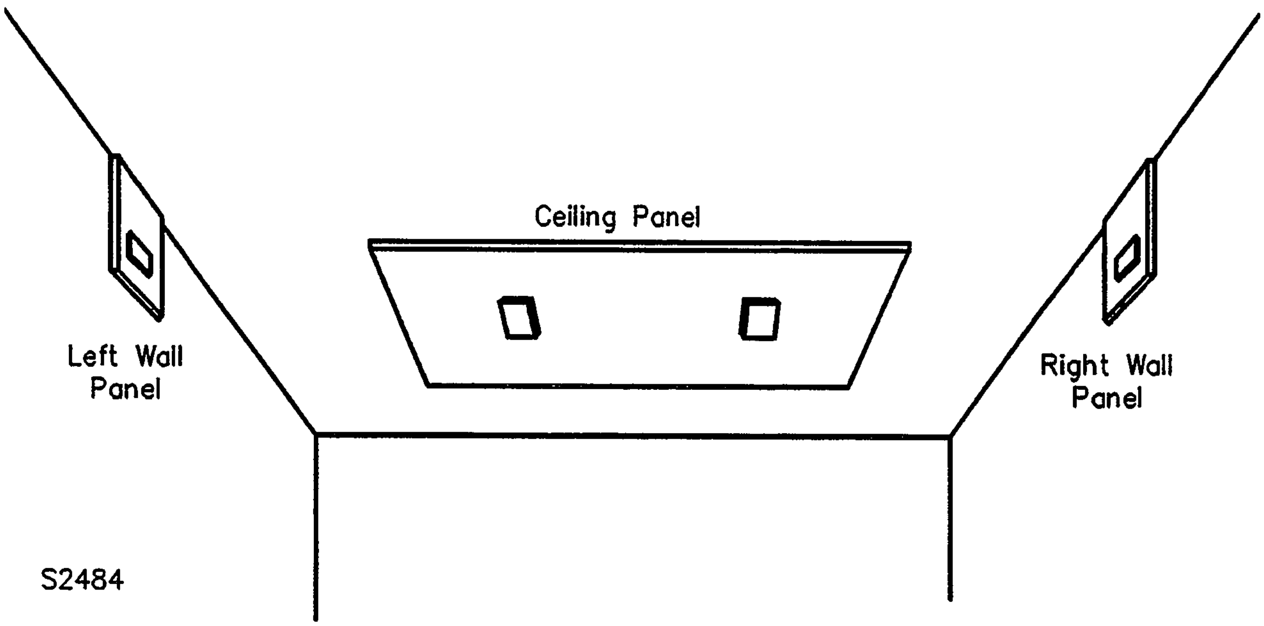


Figure 45.5

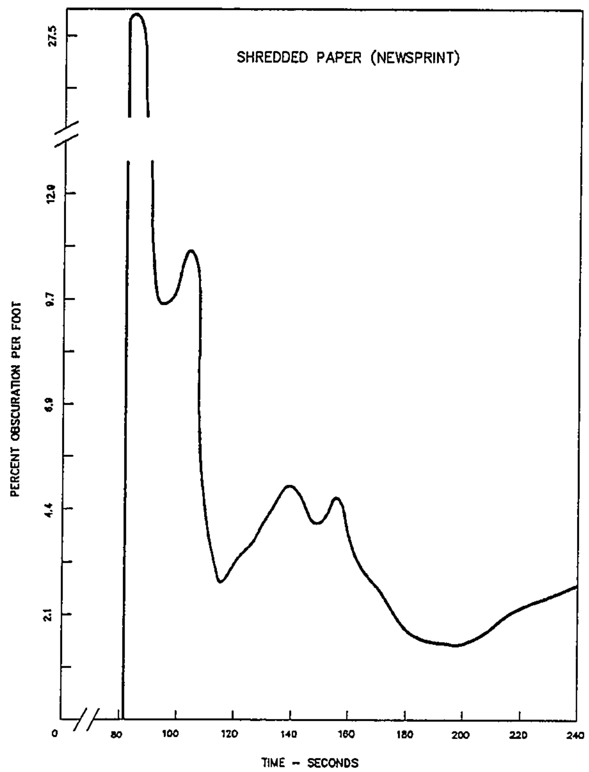


Figure 45.6

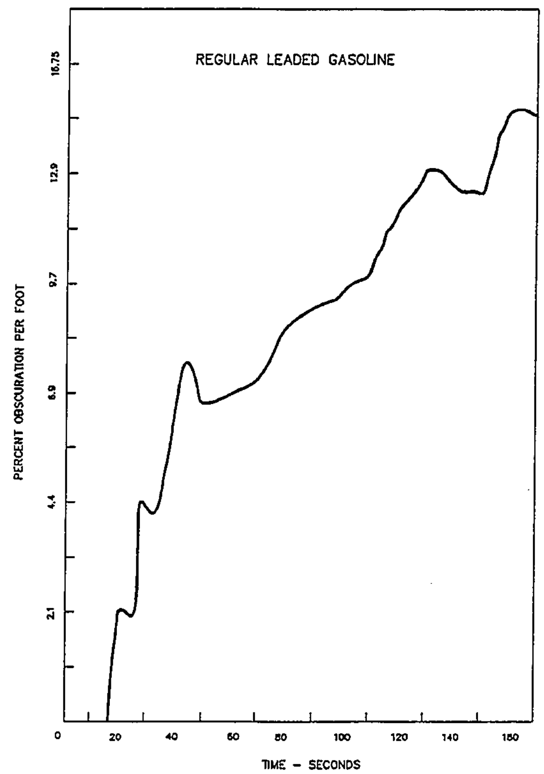


Figure 45.7

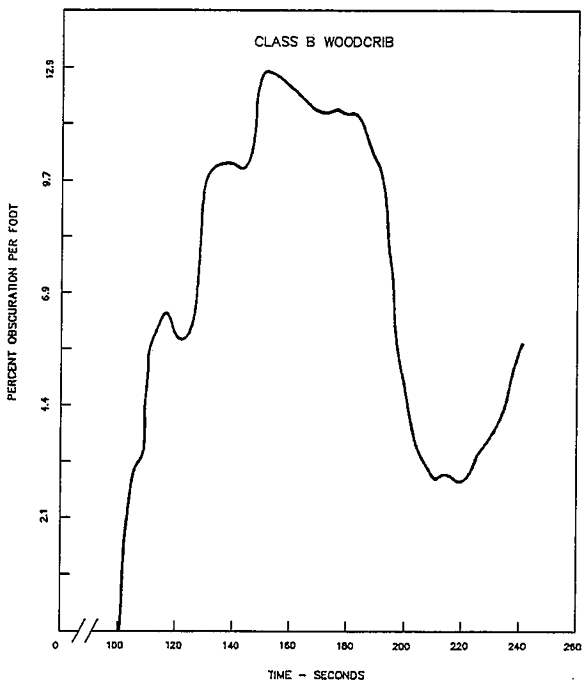
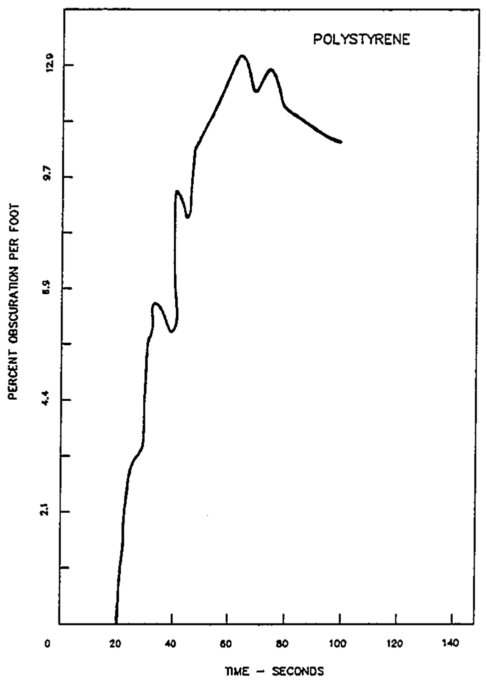


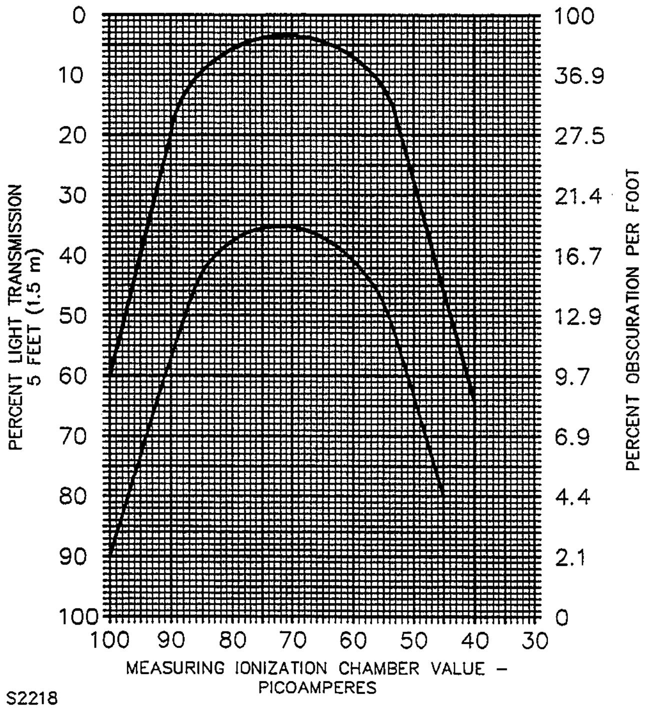
Figure 45.8



S2485

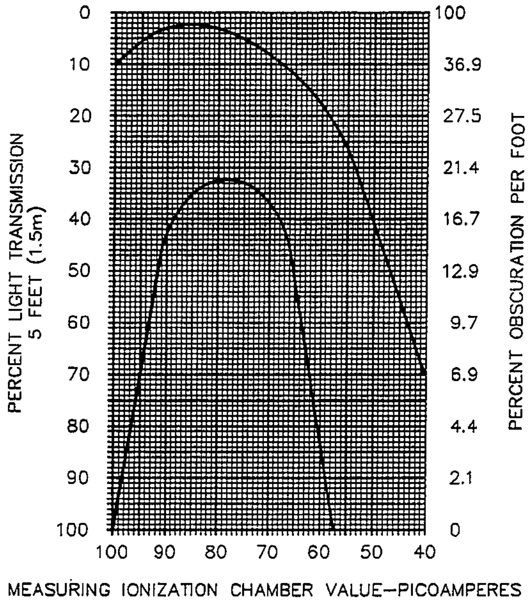
45.7.9 To determine the acceptability of the test trial for each combustible and each detector location, the relationship between the MIC output (ordinate) and the percent light obscuration (abscissa) is to be plotted. The data generated shall remain within the limits represented by the curves illustrated in Figures 45.9 – 45.16.

Figure 45.9
Paper fire – ceiling location



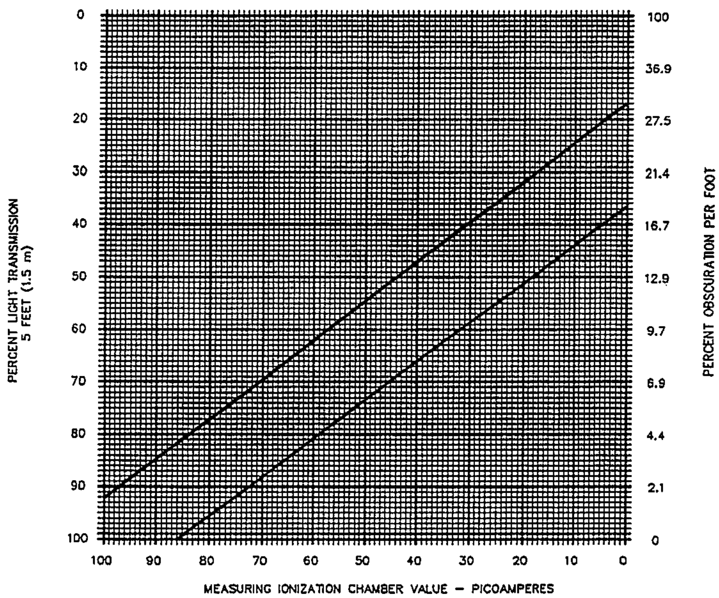
S2218

Figure 45.10
Paper fire – wall location



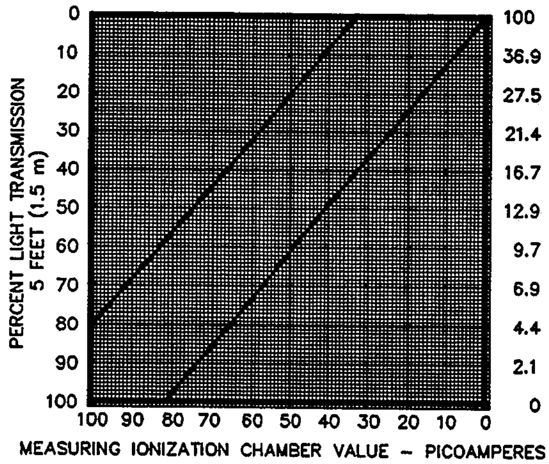
S2219

Figure 45.11
Wood fire – ceiling location



S2220

Figure 45.12
Wood fire – wall location



S2221

Figure 45.13
Gasoline fire – ceiling location

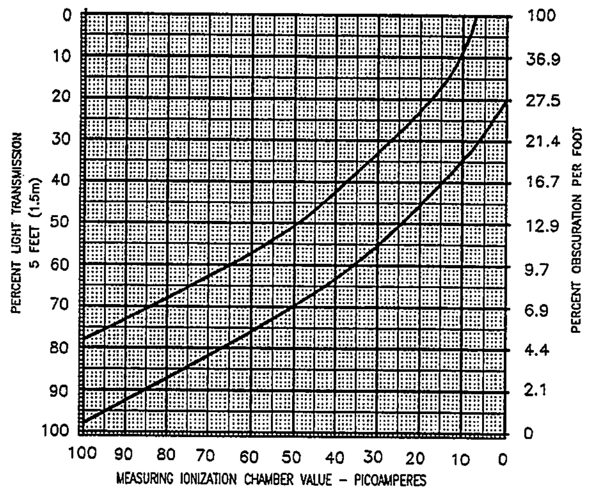


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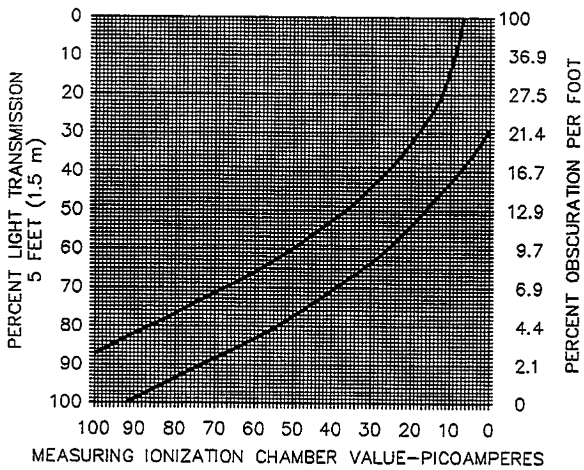
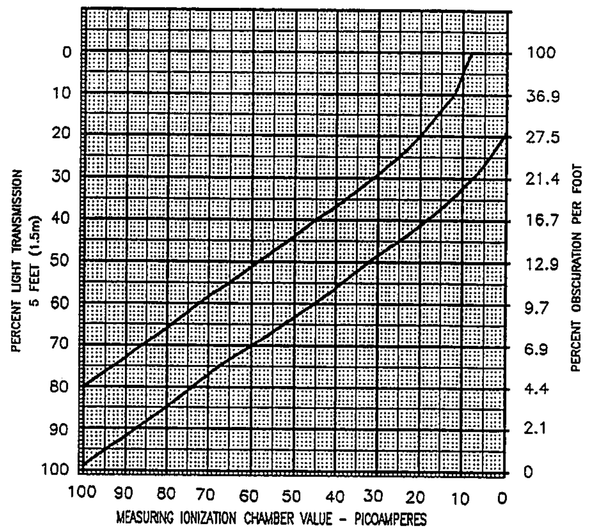
Figure 45.14
Gasoline fire – wall location



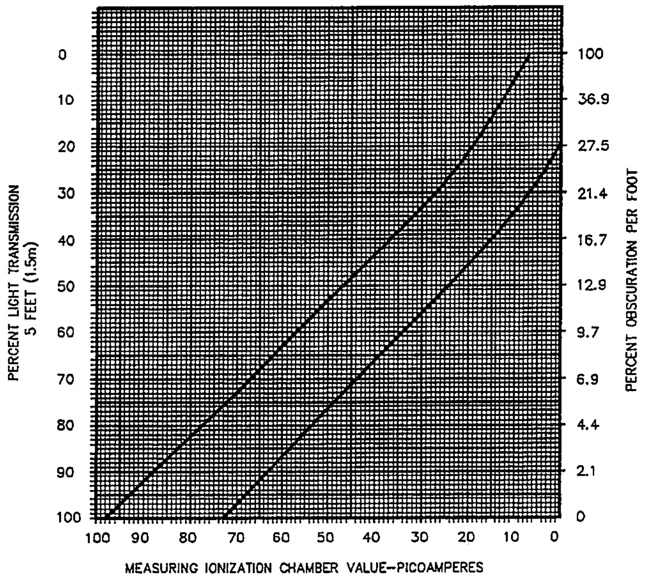
S2223

Figure 45.15
Polystyrene fire – ceiling location



S2224

Figure 45.16
Polystyrene fire – wall location



S2225

46 Smoldering Smoke Test

46.1 Each detector shall operate for continuous (steady or pulsing) alarm when installed as intended in service, and exposed to the following controlled smoldering smoke condition. For detectors whose alarm is considered nonpulsing, but that emit alarm pulses with the initial entry of smoke, a continuous alarm condition is one that is continuous (nonpulsing) for not less than 5 seconds.

46.2 Unless specifically indicated otherwise in the detector installation instructions, the detectors are to be installed in the least favorable position for smoke entry with respect to the smoldering smoke source as determined by the Directionality Test, Section 40. Detectors adjusted to the minimum production sensitivity are to be employed for this test.

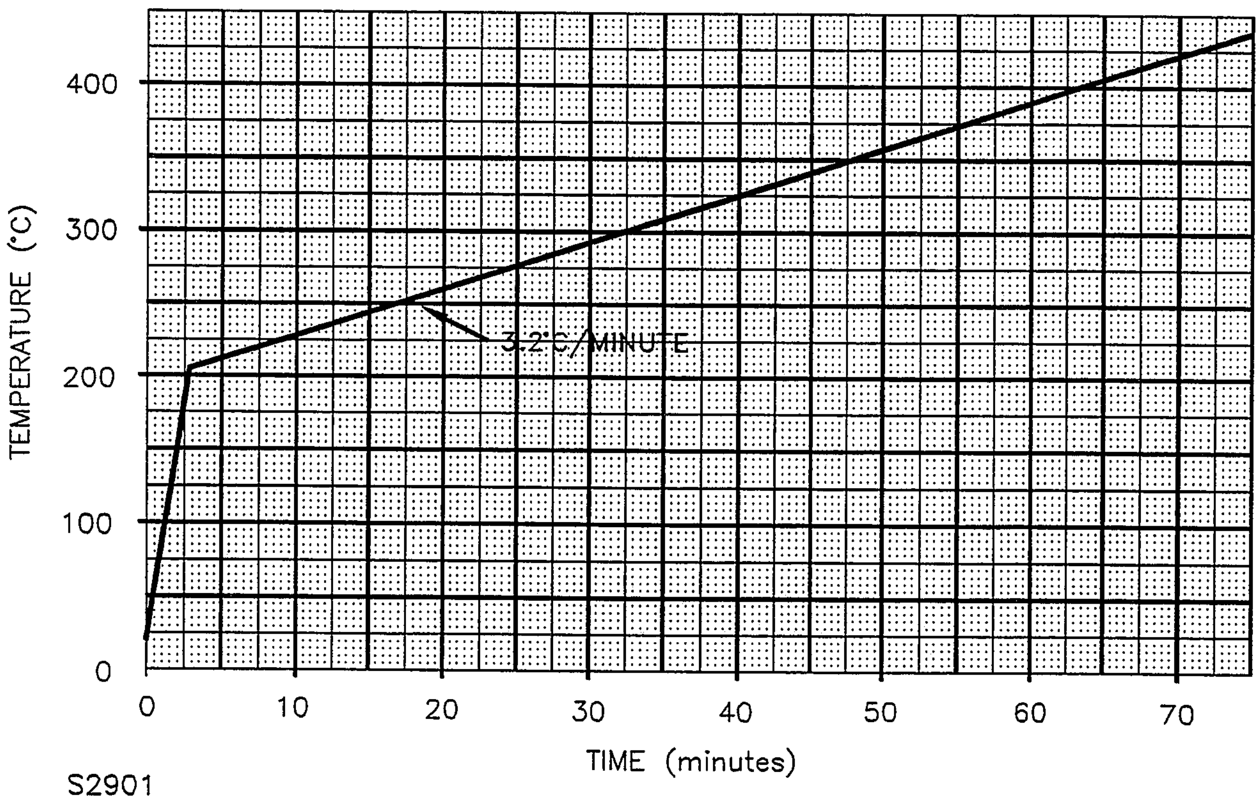
46.3 The alarm verification feature (circuit) of a detector may be bypassed during the smoldering smoke test, provided the detector is marked in accordance with 88.1(t).

46.4 The combustible for this test is to be ten Ponderosa pine sticks (nonresinous, free from knots or pitches) placed in a spoke pattern on the hotplate such that sticks are 36 degrees apart. The end of each stick is to be flush with the edge of the hotplate. Each stick is to be 3 by 1 by 3/4 inches (76.2 by 25.4 by 19.1 mm) with the 3/4 by 3 inch face in contact with the hotplate. All surfaces of each stick are to be relatively smooth and free from burrs or holes. The grain of the wood is to be approximately parallel to the stick length. Each stick is to be conditioned for not less than 48 hours at 125°F (52°C) in an air-circulating oven. The stick weight is to be 16 ±2 grams following the oven conditioning.

46.5 The heat source is to be a 240 volt, 1550 watt hotplate[1], having a steel plate 8-1/2 inch (216 mm) diameter by 1/4 inch (6.4 mm) thick, the topmost portion of which is approximately 8 inches (200 mm) above the floor. The temperature of the hotplate is to be monitored by an iron-constantan No. 30 AWG (0.05 mm^2) (Type J) thermocouple attached to the edge of the steel plate by placing its junction in a hole 0.015 inch (0.38 mm) in diameter and 1/4 inch deep and peening over the opening to secure it. The thermocouple is to be connected to a proportioning temperature controller which can be precisely set for the desired hotplate temperature. The controller sensitivity is adjusted so that all conditions for this test are met. Once set for a specific temperature, the hotplate shall be maintained at that temperature (as monitored by a temperature measuring meter). Prior to the start of the test, the hotplate temperature is to be 23 ±2°C (73 ±4°F). The initial proportioning controller temperature setting is to be 205°C (401°F). The hotplate and controller then are to be energized and the test time started (T=0). The proportioning controller setting is to be increased to obtain the temperature sequence included in Table 46.1 and Figure 46.1. (The hotplate temperature normally lags the controller setting by approximately 2 minutes during incremental increases.)

[1] A hotplate acceptable for this purpose is Emerson Electric Co. Series PH-400 Chromalox.

Figure 46.1
Hotplate temperature profile



46.6 The smoldering smoke test is to be conducted in the same room and ambient conditions and under the same mounting conditions as employed for the Fire Tests. See 45.7.1 – 45.7.3 and 45.7.5. The detector samples are to be energized from a source of supply in accordance with 34.3.1 except that detectors powered from a battery shall be energized by batteries that are depleted to their trouble signal voltage levels unless the minimum sensitivity is measured at rated battery voltage.

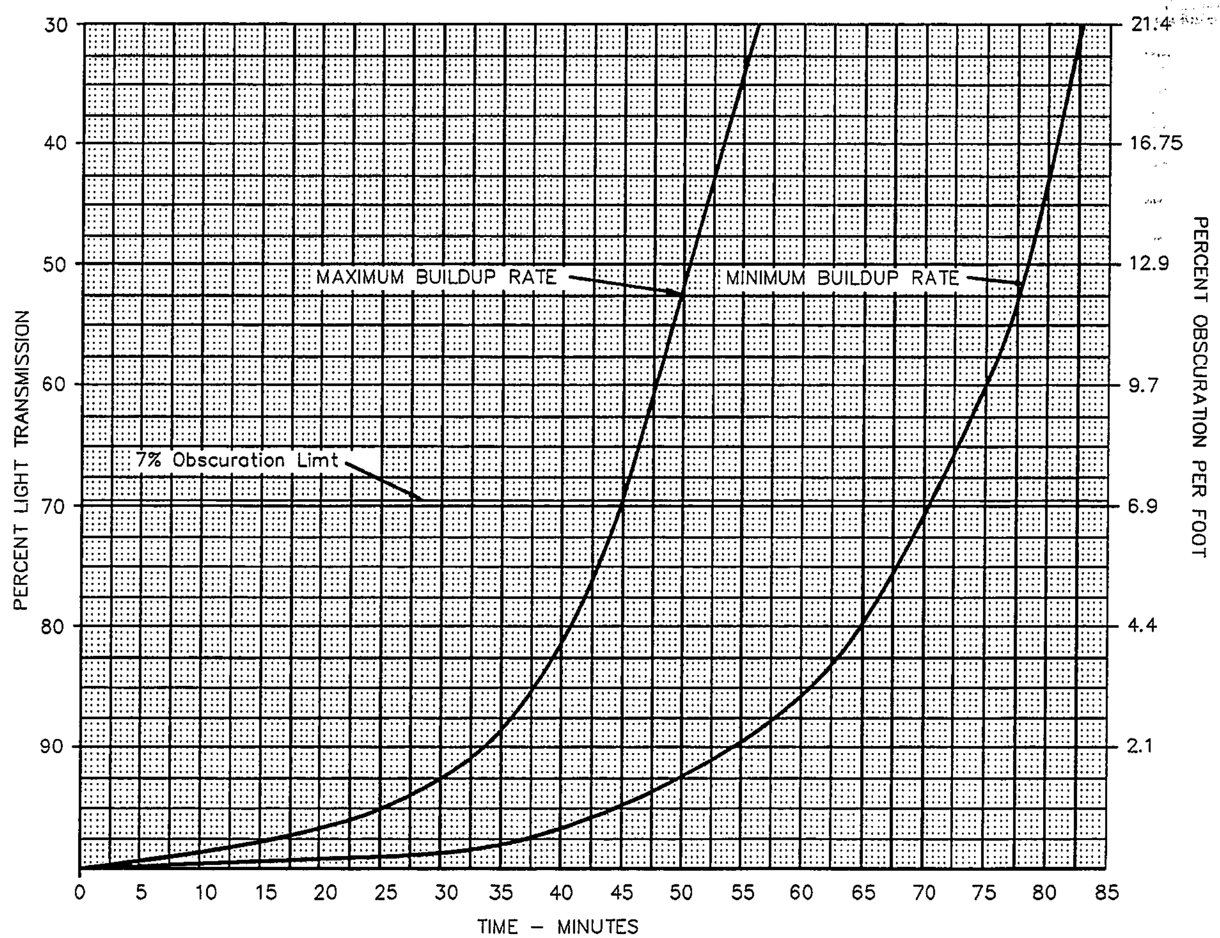
Table 46.1
Hotplate temperature

Time (minutes)	Hotplate temperature
0	23 ±2°C (73 ±4°F)
0 – 3	Increased 60.7°C (109°F) per minute to 205°C (401°F)
3 +	Increased 3.2°C (5.8°F) per minute to remainder of test

46.7 All detectors shall respond to the test trial before the obscuration level exceeds 10.0 percent per foot (29.26 percent per meter) [0.0458 OD/foot (0.15 OD/m)] at the detector location as measured by the photocell-lamp assembly described in 38.3.3 (e) and (l). Flaming of the wood shall not occur before the obscuration level is reached.

46.8 For this test, the visible smoke buildup rate is to be maintained within the limits illustrated in Figure 46.2. At no time during the test trial shall the buildup rate exceed 5 percent obscuration per minute as measured over the length of the 5 foot light beam.

Figure 46.2
Smoldering test profile



S2488

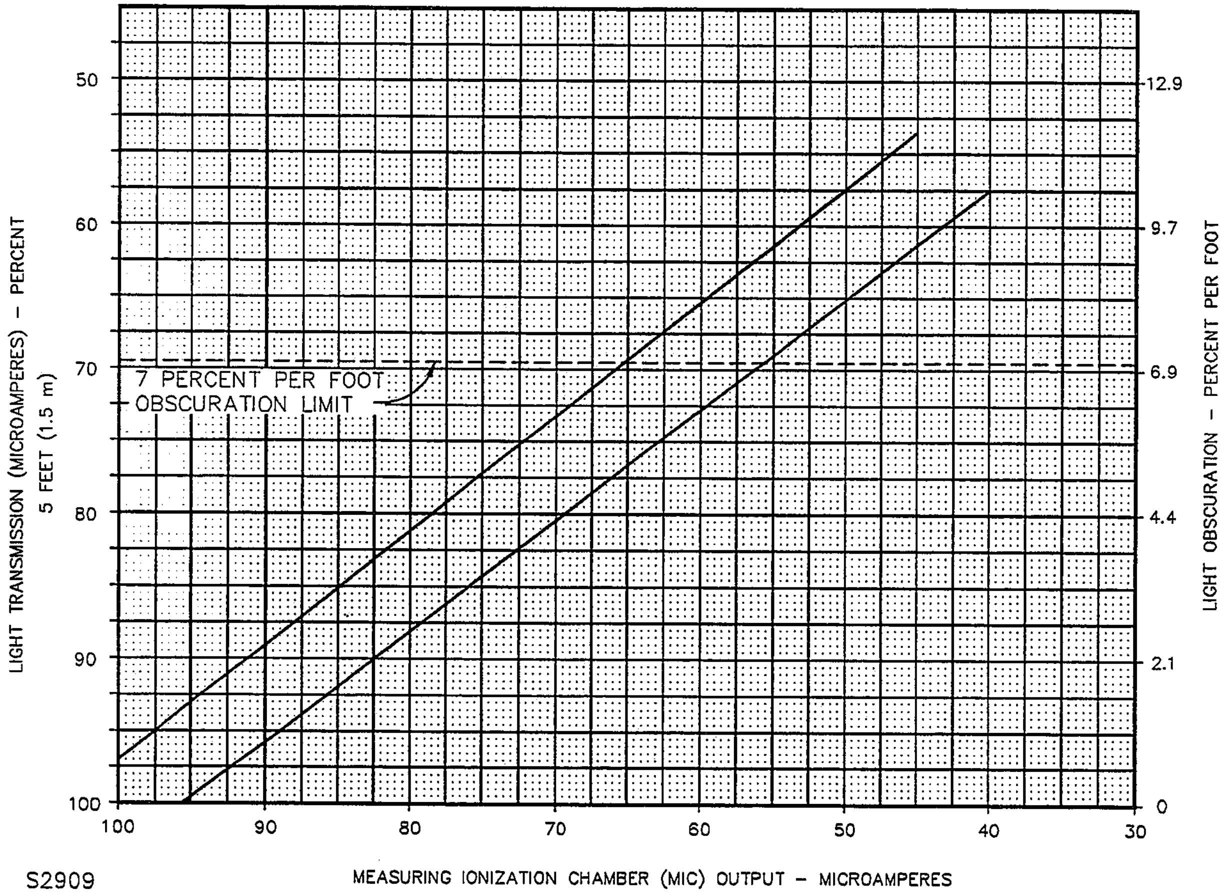
46.9 A Measuring Ionization Chamber (MIC)[m] is to be used to measure the relative buildup of particles of combustion during the test. The MIC utilizes the ionization principle with air drawn through the chamber at a rate of 25 ±5 liters per minute by a regulated vacuum pump. The monitoring head is to be located as shown in Figure 45.1.

[m] Cerberus Ltd., Mannedorf, Switzerland, or Electronikcentralen, Horsholm, Denmark, Measuring Ionization Chamber (MIC), Type EC 23095.

46.10 Prior to the test, the MIC shall be calibrated in clean air for a value of 100 picoamperes. As the smoke level increases during the test, the meter reading will decrease.

46.11 To determine the acceptability of the test trial, the relationship between the MIC output (ordinate) and the percent light transmission (abscissa) shall be plotted at 1 minute intervals during the test. The points generated shall remain within the curves illustrated in Figure 46.3.

Figure 46.3
Smoldering smoke test measuring ionization chamber/light beam limits



Note — Limits are based on a Measuring Ionization Chamber resistance of 20 x 1010 ohms measured at 21 °C, 77 percent RH, and 760 mm Hg.

47 Smoldering Smoke Test (Maximum Obscuration without Alarm)

47.1 Each of four detectors, calibrated to the maximum sensitivity anticipated in production, shall not alarm prior to an obscuration level of 0.5 percent per foot (1.65 percent/m), or less, measured in the detector area when subjected to the Smoldering Smoke Test, Section 46.

47.2 All conditions for this test are to be as described for the Smoldering Smoke Test, Section 46, except that the four samples subjected to this test are to be adjusted to the maximum production sensitivity and the samples are to be oriented in the most favorable position facing the fire as determined in the Directionality Test, Section 40.

48 Temperature Test

48.1 The materials or components employed in a detector shall not be subjected to a temperature rise greater than that indicated in Table 48.1, under any condition of operation.

Exception: If failure of a component results in an audible trouble signal, the temperature rise of the component in the standby condition may exceed the limits in Table 48.1, but in no case shall it be greater than the temperature permitted under an alarm condition.

48.2 Except as noted in 48.3, all values for temperature rises apply to equipment intended for use in prevailing ambient temperatures, usually not higher than 25°C (77°F).

48.3 If equipment is intended specifically for use with a prevailing ambient temperature constantly more than 25°C (77°F), the test of the equipment is to be made at the higher ambient temperature, and allowable temperature rises specified in Table 48.1 are to be reduced by the amount of the difference between that higher ambient temperature and 25°C (77°F).

48.4 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 clearance of 2 inches (50.8 mm) on the top, sides and rear, and the front extended to be flush with the detector cover.

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

48.6 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 a temperature measurement by either the thermocouple or change-in-resistance method is acceptable, except that the thermocouple method is not to be employed for a temperature measurement at any point where supplementary thermal insulation is employed.

48.7 Thermocouples consisting of No. 30 AWG (0.06 mm^2) iron and constantan wires and a potentiometer-type indicating instrument are to be used whenever referee temperature measurements by thermocouples are necessary.

48.8 The thermocouple wire is to conform with the requirements for special thermocouples as listed in the Table of Limits of Error in Temperature Measurement Thermocouples, ANSI MC96.1.

Table 48.1
Maximum temperature rises

Device or material	Normal standby Degrees C	Normal standby Degrees F	Alarm condition Degrees C	Alarm condition Degrees F
A. COMPONENTS				
1. Capacitors	25	45	40	72
2. Fuses	25	45	65	117
3. Rectifiers – At any point	25	45	50	90
a. Germanium	25	45	50	90
b. Selenium	50	75	75	135
c. Silicon (1) Maximum 60 percent of rated volts	25	45	75	135
(2) 60 percent > rated volts				
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 103 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			
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 electric 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

(Continued)

Table 48.1 (Cont'd)
Maximum temperature rises

Device or material	Normal standby Degrees C	Normal standby Degrees F	Alarm condition Degrees C	Alarm condition Degrees F
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 circuits), 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 which 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. 883C.

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 which 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 retested.

[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.

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

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

In which:

T is the temperature to be determined in degrees C.

t is the known temperature 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.

48.10 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.

48.11 To determine compliance with this test, a detector is to be connected to a source of supply in accordance with 34.3.1 and operated under the following conditions:

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

b) Alarm – (1 hour).

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

48.12 For 48.11(c), the temperature limits may be exceeded but there shall be no manifestation of a fire or approaching failure, and the detector shall operate as intended following the test.

48.13 The detector is to be subjected to the Dielectric Voltage-Withstand Test, Section 55, following 48.11 (b) or (c).

49 Overload Test

49.1 Detector

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

49.1.2 Rated test loads are to be connected to those output circuits of the detector which are energized from the detector power supply, such as remote indicators, relays, and the like. The test loads shall be those devices, or the equivalent, normally intended for connection. If an equivalent load is employed for a device consisting of an inductive load, a power factor of 60 percent is to be employed. The rated loads are established initially with the detector connected to a source of supply in accordance with 34.3.1 following which the voltage is increased to 115 percent of rating.

49.1.3 For dc 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 ac potential equal to the rated dc test voltage. When the inductive load has both the required dc resistance and the required inductance, the current 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.

49.2 Separately energized circuits

49.2.1 Separately energized circuits of a detector, such as dry contacts, shall be capable of operating as intended after being subjected for 50 cycles of signal operation at a rate of not more than 6 cycles per minute while connected to a source of supply in accordance with 34.3.1, with 150 percent rated loads at 60 percent power factor applied to output circuits which do not receive energy from the detector. There shall be no electrical or mechanical failure of the switching circuit.

49.2.2 The test loads shall be set at 150 percent of rated current while connected to a separate power source of supply in accordance with 34.3.1.

50 Endurance Test

50.1 Detector

50.1.1 A detector shall operate as intended after being subjected to 6000 cycles of 5 second alarm signal operation, at a rate of not more than 10 cycles per minute, with the detector connected to a source of supply in accordance with 34.3.1 and with related devices or equivalent loads connected to the output circuits. There shall be no electrical or mechanical failure or evidence of failure of the detector components. Battery operated units may be connected to an equivalent filtered dc power supply source for this test.

50.1.2 Sensitivity measurements, using gray smoke, are to be recorded before and after the Endurance Test, in accordance with the Sensitivity Test, Section 38. The sensitivity values shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to the test, and shall not, in any case, exceed the limits specified in 38.1.1.

50.2 Separately energized circuits

50.2.1 Separately energized circuits of a detector shall operate as intended, when operated for 6000 cycles at a rate of not more than 10 cycles per minute at a 50 percent duty cycle. When an electrical load is involved, the contacts of the device shall be caused to make and break the normal current at the voltage specified by 34.3.1. 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 be no electrical or mechanical malfunction of the detector nor malfunction or welding of any relay contacts.

Exception: If the contact rating is at least twice that of the load controlled, this test may be waived.

50.3 Audible signaling appliance

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

50.4 Test means

50.4.1 A sensitivity adjustment switch, test means, alarm silencing means, or reset switch provided on a detector shall operate as intended after being operated for 1500 cycles at the rate of not more than 10 cycles per minute. The time of actuation of a test means is to be sufficient to obtain at least 1 second of alarm. For this test one detector is to be connected to a rated source of supply voltage and frequency. This test may be conducted in conjunction with the Endurance Test of the detector.

51 Variable Ambient Temperature Test

51.1 Operation in high and low ambient

51.1.1 A detector shall operate for its intended signaling performance when tested in an ambient temperature of 0 and 49°C (32 and 120°F) at a relative humidity of 30 to 50 percent. Two detectors, one at maximum and one at minimum sensitivity, are to be maintained at each ambient temperature for at least 3 hours so that thermal equilibrium is reached. The units then are to be tested for sensitivity while connected to a source of supply in accordance with 34.3.1.

51.1.2 Sensitivity measurements shall be recorded before and during exposure to each ambient temperature in accordance with the Sensitivity Test, Section 38, except that the smoldering rate of the wick is to be such that the relationship between the MIC output and the percent light transmission remains within the limits represented by the curves illustrated in Figures 51.1 and 51.3 for the 0°C (32°F) and 49°C (120°F) ambients, respectively. The visible smoke buildup rates are to be maintained within the limits illustrated in Figures 51.2 and 51.4 for the 0 and 49°C ambients, respectively.

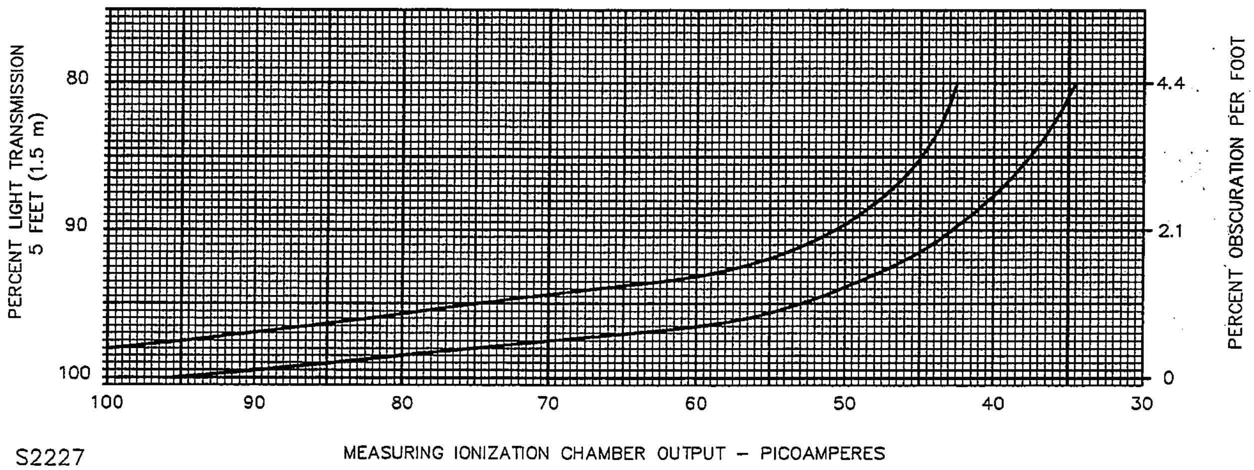
51.1.3 Each unit shall operate as intended in each ambient. The sensitivity readings using gray smoke measured in each ambient temperature shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to the Variable Ambient Temperature Test, and shall not, in any case, exceed the limits specified in 38.1.1.

51.1.4 Prior to each test, the wick is to be conditioned for each ambient as shown in Table 51.1.

Table 51.1
Variable ambient wick conditioning

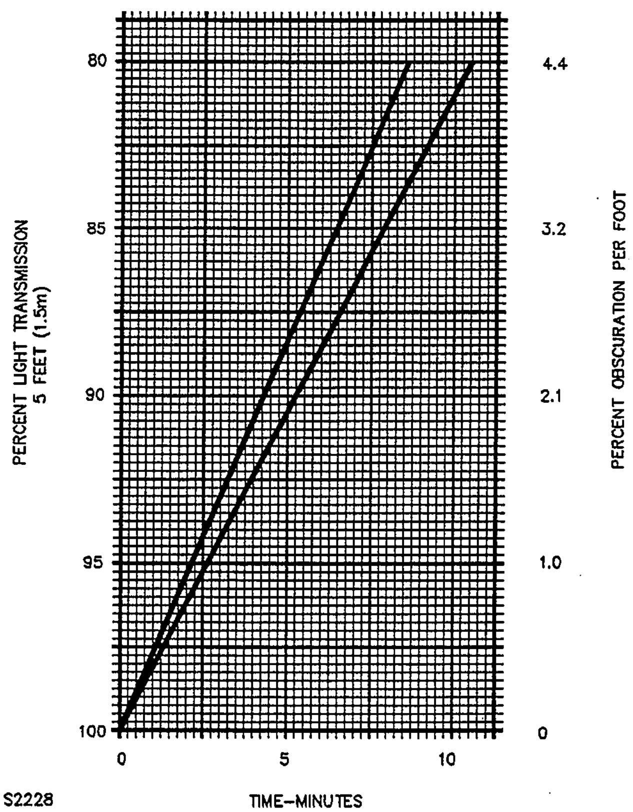
Ambient	Wick conditioning	Number of wicks used
0°C (32°F)	At least 24 hours at 0°C, 30 – 50 percent RH	1
49°C (120°F)	At least 24 hours at 49°C, 40 – 50 percent RH	2

Figure 51.1
Sensitivity test limits – 0°C ambient – gray smoke – cotton wick – 30 fpm



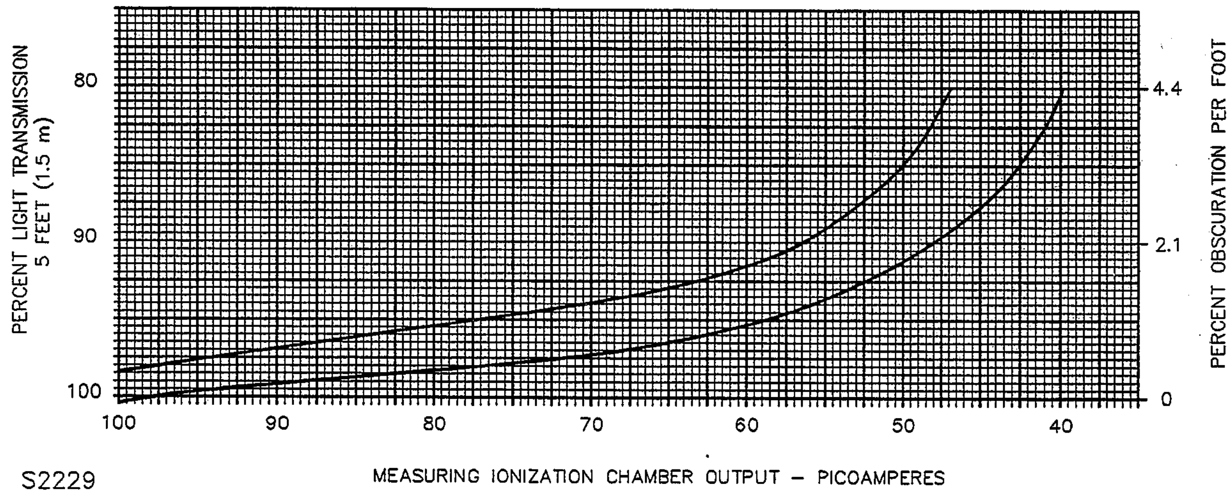
S2227

Figure 51.2
Smoke build-up rate – sensitivity test – 0°C ambient – gray smoke – cotton wick – 30 fpm



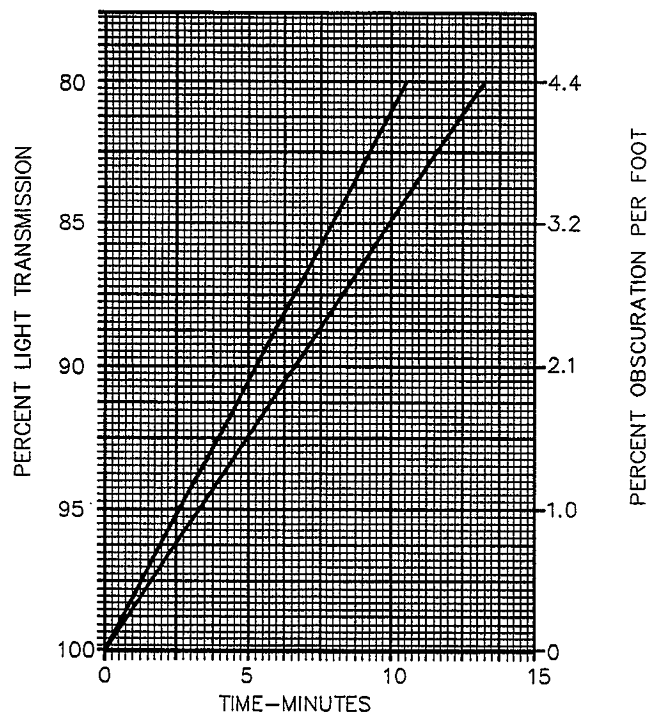
S2228

Figure 51.3
Sensitivity test limits – 49°C ambient – gray smoke – cotton wick – 30 fpm



S2229

Figure 51.4
Smoke build-up rate – sensitivity test – 40°C ambient – gray smoke – cotton wick – 30 fpm



S2230

51.2 Effect of shipping and storage

51.2.1 The sensitivity of a detector shall not be impaired by exposure to high and low temperatures representative of shipping and storage.

51.2.2 Two detectors, one at maximum and one at minimum sensitivity, are to be subjected, in turn, to a temperature of 70°C (158°F) for a period of 24 hours, allowed to cool to room temperature for at least 1 hour, exposed to a temperature of minus 30°C (minus 22°F) for at least 3 hours, and then permitted to warm up to room temperature for at least 3 hours. The detectors then are to be tested for sensitivity using gray smoke while connected to a source of supply in accordance with 34.3.1.

51.2.3 Sensitivity measurements are to be recorded, before and after exposure to both ambient conditions, in accordance with the Sensitivity Test, Section 38.

51.2.4 The sensitivity readings using gray smoke measured after exposure shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to the exposures, and shall not, in any case, exceed the limits specified in 38.1.1.

52 Humidity Test

52.1 Two detectors, one at maximum and one at minimum sensitivity, shall operate for their intended signaling performance when exposed for 168 hours to air having a relative humidity of 93 ±2 percent at a temperature of 40 ±2°C (104 ±4°F) while energized from a source of supply in accordance with 34.3.1. There shall be no false alarms during the exposure.

52.2 Sensitivity measurements shall be recorded before and during exposure to the humidity condition in accordance with the Sensitivity Test, Section 38, except that the smoldering rate of the wick is to be such that the relationship between the MIC output and the percent light transmission remains within the limits represented by the curves illustrated in Figure 38.2. The visible smoke buildup rate is to be maintained within the limits represented by the curves illustrated in Figure 38.3.

52.3 The sensitivity values using gray smoke shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to the Humidity Test, and shall not, in any case, exceed the limits specified in 38.1.1.

52.4 Prior to each test, the wick is to be conditioned for at least 24 hours at 30°C (86°F) and 80 — 90 percent relative humidity. One wick is to be used for each trial.

52.5 Following the Humidity Test, a detector other than that operating from a primary battery, shall be subjected to the Leakage Current Test, Section 53.

53 Leakage Current Test

53.1 The leakage current of a detector other than that operating from a primary battery, shall not exceed 0.5 milliampere, ac or dc when measured under all the following conditions after being subjected to the Humidity Test, Section 52. All grounding connections to the unit being tested shall be disconnected prior to making the measurement. The leakage current measurement of a permanently installed detector is to be made at the supply connection polarity indicated on the installation wiring diagram supplied with the detector. If a connection polarity is not indicated, the measurement is to be made at each polarity. See Figure 53.1.

a) Between any exposed surface of a detector that may be contacted by a person, and earth ground.

b) Between any interior parts of a detector that may be contacted by a person during servicing, and earth ground.

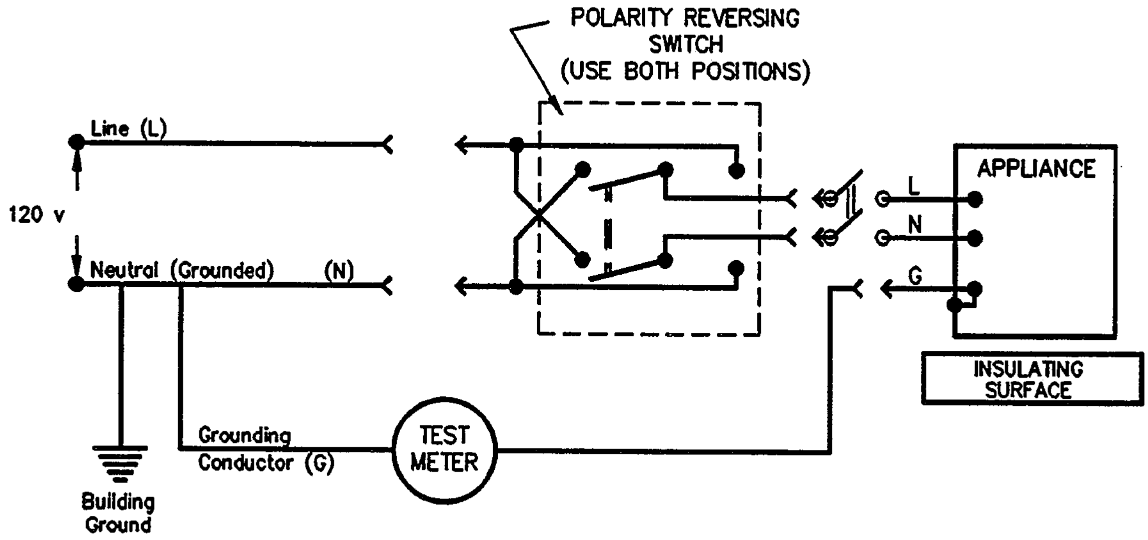
53.2 For this test the detector is to be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately reenergized from a rated source of supply. The leakage measurement then is to be made within 5 minutes of energization while in the standby and alarm conditions.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

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

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

53.5 If a detector is intended for multiple station connection, leakage currents are to be measured with the maximum number of detectors intended to be interconnected, unless it is established by circuit analysis that the leakage current is independent of interconnection.

Figure 53.1
Leakage current measurement circuit



S2489

54 Transient Tests

54.1 General

54.1.1 A detector shall operate for its intended signaling performance and its sensitivity not affected adversely when two representative samples (one preset to the maximum and one preset to the minimum production sensitivity) are subjected to 500 supply line (high-voltage) transients, 500 internally induced transients, extraneous transients, and 60 supply line (low-voltage) circuit transients, while energized from a source of supply in accordance with 34.3.1 and connected to the device(s) intended to be used with the detector.

54.1.2 Different detectors are to be used for each test. The detectors shall not false alarm for more than 1 second. Detectors using a primary battery as a power supply are to be subjected to the extraneous transients test only. If a detector is intended for multiple-station connection, the transient tests are to be conducted with the maximum number of detectors intended to be connected.

54.1.3 Sensitivity measurements using gray smoke, recorded before and after each transient condition, shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to each test and shall not, in any case, exceed the limits specified in 38.1.1.

54.2 Supply line (high-voltage) transients

54.2.1 For this test, the detector is to be connected to a transient generator, consisting of a 2 kilovolt-amperes isolating power transformer and control equipment capable of producing the transients described in 54.2.2. See Figure 54.1. The output impedance of the transient generator is to be 50 ohms.

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

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

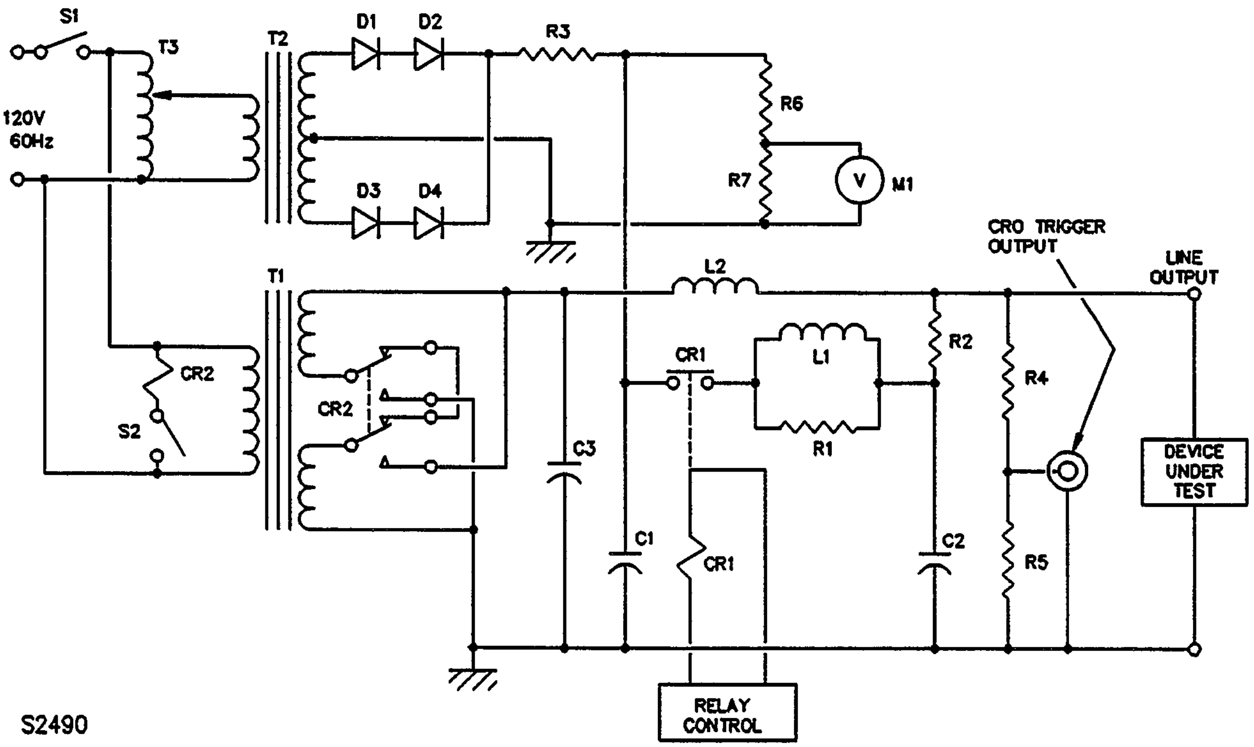
54.3 Internally induced transients

54.3.1 The detector is to be energized in the standby condition while connected to a source of supply in accordance with 34.3.1. The supply is to be interrupted for approximately 1 second at a rate of not more than 6 cycles per minute for a total of 500 cycles. Following the test the detector is operated for its intended signaling performance.

54.4 Extraneous transients

54.4.1 Single or multiple station smoke detectors shall not false alarm or their intended operation shall not be impaired when subjected to extraneous transients generated by the devices and appliances described in 54.4.2. In addition, the detector shall respond to smoke during application of the transient condition.

Figure 54.1
Surge generator circuit



S2490

C1 — Capacitor, 0.025 μF, 10 kV
C2 — Capacitor, 0.06 μF, 10 kV
C3 — Capacitor, 10 μF, 400 V

CR1 — Relay, coil 24 V, DC. Contacts, 3-pole, single throw, each contact rated 25 A, 600 V, AC maximum: All three poles wired in series.
CR2 — Relay, coil 120 V, AC. 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 V, DC

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)
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 V, AC, 1A

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

54.4.2 Two single and two sets of multiple station smoke 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 the condition specified in (a) is to be at least 2 minutes. The conditions specified in (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 10-minute duration. Near the end of the last cycle, an abnormal amount of smoke is to be introduced into the detector chamber to determine whether the unit is operational for smoke with the transient applied. For the condition specified in (b), the 1-foot distance is to be measured from the transmitter-receiver (walkie-talkie) antenna to the surface of the smoke 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 an 1/8 inch (3.2 mm) separation 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[n] with no arc suppression and rated 24 volts.

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

54.5 Supply line (low-voltage) circuit transients

54.5.1 Each of two low-voltage smoke detectors is to 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.

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

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

a) Twenty pulses (two at each transient voltage level specified in 54.5.2) 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 54.5.2) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten of the opposite polarity.

54.5.4 At the conclusion of the test, the detector shall comply with the requirements of the Normal Operation Test, Section 35, and Sensitivity Test, Section 38.

55 Dielectric Voltage-Withstand Test

55.1 A 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 high-voltage live parts and exposed dead metal parts, and live parts of high- and low-voltage circuits. The test potential is to be:

a) For a 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 detector rated between 31 and 250 volts ac rms — 1000 volts (1414 volts, if a dc potential is used).

c) For a 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).

55.2 Any reference grounds are to be disconnected prior to the test applications.

55.3 If the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is sufficient to prevent maintenance of the specified ac test potential, the capacitors and capacitor-type filters may be tested using a dc potential in accordance with 55.1.

55.4 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 applied 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.

55.5 A printed-wiring assembly or other electronic-circuit component that would short circuit or would be damaged by application of the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly may be tested instead of an entire unit.

56 Abnormal Operation Test

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

56.2 To determine if a detector complies with the requirement of 56.1, it is to be operated under the most severe circuit fault conditions likely to be encountered in service while connected to a source of supply in accordance with 34.3.1. There shall be no emission of flame or molten metal, or any other manifestation of a fire, or dielectric breakdown when tested in accordance with the Dielectric Voltage-Withstand Test, Section 55, after the abnormal test.

56.3 In determining if a detector complies with the requirement with respect to circuit-fault conditions, the fault condition is to be maintained continuously until constant temperatures are attained, or until burnout occurs, if the fault does not result in the operation of an overload protective device. Shorting of the secondary of the power supply transformer and shorting of a limited-life electrolytic capacitor would represent typical fault conditions. See 72.3.2.

57 Overvoltage and Undervoltage Tests

57.1 Overvoltage test

57.1.1 A detector other than one operating from a main battery power supply shall operate as intended:

a) In the standby condition at both maximum and minimum sensitivity settings and

b) While performing its signaling function and connected to a supply source of 110 percent of rated value.

If a nominal rated voltage value is specified, the overvoltage shall be 110 percent of the test voltage specified in 34.3.1. If an operating voltage range is specified, the overvoltage shall be either 110 percent of the high value of the voltage range or 110 percent of the test voltage specified in 34.3.1, whichever is higher. Sensitivity measurements at the increased voltage shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) for gray smoke and 4 percent per foot obscuration (0.058 optical density per meter) for black smoke from the readings measured at rated voltage, and shall not, in any case, exceed the limits specified in 38.1.1.

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

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

57.2 Undervoltage test

57.2.1 A detector shall operate for its intended signaling performance while energized from a supply of 85 percent of the test voltage specified by the manufacturer and while at both maximum and minimum sensitivity settings. For units powered from a primary battery, the test shall be conducted at the battery trouble signal voltage level. Sensitivity measurements at the reduced voltage shall vary not more than 1 percent obscuration (0.014 optical density per meter) for gray smoke and 4 percent obscuration (0.058 optical density per meter) for black smoke from the readings measured at rated voltage and shall not, in any case, exceed the limits specified in 38.1.1.

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

57.2.3 If the detector is provided with a standby battery the test is to be conducted at 85 percent of the charged battery voltage. If the standby battery provides a trouble signal requiring replacement at higher than 85 percent of the charged battery voltage, the test is to be conducted at the battery trouble signal voltage level.

57.2.4 For operation at the reduced voltage, three detectors are to be energized from a source of supply in accordance with 34.3.1, following which the voltage is to be reduced to 85 percent of the test voltage specified in 34.3.1 for ac operated detectors, or the battery trouble level voltage for battery operated detectors, and then tested for signaling operation and sensitivity.

58 Dust Test

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

58.2 To determine compliance with 58.1, a sample in its intended mounting position, is to be placed, de-energized, in an air tight chamber having an internal volume of at least 3 cubic feet (0.09 m^3).

58.3 Approximately 2 ounces (0.06 kg) of cement dust, maintained in an ambient room temperature of approximately 23 ±2°C (73.4 ±3°F) at 20 – 50 percent relative humidity and capable of passing through a 200 mesh screen, is 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 approximately 50 fpm (0.25 m/s).

58.4 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 34.3.1, and tested for sensitivity using gray smoke, unless a trouble signal or a false alarm is obtained. Sensitivity measurements following this test may vary by more than 1 percent obscuration (0.014 optical density per meter) in the direction of high sensitivity, but they shall not vary by more than 1 percent per foot obscuration (0.014 optical density per meter) in the direction of low sensitivity and shall not, in any case, exceed the limits specified in 38.1.1.

59 Static Discharge Test

59.1 The components of a detector shall be shielded so that its operation is not adversely affected when subjected to static electric discharges. Operation of the trouble circuit during this test is not considered a failure if the subsequent operation of the detector is not impaired. Operation of the alarm shall terminate in less than 5 seconds. The test is to be conducted in an ambient temperature of 23 ±3°C (73 ±5°F), at a relative humidity of 10 ±5 percent, and a barometric pressure of not less than 700 mm of mercury (194 kPa).

59.2 Each of two detectors is to be mounted in its intended mounting position and connected to a source of supply in accordance with 34.3.1. If a detector is intended to be installed on a metal back box, the box is to be connected to earth ground. A 250 picofarad low leakage capacitor, rated 10,000 volts dc, is to be connected to two high-voltage insulated leads, 3 feet (0.9 m) long. 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 capacitors are 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 the other probe is then to be touched to earth ground.

59.3 Ten discharges are to be applied to different points on the exposed surface of the detector, recharging the capacitors for each discharge. Five discharges are to be made with one lead connected to earth ground and the other lead probed on the detector surface followed by five discharges with the polarity reversed. For a detector intended to be serviced by the consumer, ten additional discharges shall be applied as described above except each lead shall be probed, in turn, on all internal parts that would be contacted by the user.

59.4 Following the discharges, the detector is to be tested for sensitivity using gray smoke. Sensitivity measurements shall be within 1 percent per foot obscuration (0.014 optical density per meter) of the average of the readings measured prior to this test and shall not, in any case, exceed the limits specified in 38.1.1.

60 Vibration Test

60.1 A detector shall withstand vibration without breakage or damage of parts. Following the vibration, the detector shall operate for its intended signaling operation.

60.2 To determine compliance with 60.1, sensitivity measurements using gray smoke following the vibration shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to this test, and shall not, in any case, exceed the limits specified in 38.1.1.

60.3 Two samples, one at the maximum and one at the minimum sensitivity setting, are to be secured in their intended mounting position on a mounting board and the board, in turn, securely fastened to a variable speed vibration machine having an amplitude of 0.01 inch (0.25 mm). The frequency of vibration is to be varied from 10 to 35 cycles per second in increments of 5 cycles per second until a resonant frequency is obtained. The samples are then to be vibrated at the maximum resonant frequency for a period of 1/4 hour. If no resonant frequency is obtained, the samples are to be vibrated at 35 cycles per second for a period of 4 hours.

60.4 For tests, amplitude is defined as the maximum displacement of sinusoidal motion from a position of rest or one-half of the total table displacement. Resonance is defined as the maximum magnification of the applied vibration.

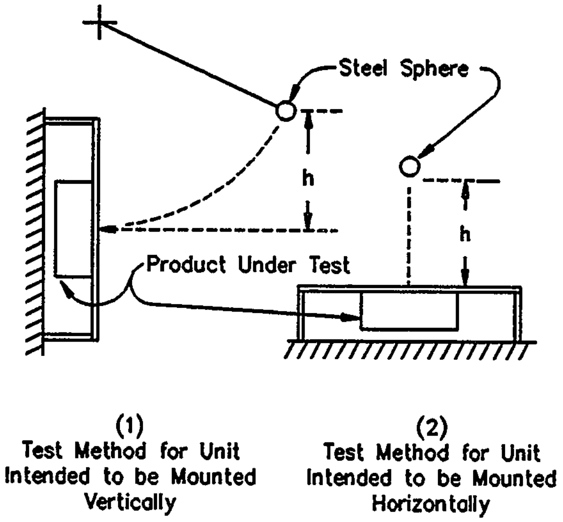
61 Jarring Test

61.1 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 adversely affecting its subsequent operation. A momentary audible trouble signal, resulting from the jarring is acceptable provided that the detector operation is not affected. Dislodgement of parts is acceptable provided that the dislodged part(s) does not affect the operation of the unit, there are no high-voltage parts exposed, and the condition is visually obvious.

61.2 The detector and associated equipment, if any, are to be mounted in a position of intended use, see Figure 61.1, 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 which is secured in place at four corners. A 3 foot-pound (4.08 J) 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 either 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 (775 mm), to apply 3 foot-pounds (4.08 J) of energy.

61.3 During this test, the detector is to be in the standby condition and connected to a rated source of supply in accordance with 34.3.1. Following the test, sensitivity measurements using gray smoke shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the readings measured prior to the tests and shall not, in any case, exceed the limits specified in 38.1.1.

Figure 61.1
Jarring test



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62 Corrosion Test

62.1 General

62.1.1 A detector shall operate as intended after being subjected to the corrosive atmosphere tests described in 62.1.2 – 62.2.1. The samples are to be placed in the test chambers that are located in an ambient room temperature of approximately 23 ±2°C (73.4 ±3°F), maintained at 20 – 50 percent relative humidity, and are to be mounted in the intended position of use on a platform approximately 2 inches (50.8 mm) above the bottom of the exposure chamber. The relative humidity inside the chamber during the test is to be approximately 95 percent.

62.1.2 Moist Hydrogen Sulfide-Air Mixture Exposure – Two samples, one at maximum and one at minimum sensitivity setting, are to be exposed to a moist hydrogen sulfide-air mixture in a closed glass chamber for a period of 10 days. On the first through fourth and seventh through tenth days, an amount of hydrogen sulfide equivalent to 0.1 percent of the volume of the chamber is to be introduced into the chamber from a commercial gas cylinder, the volume required being measured with a flowmeter and stopwatch. Prior to each introduction of gas, the remaining gas-air mixture from the previous day is thoroughly purged from the chamber. On the fifth and sixth day of the exposure, the chamber is to remain closed and no purging or introduction of gas is to be provided. During the exposure, the gas-air mixture is gently stirred by means of a small motor driven fan located in the upper middle portion of the chamber. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

62.1.3 Moist Carbon Dioxide-Sulfur Dioxide-Air Mixture Exposure – Two samples, one at maximum and one at minimum sensitivity setting, are to be exposed to a moist carbon dioxide-sulfur dioxide-air mixture in a closed glass chamber for a period of 10 days. On the first through fourth and seventh through tenth days, an amount of carbon dioxide equivalent to 1.0 percent of the volume of the chamber, plus an amount of sulfur dioxide equivalent to 0.5 percent of the volume of the chamber, is to be introduced. On the fifth and sixth day of the exposure period, the chamber is to remain closed and no purging or introduction of gas is to be provided. A small amount of water (10 ml/0.003 m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

62.2 Test equipment

62.2.1 A typical test apparatus for the carbon dioxide-sulfur dioxide-moist air exposure test and the hydrogen sulfide-moist air exposure test may consist of:

a) Compressed Gas Cylinders (Commercial Grade SO_2, Bone Dry Grade CO_2, C.P. Grade H_2S).

b) Needle Valves (to adjust flow).

c) Selector Valve (selects CO_2 or SO_2).

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

e) Gas inlets to exposure chamber.

f) Glass exposure chamber with glass cover (holes in cover for gas inlet and outlet).

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

h) Support Platform (plastic "egg-crate" grid material).

i) Test Sample. Normally two employed.

Different type chambers may be used provided the equivalent gas concentrations and water are maintained.

62.2.2 The detectors are to be tested for sensitivity using gray smoke prior to exposure to the corrosive atmospheres. Following the corrosive exposures described in 62.1.2 and 62.1.3, the detectors are to be dried in a circulating air oven at a temperature of approximately 40°C (104°F) for a period of at least 24 hours, after which the detectors are to be tested again for sensitivity. Sensitivity measurements following the exposure to the corrosive atmospheres may vary by more than 1 percent per foot obscuration (0.014 optical density per meter) in the direction of high sensitivity but there shall be no false alarm, and the sensitivity shall vary by not more than 1 percent per foot obscuration (0.014 optical density per meter) in the direction of low sensitivity. In no case, shall the sensitivity exceed the limits specified in the Sensitivity Test, Section 38.

62.2.3 Detectors are to be subjected to the corrosive atmospheres while de-energized so as not to produce an alarm signal. Battery operated detectors are to be tested with the batteries in place, but the leads to the clips disconnected for the same reason. After the exposure the leads are to be reconnected and the Sensitivity Test, Section 38, conducted.

63 Reduction in Light Output Test

63.1 The sensitivity of a detector employing an LED as the functional light source shall not be reduced abnormally when the light output from the LED is reduced to 50 percent of normal or to the light level anticipated at the end of the Reliability Prediction described in Detector Reliability Prediction, Section 4.

63.2 To determine compliance with 63.1, three samples calibrated to the minimum sensitivity, are to be subjected to the Sensitivity Test, Section 38, while connected to a source of rated voltage and frequency. Following this, the light output from the LED is to be reduced to 50 percent of intended output, or to the light level anticipated at the end of the reliability prediction, if less than 50 percent, by reducing the supply voltage to the detector, or an equivalent method. (The level of reduction of light is to be determined initially by means of an acceptable light meter, review of curve sheets, or the equivalent.) Sensitivity measurements at the reduced light output level shall not vary more than 1 percent per foot obscuration (0.014 optical density per meter) for gray smoke and not more than 4 percent per foot obscuration (0.058 optical density per meter) for black smoke toward the low sensitivity region from the value of rated light output. In no case shall they exceed the limits specified by 38.1.1 for both gray and black smoke.

63.3 For a detector that employs a battery as the main source of supply, the test is to be conducted at the trouble signal level of the battery.

64 Battery Tests

64.1 If a battery is employed as the main source of power of a single station smoke detector, it shall provide power to the unit under intended ambient conditions for at least 1 year in the standby condition, including novelty and weekly alarm testing, and then operate the detector for a minimum of 4 minutes of alarm, followed by 7 days of trouble signal. See 37.3.1.

64.2 Six samples of the battery or sets of batteries, if more than one is used for primary power, are to be tested under each of the following ambient conditions for a minimum of 1 year while connected to the detector or a simulated load to which the battery is to supply power.

a) Room Ambient — 23 ±3°C (73.4 ±5°F), 30 — 50 percent relative humidity, 760 mm Hg.

b) High Temperature — 45°C (113°F).

c) Low Temperature — 0°C (32°F).

d) Humidity — 30 ±2°C (86 ±3°F), 85 ±5 percent relative humidity.

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

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

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

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

64.7 At the end of the year all batteries shall have sufficient capacity to operate the alarm signal for a minimum of 4 minutes followed by 7 days of trouble signal. To obtain the trouble signal level, it may be necessary to continue the test with the standby current drain for longer than 1 year. The length of time that the batteries subjected to conditions of 64.2 (b), (c), and (d) to operate the alarm signal may be less than 1 year, but not less than 6 months, provided that the detector is marked to indicate the battery limitations for the ambient condition involved.

65 Audibility Test

65.1 General

65.1.1 Except as permitted in 65.5.1, the alarm sounding appliance, either integral with the detector or intended to be connected separately, shall be capable of providing for at least 4 minutes, a sound output equivalent to that of an omnidirectional source with an A-weighted sound pressure level of at least 85 decibels (db) at 10 feet (3.05 m) with two reflecting planes assumed. To determine compliance with this paragraph the method described in 65.2.1 – 65.3.2 is to be employed.

65.2 Sound output measurement

65.2.1 The sound power output of the detector shall be measured in a reverberation room using procedures outlined in ANSI Standards S12.31 (Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms) or S12.32 (Precision Methods for the Determination of Sound Power Levels of Discrete Frequency and Narrow Band Noise Sources in Reverberation Rooms). The sound power in each 1/3 octave band shall be determined using the comparison method. The A-weighting factor shall be added to each 1/3 octave band. The total power is to be determined on the basis of actual power. The total power is then to be converted to an equivalent sound pressure level for a radius of 10 feet (3.05 m). An additional 6 db is to be added to allow for two reflecting planes.

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

65.2.3 For this test an ac powered detector is to be energized from a source of rated voltage and frequency. A battery powered detector is to be energized from batteries under each of the following conditions along the trouble signal level curve illustrated in Figure 36.2, or equivalent:

a) Nondischarged battery (a battery with some unknown shelf life, as would be purchased at a retail outlet) with sufficient added resistance to obtain a trouble signal (Point D of Figure 36.2), or the maximum resistance for the particular battery based on documented data, whichever is less.

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

c) Battery depleted to a voltage value between conditions A and B above which is evaluated to be the least favorable for sound output. For a straight line curve it would be the midpoint voltage. For a nonlinear curve it is to be selected.

The equivalent of a battery shall be considered to be a voltage source with a series resistance adjusted to a level at which a trouble signal is obtained during the normal standby condition. The resistance and voltages used are to be those that were determined during the Circuit Measurement Test, Section 36.

65.2.4 At least two samples shall be tested. Units intended for multiple-station connection shall also be tested interconnected as multiple-stations with the maximum line resistance as defined in 57.2.2. For ac powered units employing a nonrechargeable standby battery, the measurement shall be made with the detector connected to a rated ac voltage source, and then with the ac power de-energized and energy obtained from a standby battery depleted to 85 percent of rated battery voltage, or at the voltage level at which a trouble signal is obtained. For an ac unit employing a rechargeable standby battery, the measurement is to be made using a fully recharged battery.

65.3 Alarm duration test

65.3.1 An alarm sounding appliance of a detector powered by a primary battery that has been discharged to the trouble level condition shall provide the equivalent of 85 db at 10 feet (3.05 m) after 1 minute of continuous alarm operation and shall provide at least 82 db after 4 minutes.

65.3.2 To determine compliance with 61.3.1, a measurement shall be made under the following conditions. The ambient noise level is to be at least 10 db below the measured level produced by the signaling appliance. The detector is to be mounted 1 foot (302 mm) from the microphone placed in a direct line with the detector. The detector is then to be energized in the alarm condition and the sound output is to be measured at 1 minute intervals, using a sound level meter[o] employing the A-weighting network. A maximum of 3 db decrease from the original 1 minute reading, after 4 minutes shall determine compliance for a battery operated detector that is providing a trouble signal.

[o] A suitable meter for the purpose is a General Radio Type 1551 sound level meter (Type II).

65.4 Supplementary remote sounding appliances

65.4.1 The sound output of a supplementary remote sounding appliance, intended to be installed in the same room as a user, such as a bedroom, shall be not less than 85 db. The sound output may be less than 85 db but not less than 75 db provided the appliance is marked with the following, or equivalent, text to indicate the specific use:

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

66 Tests of Thermoplastic Materials

66.1 General

66.1.1 Thermoplastic materials intended for the sole support of current-carrying parts or as an enclosure of a detector shall be subjected to the following tests. If possible, a complete detector shall be used.

66.2 Accelerated air-oven aging test

66.2.1 There shall be no excessive warping or exposure of high-voltage uninsulated current-carrying parts so as to impair operation or provide access to uninsulated high-voltage parts when representative samples of a plastic material are aged for 7 days in a circulating-air oven maintained at 90°C (194°F), or for 28 days at a temperature of 70°C (158°F), and in both cases at a relative humidity of 0 — 10 percent.

66.2.2 At least three representative samples are to be mounted on supports as intended in service and placed in the oven. At the end of the aging period indicated in 66.2.1, the samples are to be removed, permitted to cool, and then examined for adverse distortion. Falling off of a detector cover is acceptable during the test provided no high-voltage parts are exposed, operation for smoke is not affected, and the cover can be replaced as intended.

66.3 Flame test

66.3.1 An insulating material employed as part of a detector for the sole support of current-carrying parts which may be ignited during a fault condition from adjacent current-carrying parts, or as an enclosure shall comply with the requirements for Type 94-5V when tested in accordance with the requirement for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: For battery-powered units, the thermoplastic material may comply with the requirements for Type 94-HB.

66.3.2 Three samples of the material or three test specimens consisting of a part or section of the enclosure shall be subjected to this test. Consideration may be given to leaving in place components and other parts which may influence the performance.

66.3.3 Two of the three test samples shall show acceptable performance. If one sample does not show acceptable performance, the test is to be repeated on a new sample with the flame applied under the same conditions as for the failing sample. If the new specimen fails to comply with the requirements, the material is not acceptable.

66.3.4 The test samples are to be conditioned in a circulating-air oven in accordance with either test condition described in 56.2. Prior to the test the samples are to be cooled to room temperature.

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

67 Paint Loading Test

67.1 Unless marked in accordance with 88.1(j), a detector shall operate as intended and shall comply with the requirements of the Sensitivity Test, Section 38, after painting, if the detector assembly, screens, openings, or the like are likely to be clogged or covered by painting.

67.2 The exterior surface of two samples, including screened openings, or the like are to be coated with a rubber base paint which is spread at approximately two times the paint manufacturer's recommended spreading rate. The paint is to be allowed to dry for 5 days at room temperature. Following this, the samples are to be given a second identical application of paint and again permitted to dry for 5 days. The detectors are to be tested for sensitivity using gray smoke before and after the specified paint loading. Sensitivity measurements following this test shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the average of the readings measured before this test, and shall not, in any case, exceed the limits specified in 38.1.1.

68 Replacement Test, Head and Cover

68.1 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 closing, as applicable, of the cover.

68.2 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 then is to be subjected to the Jarring Test, Section 61.

69 Battery Replacement Test

69.1 The battery clips and holders of a battery operated single station smoke detector shall withstand 50 cycles of battery removal and replacement at a rate not to exceed 6 cycles per minute without any reduction in contact or mounting integrity. During battery replacement, the alarm device shall not sound for more than 1 second. The test shall have no adverse effect on the operation of the detector. [See 44.1(g).]

69.2 For this test a detector is to be installed as intended in service and the battery(s) removed and replaced as recommended by the manufacturer. The unit shall then be tested for its intended operation.

70 Polarity Reversal Test

70.1 A smoke detector shall operate as intended after being connected in each polarity. This includes high-voltage cord connected and fixed wiring (splice lead) types, battery types (main or standby), and multiple station interconnection leads. Each polarity is to be applied for at least 24 hours on all units unless a trouble signal or alarm signal is obtained. For battery operated detectors intended to be connected by a polarized clip assembly the reverse polarity is to be applied for a minimum of 1 second. A trouble or alarm signal is to be permitted under any incorrect polarity applied. A maximum 1-second alarm is permitted when the correct polarity is connected.

70.2 Two samples are to be subjected to this test. Sensitivity measurements using gray smoke prior to and following the test are to be made in accordance with the Sensitivity Test, Section 38. Measurements following the polarity reversal shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to the test and shall not, in any case, exceed the limits in 38.1.1.

71 Strain Relief Test

71.1 General

71.1.1 A cord or lead that depends upon a thermoplastic enclosure or part for strain relief is to be subjected to the applicable tests specified in 71.2.1 – 71.3.1 following exposure to either temperature conditioning test described in 56.2.

71.2 Power-supply cord

71.2.1 When tested in accordance with 16.2, the strain relief means provided on the flexible cord shall withstand for 1 minute, without displacement, a pull of 35 pounds-force (156 N) applied to the cord with the connections within the detector disconnected.

71.2.2 A 35 pound-mass (15.9 kg) weight is to be suspended on the cord and supported by the detector so that the strain relief means will be stressed from any angle that the construction of the detector permits. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress would have resulted on the connections.

71.3 Field-wiring leads

71.3.1 Each lead employed for field connections, including a battery clip lead assembly, shall withstand for 1 minute a pull of 10 pounds-force (44.5 N) without any evidence of damage or of transmittal of stress to internal connections.

72 Power Supply Tests

72.1 General

72.1.1 If a separate power supply is used to provide energy to one or more detectors, it is to be subjected to the test in 72.2.1 – 72.3.2.

72.2 Volt-amperes capacity

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

72.2.2 To determine compliance with the requirements of 72.2.1, a variable resistive load is to be connected to the output circuit of the power supply. With the power supply connected to a rated source of supply, the load is to be varied between open circuit to short circuit in an elapsed time of no less than 1-1/2 nor more than 2-1/2 minutes. Voltage and current measurements are to be recorded for each value and the maximum VA is to be calculated. If an overcurrent protective device is provided, it may be shunted out during the test, if necessary.

72.3 Burnout test

72.3.1 There shall be no damage to the enclosure, charring or burning of the cheesecloth, nor emission of flame or molten metal when a power supply is operated under the conditions described in 72.3.2. While still in a heated condition following this test, the power supply shall comply with the requirements of the Leakage Current Test, Section 53, and the Dielectric Voltage-Withstand Test, Section 55.

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

73 Fire Test (Optional Heat Detector)

73.1 An optional heat detector, provided as part of a single station smoke detector assembly, shall comply with the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521. It shall be sufficiently sensitive to qualify for at least a 50 foot (15.2 m) spacing when subjected to the Fire Tests described in UL 521.

73.2 Two samples of the smoke detector incorporating the heat detector shall be subjected to the Fire Tests described in the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521, while installed on a 50 foot (15.2 m) spacing.

74 Optional Fire and Smoldering Smoke Tests

74.1 The sensitivity of detectors subjected to any one of the following tests may exceed the maximum value permitted for that particular test if the same samples, adjusted to their minimum sensitivity setting, comply with the Fire Tests, Section 45, and the Smoldering Smoke Test, Section 46.

a) Undervoltage Test.

b) Overvoltage Test.

c) Jarring Test.

d) Corrosion Test.

e) Vibration Test.

f) Dust Test.

g) Paint Loading Test.

h) Lamp Interchangeability Test.

i) Reduction in Light Output Test.

74.2 For 74.1 (a) and (b), the supply voltage to the detectors in the Fire Test and Smoldering Smoke Test shall be at the voltage indicated for the applicable test. For detectors employing a battery as the main power supply, the test voltage shall be at the trouble signal level, unless the minimum sensitivity is measured at rated battery voltage.

75 Accelerated Aging Test (Optional Long-Term Stability Test)

75.1 This test is an alternate test method to the 90-day stability test requirements of 44.1 (a) and (b).

75.2 A detector shall operate for its intended signaling performance after being subjected for 14 days to an ambient temperature of 66 ±3°C (150 ±6°F) 0 — 10 percent relative humidity, followed by 10 cycles of change of air velocity from 0 to 300 ±25 fpm (0 to 1.5 ±0.13 m/s). No false alarms shall occur during or following the aging or during exposure to the changes in air velocity.

75.3 Sensitivity measurements using gray smoke, recorded before and after the exposures shall be in compliance with the Sensitivity Test, Section 38, and shall not vary more than 1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to the aging.

75.4 Two samples, one at maximum and one at minimum sensitivity, or both at the sensitivity that is most likely to be affected by the test temperature (as determined during the Variable Ambient Temperature Test, Section 51) are to be placed in a circulating air oven and energized for a period of 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 and subjected, in turn, to 10 cycles of the change of air velocity test described in 44.1(e) and then to the Sensitivity Test, Section 38. Batteries need not be subjected to the elevated ambient temperature.

76 Drop Test

76.1 This test is to be conducted only on detectors intended for transient use, such as a travel alarm, and is not to be conducted on detectors intended for stationary installation.

76.2 A detector shall withstand five drops from a height of 7 feet (2.1 m) onto a tiled concrete floor without exposure of internal high-voltage parts or affecting its intended operation and sensitivity. The sample is to be held so that each impact with the floor is at a different location on the detector. Dislodgement of parts is permitted if:

a) The dislodged part does not affect operation or sensitivity of the unit,

b) The dislodged part can be replaced (such as a cover),

c) There are no high-voltage parts exposed, and

d) The condition is visually obvious.

76.3 Each of two detectors is to be raised to a height of 7 feet (2.1 m) and permitted to drop five times onto a concrete floor covered with a 1/8 inch (3.2 mm) thick uncushioned vinyl tile. Following the drops, the unit is to be examined for damage and tested for sensitivity. Sensitivity measurements, recorded after the drop test, shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to the test, and shall not, in any case exceed the limits specified in 38.1.1.

SMOKE DETECTORS FOR USE IN RECREATIONAL VEHICLES

77 General

77.1 A smoke detector intended for use in recreational vehicles shall comply with the requirements specified in Sections 78 — 81, in addition to the requirements specified in Sections 1 — 76 and 82 — 90, inclusive.

78 Variable Ambient Temperature and Humidity Test

78.1 There shall be no false alarms or adverse change in performance when two units, one at maximum and one at minimum sensitivity, are subjected, in turn, to each of the following conditions:

a) Thirty days in air at 66 ±3°C (150 ±6°F).

b) At least 72 hours at minus 35 ±2°C (minus 17 ±4°F).

c) Ten days in 93 ±2 percent humidity at 61 ±2°C (142 ±4°F).

78.2 Sensitivity measurements, recorded in the environmental chamber smoke box, shall not vary more than 1 percent per foot obscuration using gray smoke. During the sensitivity measurement, the environmental chamber is to be as close as possible to the test conditions specified in 78.1 (a), (b), and (c) (49°C for 66°C condition, 0°C for minus 35°C condition, and 85 percent relative humidity for the 93 percent relative humidity condition, respectively).

78.3 During each test condition, the detector is to be connected to a source of rated voltage or battery.

79 Corrosion (Salt Spray) Test

79.1 A detector shall operate as intended and shall not false alarm after exposure for 48 hours to a salt spray in accordance with the procedure specified in the Standard for Salt Spray (Fog) Testing, ASTM B117-73(1979).

79.2 Two detectors, one at maximum and one at minimum sensitivity, are to be subjected to the salt spray while in a de-energized condition. Following the exposure, the samples are to be removed, dried for at least 24 hours in an air circulating oven or air dried for at least 48 hours, and then subjected to the Sensitivity Test, Section 38.

79.3 Sensitivity measurements following the exposure may vary by more than 1 percent per foot obscuration (0.014 optical density/m) in the direction of high sensitivity, but the detector shall not false alarm, and the sensitivity shall not vary more than 1 percent per foot obscuration in the direction of low sensitivity. In any case, the sensitivity shall not exceed the limits specified in the Sensitivity Test, Section 38, using gray smoke.

80 Vibration Test

80.1 After vibration in accordance with 80.2, a detector shall not false alarm or be adversely damaged. Sensitivity measurements shall be not greater than 1 percent per foot in the direction of low sensitivity, may be greater than 1 percent per foot in the direction of high sensitivity, but in no case shall exceed the limits specified in the Sensitivity Test, Section 38.

80.2 Two detectors, one at maximum and one at minimum sensitivity, are to be subjected to vibration for 120 hours in accordance with the Vibration Test, Section 60. Sensitivity measurements are to be recorded before and after the test.

81 Contamination Test (Cooking By-Products)

81.1 After exposure in accordance with 81.2 — 81.5, a detector shall not false alarm or otherwise be adversely affected. Sensitivity measurements following the exposure shall not be greater than 1 percent per foot in the direction of low sensitivity, may be greater than 1 percent per foot in the direction of high sensitivity, but in no case shall exceed the limits of the Sensitivity Test, Section 38.

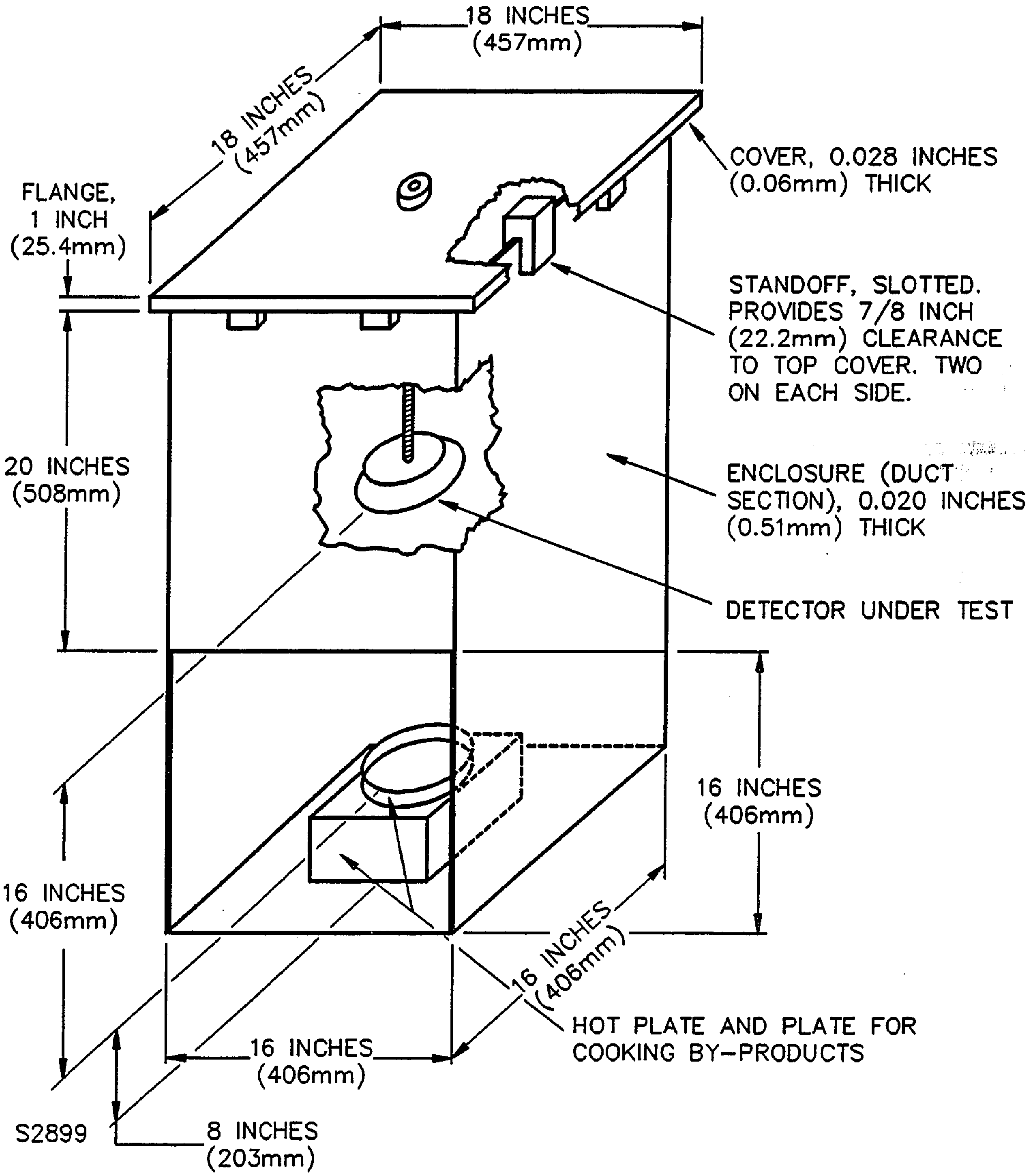
81.2 Two samples are to be subjected to the vaporization of a mixture of 50 grams of animal fat (lard), 50 grams of vegetable fat (Crisco), and 100 grams of beef gravy (Franco-American). The mixture is to be placed in an 8 inch (203 mm) diameter aluminum plate that is heated on an 8-1/2 inch (216 mm) diameter hotplate located on the bottom center of a galvanized sheet metal enclosure.

81.3 The enclosure is to measure approximately 3 feet (914 mm) high, 16 inches (406 mm) square and have an open top and a 16 inch square opening at the bottom of one side. A sheet metal cover, approximately 18 inches (457 mm) square, with 1 inch (25 mm) flanges, is to be supported at the enclosure top by 7/8 inch (20 mm) high standoffs. See Figure 81.1.

81.4 The detector under test is to be supported on the end of a threaded (1/4 inch (61 mm) steel rod positioned so that the exposed face of the detector is approximately 12 inches (304 mm) below the enclosure cover and 16 inches (406 mm) above the aluminum plate. The detector is not to be energized during the test.

81.5 Each sample is to be subjected to five complete vaporization exposures. Following the fifth exposure, each sample is to be removed, permitted to cool for at least 3 hours, and then tested for sensitivity as specified in the Sensitivity Test, Section 38.

Figure 81.1
Contamination test (cooking by-products)



MANUFACTURING AND PRODUCTION TESTS

82 General

82.1 To verify compliance with these requirements in production, the manufacturer shall provide the necessary production control, inspection and tests. The program shall include at least the Sensitivity Calibration Tests, Section 83, and the Photocell Illuminating Lamp Test (Photoelectric Detectors), Section 84, conducted on 100 percent of the production.

83 Sensitivity Calibration Tests

83.1 The sensitivity of each detector shall be checked, following the warm-up period recommended by the manufacturer, using appropriate instruments to determine that the sensitivity levels are within the marked rating including tolerance, which is within the specified limits of the detector. The test equipment shall verify the value or range of sensitivities marked on the detector. The value of indication shall be in the form of percent per foot obscuration.

83.2 For the warm-up period, the detectors are to be energized from a source of supply in accordance with 34.3.1. If the detector sensitivity is not within the manufacturer's specifications, the unit is to be corrected and retested. If a retested sample is still outside the specification, it is to be rejected.

83.3 A warm-up period is required for those detectors employing components whose characteristics are likely to vary during initial warm-up, such as solid-state devices operating at greater than 25 percent of rating, lamp filaments, resistors, and other components that affect sensitivity.

83.4 A warm-up period is not required if the detector components are operated at not more than 25 percent of rating in the standby condition or if the individual components are burned-in prior to assembly.

84 Photocell Illuminating Lamp Test (Photoelectric Detectors)

84.1 The manufacturer shall provide facilities for measurement of all the photocell illuminating lamps, including any replacement lamps which may be provided, to determine that the illumination output is uniform and within the specifications for the intended use.

85 Production Line Dielectric Voltage-Withstand Tests

85.1 Each 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 detector rated at 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 detector rated at more than 250 volts – either 1000 volts plus twice the rated voltage (1414 volts plus 2.828 times the rated ac rms voltage, if a dc potential is used) applied for 60 seconds or 1200 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.

Exception: A product, the housing of which is entirely comprised of polymeric materials, need not be subjected to this test if there are no exposed dead metal parts that may become energized under fault conditions.

85.2 If the detector employs high-voltage and low-voltage circuits, the test is to be conducted with the low-voltage circuit connected to the cabinet, chassis, or other dead metal parts so that the potential that is applied between the high-voltage live parts and dead metal parts will be applied simultaneously between high-voltage live parts and low-voltage circuits.

85.3 A printed-wiring assembly or other electronic-circuit component that would be damaged by application of, or would short-circuit, the test potential is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly may be tested instead of an entire unit.

85.4 A 500 volt-amperes or larger transformer, the output voltage of which can be varied, is to be used to determine compliance with 85.1. The requirement of a 500 volt-amperes or larger transformer may be waived if the high potential testing equipment used is such that it maintains the specified high potential voltage at the equipment for the duration of the tests.

85.5 The test equipment used for this test is to include a visible indication of application of the test potential and an audible or visible indication, or both, of breakdown. In the event of breakdown, manual reset of an external switch is to be required, or an automatic reject of the unit under test is to result. Other arrangements may be considered and accepted if found to achieve the results contemplated.

85.6 If the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is sufficient to prevent maintaining the specified ac test potential, the detector is to be tested using a dc test potential in accordance with 85.1.

86 Production Line Grounding Continuity Tests

86.1 The manufacturer shall test each detector that has a power-supply cord terminating in an attachment-plug employing a grounding pin to verify electrical continuity between the device and the grounding blade of the attachment-plug.

86.2 For this test, the manufacturer is to employ an acceptable resistance-indicating instrument with leads and terminals by which the grounding circuit continuity may be determined.

86.3 If an investigation of the detector has shown all exposed dead metal parts that are likely to become energized and all dead metal parts within the enclosure that are exposed to contact during servicing to be acceptably bonded to the frame and enclosure of the detector, a test that determines the electrical continuity between the grounding blade and the frame or enclosure is sufficient.

87 Detector Shipment

87.1 The battery intended to be employed with the detector shall be shipped from the factory with the detector in the same package. To prevent unnecessary drain during shipment and storage, the battery shall not be connected in the detector.

87.2 A nonrechargeable standby battery of an ac operated accessory to a single- or multiple-station smoke detector need not be shipped with the unit provided instructions on the unit specify the battery to be used by model number and manufacturer, as well as a source of purchase. A rechargeable standby battery shall be shipped with the unit in which it is to be employed.

MARKING

88 General

88.1 A detector shall be permanently marked with the following information unless specifically indicated that it may appear on the installation wiring diagram. The marking shall be in a contrasting color, finish, or equivalent. Unless the letter height is specified, all markings shall be at least 3/64 inch (1.2 mm) high.

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

b) Model number and date of manufacture, or equivalent.

c) Electrical rating, in volts, amperes, or watts, and frequency. Not required for battery operated detectors.

d) Correct mounting position if a unit is intended to be mounted in a definite position. (May appear in the installation instructions.)

e) Identification of lights, switches, meters, and the like regarding their function unless their function is obvious.

f) Maximum rating of fuse in each fuseholder and temperature rating of supplementary heat detector, if provided, in degrees Fahrenheit and Celsius.

g) Identification of spare lamps and batteries by part number, manufacturer's model number or equivalent. Located adjacent to the component.

h) Reference to an installation diagram and/or owner's manual.

i) For a detector that employs a radioactive material, the following information shall be indicated directly on the exterior (back of detector acceptable) of the unit:

1) The statement "CONTAINS RADIOACTIVE MATERIAL,"

2) Name or Radionuclide and quantity (no abbreviations), and

3) The statement, "U.S. NRC License No. XXX." (XXX – No. of License) or the name of the Licensee.

j) A detector not intended to be painted in use shall be marked on the outer surface of the enclosure with the following or equivalent notice: "Do Not Paint." The letters shall not be less than 1/8 inch (3.2 mm) high and shall be located so as to be readily visible after the detector is mounted in its intended manner. See 67.1.

k) The following or equivalent qualifying statement on a battery-operated detector where battery operation, under other than normal room temperature conditions during the long term (minimum 1 year) battery tests, is less than 1 year:

"CONSTANT EXPOSURES TO HIGH OR LOW TEMPERATURES OR HIGH HUMIDITY MAY REDUCE BATTERY LIFE."

Applicable wording shall be used.

l) Distinction between alarm and trouble signals on those units employing both.

m) Reference to a source for battery replacement. (May appear in the homeowner's manual.)

n) For a battery operated detector, the word "WARNING" and the following or equivalent marking shall be included on the unit: "Use Only Batteries Specified In Marking. Use Of A Different Battery May Have A Detrimental Effect On Detector Operation." The letter height shall be a minimum of 1/8 inch (3.2 mm) for "WARNING" and 3/64 inch for the rest of the notice.

o) For a detector employing a nonrechargeable standby battery the marking information described in 14.1, 14.3, and 14.4 shall be in letters not less than 1/8 inch high.

p) Test instructions and frequency. Not less than once per week for battery-powered detectors and not less than once per month for other than battery-powered detectors.

q) Maintenance instructions, such as cleaning, lamp and battery replacement.

r) Name and address of firm to whom detector is to be sent for servicing.

s) Sealed units intended to be returned to the manufacturer for servicing shall be marked as follows on the outside of the detector: "RETURN TO (+) ____ FOR SERVICING," or equivalent. Units on which the cover is removable but that are also intended to be returned to the manufacturer for servicing, may have the marking on the inside of the detector.

(+) Name and address of manufacturer or supplier

t) A detector employing alarm verification that is bypassed in order to comply with the Fire Tests, Section 45, and the Smoldering Smoke Test, Section 46, shall be marked with the following text: "This Detector Employs A Maximum Alarm Verification Time Delay Of ___ Seconds." The applicable time shall be inserted in the blank space.

u) An AC operated detector without a standby battery shall be marked with the word "WARNING" and the following or equivalent wording: "UNIT WILL NOT OPERATE DURING POWER FAILURE." The marking shall be in a location on the unit that is visible after installation. The letter height shall be a minimum of 1/8 inch.

v) The sensitivity setting for a detector having a fixed setting. If a detector is intended to be adjusted in the field, the range of sensitivity shall be indicated. The marked sensitivity shall be indicated as a percent per foot obscuration level. The marking shall include a nominal value plus tolerance.

88.2 Information required to appear directly on the detector shall be readily visible after installation. Except for 88.1(j), the removal or opening of an enclosure cover or the removal of not more than one mounting screw, or an equivalent arrangement to view the marking is acceptable.

88.3 If markings are placed on the base (bottom) of a detector intended for permanent installation, the word "CAUTION" and the following or equivalent marking in letters 1/8 inch (3.2 mm) high is to be provided on the outside or inside of the detector: "Additional marking on back. Disconnect power."

88.4 Additional marking requirements are specified by 9.2.1, 11.6.4, 12.1, 12.3, 12.4, 17.2.2, 19.2.1, 25.2, and 90.2.

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

88.6 With regard to the requirement in 8.2, a warning flag, hinged cover as described in 8.1 (inside or outside), or equivalent, shall be marked with the word "WARNING" and the following or equivalent text: "Risk of Fire — Battery Has Been Removed." The letter height shall be a minimum of 3/8 inch (9.5 mm).

89 Packaging Marking

89.1 The point-of-sale carton, in which a detector employing a radionuclide is packaged, shall be permanently marked on the exterior with the following information. The letter height shall be at least 3/64 inch (1.2 mm) high and shall be in contrasting color, finish, or equivalent.

a) Name of radionuclide and amount (no abbreviations).

b) The statement, "U.S. NRC License No. XXX" (XXX – No. of License) or the name of the Licensee.

c) The following or equivalent statement:

"THIS DETECTOR CONTAINS RADIOACTIVE MATERIAL AND HAS BEEN MANUFACTURED IN COMPLIANCE WITH U.S. NRC SAFETY CRITERIA IN 10 CFR 32.27. THE PURCHASER IS EXEMPT FROM ANY REGULATORY REQUIREMENTS."

INSTRUCTIONS

90 General

90.1 Each single and multiple station smoke detector shall be provided with installation instructions which shall include the following information.

a) Typical installation drawing layouts for the unit(s) indicating recommended locations and wiring methods which shall be in accordance with Household Fire Warning Equipment, ANSI/NFPA 74. Locations where detector installations are not recommended shall also be included.

b) Description of the operation, testing, and proper maintenance procedures for the unit(s). The frequency of testing shall be in accordance with NFPA 74.

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

d) The following text:

"For your information, the National Fire Protection Association's Standard 74, Section 2 — 4 reads as follows:

"2-4.1.1 Smoke detectors shall be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms and on each additional story of the family living unit including basements and excluding crawl spaces and unfinished attics.[1]

[1] The provisions of 2-4.1.1 represent the minimum number of detectors required by this standard. It is recommended that the householder consider the use of additional smoke or heat detectors for increased protection for those areas separated by a door from the areas protected by the required smoke detectors under 2-4.1.1 above. The recommended additional areas are living room, dining room, bedroom(s), kitchen, attic (finished or unfinished), furnace room, utility room, basement, integral or attached garage, and hallways not included in 2-4.1.1 above. However, the use of additional detectors remains the option of the householder."

e) Description of the various situations against which the smoke detector may not be effective; for example, smoking in bed.

f) More detailed information on the alarm and trouble signals and an indication where false alarms or trouble signals would be anticipated.

g) Identification of the homeowner's manual or instruction sheet by number or equivalent.

h) An indication that the device shall not be installed in locations where the normal ambient temperature is below 40°F (4.4°C) or exceeds 100°F (37.8°C), unless the detector has been found acceptable for installation at a higher or lower ambient temperature.

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

j) The manufacturer shall either provide information on an evacuation plan or include a copy of a separate booklet, or equivalent, which is published by the National Fire Protection Association, National Fire Prevention and Control Administration, or an equivalent agency. If the manufacturer provides information on an evacuation plan, it shall be in accordance with published information available from the National Fire Protection Association.

k) The following information:

1) Name and address of manufacturer or private labeler.

2) Model number.

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

4) Temperature rating of optional heat detector, if provided.

5) Test instructions and frequency.

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

7) Name and address of firm to whom detector is to be sent for servicing.

8) The following notice: THIS EQUIPMENT SHOULD BE INSTALLED IN ACCORDANCE WITH THE NATIONAL FIRE PROTECTION ASSOCIATION'S STANDARD 74 (National Fire Protection Association, Batterymarch Park, Quincy, MA 02269).

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

m) For detectors also acceptable for installation in recreational vehicles, the word "WARNING," and the following or equivalent text: "TEST SMOKE DETECTOR OPERATION AFTER VEHICLE HAS BEEN IN STORAGE, BEFORE EACH TRIP, AND AT LEAST ONCE PER WEEK DURING USE. An identical marking is to be provided by the recreational vehicle manufacturer that shall be permanent and located, visibly, within 24 inches (610 mm) of the smoke detector."

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

90.3 The material shipped with the detector, including the package, instructions, or user's manual, shall not include information other than that specified in 90.1, such as manufacturer's claims on the operation of the detector which have not been substantiated by the performance tests included in this standard, or that are not covered in Household Fire Warning Equipment, ANSI/NFPA 74 or other applicable NFPA standards.

SUPPLEMENT SA – SMOKE DETECTOR RELIABILITY PREDICTION

GENERAL

SA1 Instructions for Determining a Reliability Prediction for Smoke Detectors

SA1.1 Make a list of every component in the detector.

SA1.2 By circuit analysis or experimentation, determine the effect of any failure mode (short or open) of each component on the detector operation and the rationale for the decision. This will determine if a component is to be considered critical, conditionally critical, or noncritical.

SA1.3 A component is considered noncritical if all failure modes of the component will result in a trouble signal[a], or have no effect on the intended operation of the detector for alarm and trouble signals, and will not affect the detector sensitivity.

[a] A trouble signal may be indicated by energization of an audible signal, energization of a separate visual indication (amber or orange), or de-energization of a power-on light. If a visual indication is depended on to denote a trouble condition, it shall have a documented predicted failure rate of not greater than 2.5 failures per million hours.

SA1.4 A component is considered critical if two or more failure modes of the component, which will affect the intended operation or the sensitivity of the detector, do not result in a trouble signal.[a]

SA1.5 A component is considered conditionally critical if only one failure mode of the component will affect the intended operation or the sensitivity of the detector, and does not result in a trouble signal.[a]

SA1.6 Make a list of all critical and conditionally critical components in the detector.

SA1.7 For each critical and conditionally critical component, the expected failure rate, based upon a minimum confidence factor of 60 percent, may be determined from the screening burn-in or published component reliability data method.

SA1.8 For each conditionally critical component, the expected failure rate may be determined by calculating only the failure rate for the mode meeting the conditions of SA1.5 or by applying a 0.75 multiplying factor to the value determined by the PARTS COUNT or PARTS STRESS ANALYSIS method described in MIL-HDBK 217B.

SA2 Methods of Determining Failure Rate

SA2.1 PARTS COUNT METHOD – When using this method the failure rate is to be determined as follows, using Section 3 of MIL-HDBK 217B.

a) Employ generic failure rate from Tables SA2.1 – SA2.6 which most closely approximates the component employed.

b) Determine the quality factor multiplier for each component from Tables S2A.7 – SA2.9.

c) Multiply each generic failure rate by its associated quality factor multiplier to obtain the final failure rate for the component. See sample calculation, Table SA2.10.

d) Add all individual failure rates of critical and conditionally critical components to obtain the overall failure rate for the detector.

Note: Mil-specification numbers in Tables SA2.4 and SA2.5 are provided for reference only to determine general component type.

Table SA2.1
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 SA2.2
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 SA2.3
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/10^6hrs) may be assigned provided the construction of the device is comparable to that of a thyrister.

Table SA2.4
Generic failure rate for resistors in failures per million hours

Resistors, fixed			
Construction	**Style**	**Mil-R-Spec. (ref. only)**	**Failure rate**
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 SA2.5
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 SA2.6
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
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 SA2.7
Quality factors for Tables SA2.1 and SA2.2

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 SA5.1	8

Table SA2.8
Quality factor for Table SA2.3

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

Table SA2.9
Quality factor for Tables SA2.4 and SA2.5

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 SA2.10
Detector reliability prediction – parts count method sample calculation

Component	Generic failure rate (A)	Quality factor multiplier (B)	Failure rate 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
		TOTAL DETECTOR FAILURE RATE	3.371

Table SA2.11
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
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

(Continued)

Table SA2.11 (Cont'd)
Parts stress analysis method references

Type device	Applicable equation	MIL-HDBK-217B 9/20/74 page reference
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 SA5.1 screening is conducted

Figure SA2.1
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
																		Overall System Failure Rate Failures/10^6hours	

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

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SA2.2 PARTS STRESS ANALYSIS METHOD[b] — The failure rate is calculated using the procedure in MIL-HBK-217B, Section 2. Calculations and supporting data on rating of components for the determination will be required for review. See also Table SA2.11 and Figure SA2.1 for equations and tabulation sheets.

[b] 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 vendor.

SA2.3 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 shall 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. Refer to Sections SA4 — SA6.

SA2.4 ALTERNATE METHOD (GENERIC DEVICES ONLY) — An alternate for generic components only shall consist of the burn-in test program to determine the numerical failure rate coupled with the component manufacturer's standard screening program which is employed for the device family[c] of the component. The condition of acceptance of the limited screening shall include the following:

a) A test sample lot shall be screened in accordance with the component manufacturer's standard program and then subjected to the burn-in test described in Sections SA4 — SA6.

b) The component manufacturer shall provide failure rate data on the particular device being tested or the device family[c] from a second source, such as field failure rate data or a separate burn-in test.

c) A comparison of the burn-in test data from (a) and (b) shall be made and results from (a) shall not be worse than those in (b) by one order of magnitude (10:1).

[c] Similar devices manufactured under same process and design rules.

SA2.5 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," "Digital Generic Data." Devices evaluated by this method shall conform to the identification program in SA4.3, and minimum screening program of Table SA5.1.

SA2.6 The overall failure rate of the components of a detector may be evaluated by any combination of two or more of the failure rate determination methods described in SA2.1, SA2.2, SA2.3, SA2.4, and SA2.5.

SA3 Maximum Detector Failure Rates

SA3.1 The overall failure rates for the detector shall be not greater than indicated in the following table:

Method of failure rate computation	Maximum detector failure rate (failures per million hours)
Parts count	3.5
Parts stress analysis	4.0
Screening burn-in	4.0
Published reliability data	4.0
Any combination of above	Lower failure rate number

CRITERIA FOR ACCEPTANCE OF MICROELECTRONIC DEVICES

SA4 General

SA4.1 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.

SA4.2 Although this program is oriented primarily to custom integrated circuit "chips," it can also be applied for other microelectronic devices.

SA4.3 Components that meet 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.

SA5 Quality Assurance Screening Program

SA5.1 The following minimum screening program (see Table SA5.1) is to be established by either the component manufacturer (vendor) or the detector manufacturer. If the screening program is conducted by the component manufacturer, each lot or shipment to the detector manufacturer is to be accompanied by a certificate of compliance with the Quality Assurance Screening Program.

SA5.2 The test methods and conditions referenced in Table SA5.1 are based on MIL-STD-883B dated July 31, 1977 and its most current revisions.

Table SA5.1
Minimum screening program

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, Method 1014B, $5x10^{-8}$CC/sec)	100 percent[d]
6.	Seal (Gross leak – 1014B fluorocarbon)	100 percent
7.	Functional electrical, 25°C	100 percent
8.	External visual, Method 2009	100 percent
9.	Quality conformance a) Functional electrical, 25°C b) Temperature cycling (Method 1010C, -55°C to 150°C, 10 cycles) c) Seal (Fine leak, Method 1040B, $5x10^{-8}$CC/sec)[c] d) External visual, Method 2009	AQL 1.5% per MIL-STD 105 Level II
Plastic packages		
1.	Internal visual (Method 2010.1, condition B modified)	100 percent[a]
2.	Bond strength (Method 2011)	Sample basis[a]
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 a) Functional electrical test, 25°C b) Temperature cycling (Method 1010C, -55°C to 150°C, 10 cycles) c) External visual, Method 2009	AQL 1.5% per MIL-STD 105 Level II

(Continued)

Table SA5.1 (Cont'd)

[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 (Methods 1010C or 1011.1, Conditions B or C, MIL-STD-883D, April 9, 1979). Records shall be maintained for inspection.

SA6 Determination of Failure Rate Number Supplemented by Burn-In Test

SA6.1 General

SA6.1.1 The objective of this part is to determine a numerical failure rate for the device to be employed in the overall reliability calculation of the detector. The method employs Arrehenius 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).

SA6.2 Determination sequence

SA6.2.1 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 SA6.1 to determine related test time for initial conditional acceptance and final acceptance.

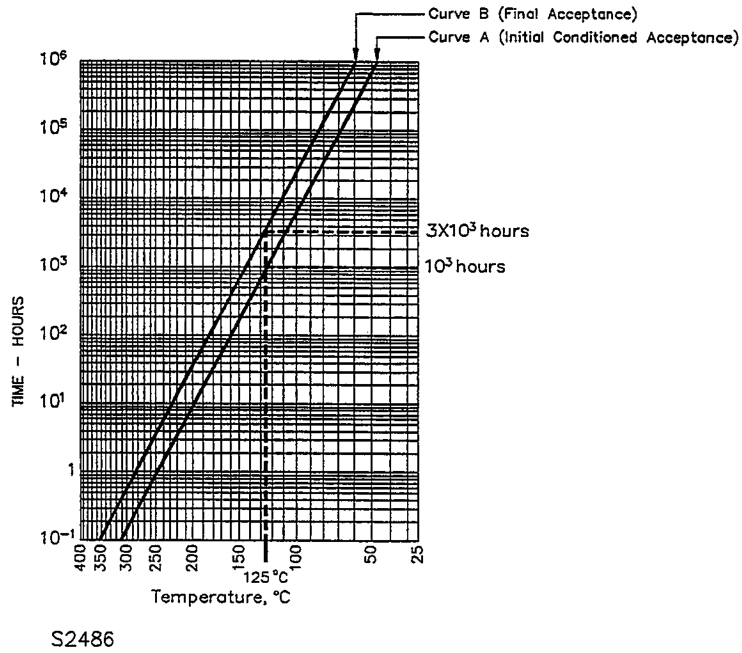
d) Using the equation in SA6.5.1 and the initial conditioning test time determined in (c) calculate the failure rate of the device for conditional acceptance.

e) Sample lot size to be used in temperature test is determined from Table SA6.1. 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[d] at a 60 percent confidence level.

[d] Reliability Handbook by W. Grant Ireson

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

Figure SA6.1
Time-temperature regression and allowable time limits for test condition



SA6.3 Test calculations and procedures

SA6.3.1 Figure SA6.1 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 (251°F).

SA6.3.2 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).

SA6.3.3 The following examples illustrate the use of the curves in Figure SA6.1 for calculations of final and initial conditional acceptance at temperatures other than 125°C (251°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).

Table SA6.1
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

SA6.4 Test conditions

SA6.4.1 Suitable 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 so designed 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. If the device incorporates on board elements which directly drive such things as the detector horn, battery pulse test or beacon LED of a photoelectric smoke detector, these shall be pulsed during the test for a number of cycles equivalent to the operation life of the intersection of curve B, Figure SA6.1, with the 38°C (100°F) line.

SA6.4.2 Power supplies and current-setting resistors shall be capable of maintaining the specified operating conditions, as minimal throughout the testing period with normal variations in their source voltages, ambient temperatures, and the like. The test equipment shall preferably be so arranged that only natural convection cooling of the devices occurs. 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 normal variations in individual device characteristics but shall be arranged so that the existence of failed or abnormal (that is, open, short, or the like) devices in a group does not negate the effect of the test for other devices in the group.

SA6.5 Failure rate number calculation

SA6.5.1 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 38°C smoke detector operating condition by use of the Arrehenius 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). Documentation shall be provided to support value employed. If documentation is not provided, value of 0.65 ev is to be used.

K is Boltzman's constant (8.62×10^{-5} ev/°K).

T is the absolute temperature in degrees Kelvin.

Example:

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 SA6.1 for conditional acceptance is 1000 hours and for final acceptance is 3000 hours.

d) Using the equation in SA6.5.1 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

K is 8.62 X 10^{-5} ev/°K

Then

$$\lambda_1 = \lambda_2 \ \ln^{-1}\left[\frac{-0.65}{8.62 \times 10^{-5}} \left(\frac{1}{398} - \frac{1}{311} \right) \right]$$

In which:

λ_1 is 20 X 10^{-6} failures/hour.

λ_1 is 20 failures/10^6 hour.

λ_1 is 0.02 failure/1000 hour.

λ_1 is 2.0 percent/1000 hour.

e) Referring to Table SA6.1, 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%/1000 hours:

C = 0 N = 47
C = 1 N = 109
C = 2 N = 155, and the like.

From the equation and Table SA6.1, 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

Obscuration — Optical Density Chart

Obscuration – optical density chart
Based on a 5 foot (1.52 m) light beam

Light transmission (meter reading) (microamperes)	Obscuration (Ou)		Total obscuration Od	Optical density (OD)		Total optical density ODt
	Percent per foot	Percent per meter		Per foot	Per meter	
100.0	0.000	0.000	0.000	0.0000	0.0000	0.0000
99.5	0.100	0.328	0.500	0.0004	0.0014	0.0022
99.0	0.201	0.657	1.000	0.0009	0.0029	0.0044
98.5	0.302	0.987	1.500	0.0013	0.0043	0.0066
98.0	0.403	1.317	2.000	0.0018	0.0058	0.0088
97.5	0.505	1.648	2.500	0.0022	0.0072	0.0110
97.0	0.607	1.979	3.000	0.0027	0.0087	0.0132
96.5	0.710	2.311	3.500	0.0031	0.0102	0.0155
96.0	0.813	2.643	4.000	0.0036	0.0116	0.0177
95.5	0.917	2.976	4.500	0.0040	0.0131	0.0200
95.0	1.021	3.310	5.000	0.0045	0.0146	0.0223
94.5	1.125	3.644	5.500	0.0049	0.0161	0.0246
94.0	1.230	3.979	6.000	0.0054	0.0176	0.0269
93.5	1.335	4.314	6.500	0.0058	0.0192	0.0292
93.0	1.441	4.650	7.000	0.0063	0.0207	0.0315
92.5	1.547	4.987	7.500	0.0068	0.0222	0.0339
92.0	1.654	5.324	8.000	0.0072	0.0238	0.0362
91.5	1.761	5.662	8.500	0.0077	0.0253	0.0386
91.0	1.869	6.001	9.000	0.0082	0.0269	0.0410
90.5	1.977	6.340	9.500	0.0087	0.0285	0.0434
90.0	2.085	6.680	10.00	0.0092	0.0300	0.0458
89.5	2.194	7.020	10.50	0.0096	0.0316	0.0482
89.0	2.304	7.362	11.00	0.0101	0.0332	0.0506
88.5	2.414	7.703	11.50	0.0106	0.0348	0.0531
88.0	2.524	8.046	12.00	0.0111	0.0364	0.0555
87.5	2.635	8.389	12.50	0.0116	0.0381	0.0580
87.0	2.747	8.733	13.00	0.0121	0.0397	0.0605
86.5	2.859	9.077	13.50	0.0126	0.0413	0.0630
86.0	2.971	9.423	14.00	0.0131	0.0430	0.0655
85.5	3.085	9.768	14.50	0.0136	0.0446	0.0680
85.0	3.198	10.12	15.00	0.0141	0.0463	0.0706
84.5	3.312	10.46	15.50	0.0146	0.0480	0.0732
84.0	3.427	10.81	16.00	0.0152	0.0497	0.0757
83.5	3.542	11.16	16.50	0.0157	0.0514	0.0783
83.0	3.658	11.51	17.00	0.0162	0.0531	0.0809
82.5	3.774	11.86	17.50	0.0167	0.0548	0.0836
82.0	3.891	12.21	18.00	0.0172	0.0566	0.0862
81.5	4.009	12.56	18.50	0.0178	0.0583	0.0889
81.0	4.127	12.91	19.00	0.0183	0.0600	0.0915
80.5	4.246	13.27	19.50	0.0188	0.0618	0.0942
80.0	4.365	13.62	20.00	0.0194	0.0636	0.0969
79.5	4.48	13.48	20.5	0.0199	0.0654	0.0996
79.0	4.61	14.33	21.0	0.0204	0.0672	0.1023

(Continued)

Obscuration – optical density chart (Cont'd)
Based on a 5 foot (1.52 m) light beam

Light transmission (meter reading) (microamperes)	Obscuration (Ou)		Total obscuration Od	Optical density (OD)		Total optical density ODt
	Percent per foot	Percent per meter		Per foot	Per meter	
78.5	4.73	14.64	21.5	0.0210	0.0690	0.1051
78.0	4.85	15.04	22.0	0.0215	0.0708	0.1079
77.5	4.97	15.40	22.5	0.0221	0.0726	0.1107
77.0	5.09	15.76	23.0	0.0227	0.0745	0.1135
76.5	5.22	16.12	23.5	0.0232	0.0763	0.1163
76.0	5.34	16.48	24.0	0.0238	0.0782	0.1191
75.5	5.47	16.84	24.5	0.0244	0.0801	0.1220
75.0	5.59	17.20	25.0	0.0249	0.0820	0.1249
74.5	5.72	17.56	25.5	0.0255	0.0839	0.1278
74.0	5.84	17.93	26.0	0.0261	0.0858	0.1307
73.5	5.97	18.29	26.5	0.0267	0.0877	0.1337
73.0	6.10	18.66	27.0	0.0273	0.0897	0.1366
72.5	6.23	19.02	27.5	0.0279	0.0916	0.1396
72.0	6.36	19.39	28.0	0.0285	0.0936	0.1426
71.5	6.49	19.76	28.5	0.0291	0.0956	0.1456
71.0	6.62	20.13	29.0	0.0297	0.0976	0.1487
70.5	6.75	20.50	29.5	0.0303	0.0996	0.1518
70.0	6.89	20.87	30.0	0.0309	0.1016	0.1549
69.5	7.02	21.24	30.5	0.0316	0.1037	0.1580
69.0	7.15	21.61	31.0	0.0322	0.1057	0.1611
68.5	7.29	21.98	31.5	0.0328	0.1078	0.1643
68.0	7.42	22.36	32.0	0.0335	0.1099	0.1674
67.5	7.56	22.73	32.5	0.0341	0.1120	0.1707
67.0	7.70	23.11	33.0	0.0347	0.1141	0.1739
66.5	7.84	23.49	33.5	0.0354	0.1163	0.1771
66.0	7.97	23.86	34.0	0.0360	0.1184	0.1804
65.5	8.11	24.24	34.5	0.0367	0.1206	0.1837
65.0	8.25	24.62	35.0	0.0374	0.1228	0.1870
64.5	8.40	25.00	35.5	0.0380	0.1250	0.1904
64.0	8.54	25.39	36.0	0.0387	0.1272	0.1938
63.5	8.68	25.77	36.5	0.0394	0.1294	0.1972
63.0	8.83	26.15	37.0	0.0401	0.1317	0.2006
62.5	8.97	26.54	37.5	0.0408	0.1339	0.2041
62.0	9.12	26.92	38.0	0.0415	0.1362	0.2076
61.5	9.26	27.31	38.5	0.0422	0.1385	0.2111
61.0	9.41	27.70	39.0	0.0429	0.1409	0.2146
60.5	9.56	28.09	39.5	0.0436	0.1432	0.2182
60.0	9.71	28.48	40.0	0.0443	0.1456	0.2218
59.5	9.86	28.87	40.5	0.0451	0.1480	0.2254
59.0	10.01	29.26	41.0	0.0458	0.1504	0.2291
NOTE – See 38.3.1.						

APPENDIX B

Standards for Components

Standards under which components of the products covered by this standard are judged 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
Protectors for Motors, Thermal — UL 547
Switches, Snap, General-Use — UL 20
Tape, Electrical 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, Rubber-Insulated — UL 44
Wires and Cables, Thermoplastic-Insulated — UL 83