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Single and Multiple Station Smoke Alarms

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UL Standard for Safety for Single and Multiple Station Smoke Alarms, UL 217

Sixth Edition, Dated August 25, 2006

Revisions: This Standard contains revisions through and including May 22, 2007.

Summary of Topics

The revisions dated May 22, 2007 are a correction to paragraph 94.1 (d). The credit statements attributed to the use of reproduced text from the National Fire Alarm Code, NFPA 72, were inadvertently omitted when the sixth edition of UL 217 was issued on August 25, 2006.

These revisions are editorial only.

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The revisions dated May 22, 2007 were issued to correct paragraph 94.1 (d) and include a reprinted title page (page1) for this Standard.

The following table lists the future effective dates with the corresponding item.

Future Effective Date	References
August 25, 2008	14.1, 20.2, 36.3.2, 36.3.3, 36.3.4, 93.1, and 93.2

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: http://ulstandardsinfonet.ul.com/ulforeword.html

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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

Page	Date
1	May 22, 2007
2-25	August 25, 2006
26	September 13, 2006
27-128	August 25, 2006
129-131	May 22, 2007
132	August 25, 2006
SA1-SA20	August 25, 2006
A1-A2	August 25, 2006
B1-B2	August 25, 2006
SR1-SR2	May 22, 2007

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Standard for Single and Multiple Station Smoke Alarms

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Second Edition – October, 1978
Third Edition – October, 1985
Fourth Edition – May, 1993
Fifth Edition – February, 1997

Sixth Edition

August 25, 2006

The most recent designation of ANSI/UL 217 as an American National Standard (ANSI) occurred on August 25, 2006.

This ANSI/UL Standard for Safety, which consists of the Sixth Edition with revisions through May 22, 2007, is under continuous maintenance, whereby each revision is ANSI approved upon publication.

The ANSI approval for this standard does not include Appendices A & B, or Supplement SA.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover electrically operated single and multiple station smoke alarms intended for open area protection in indoor locations of residential units in accordance with the National Fire Alarm Code, NFPA 72, smoke alarms intended for use in recreational vehicles in accordance with the Standard for Recreational Vehicles, NFPA 501C, and portable smoke alarms used as ″travel″ alarms.

1.2 A single station smoke alarm, 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. Possible accessories include a supplemental heat detector, terminals for connection to a remote audible signaling appliance or accessory, and an integral transmitter to energize a remote audible signaling appliance.

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

1.4 These requirements, where applicable, also cover all remote accessories that are to be connected to or are intended to be used with a single or multiple station smoke alarm. See 33.2.1.

1.5 This standard does not cover the following:

a) Smoke detectors of the non-self-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 the Fire Test (Heat Detector), Section 73] incorporated as part of a single station smoke alarm assembly whose requirements are covered in the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521.

2 General

2.1 Components

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

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

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

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

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

2.3 Undated references

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

3 Glossary

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

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

3.3 COMBINATION SMOKE ALARM – An alarm that employs more than one smoke detecting principle in one unit. To qualify as a combination smoke alarm it is required that each principle contributes in response, either wholly or partially, to at least one of the Fire Tests, Section 44, or the Smoldering Smoke Test, Section 45.

3.4 COMPONENT, LIMITED LIFE – A component that is expected to fail and be periodically replaced and whose failure is supervised. Typical examples of such components include incandescent lamps, electronic tube heaters, functional heating elements, and batteries. See also 36.4.2.

3.5 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.

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

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

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

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

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

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

3.8 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.

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

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

3.11 TROUBLE SIGNAL – A visible 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, or depletion of the supply battery.

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

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

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

4 Alarm Reliability Prediction

4.1 The maximum failure rate for alarm units shall be 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. When actual equivalent data is available from the manufacturer, it shall be used in lieu of the projected data for the purpose of determining reliability.

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

does not require inclusion in the failure rate calculation. Examples include the audible signal appliance, 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 affects the normal operation of the alarm.

4.4 A reliable light emitting diode (LED) of a single station smoke alarm employing a photocell-light assembly shall have a predicted failure rate of not greater than 2.5 failures per million hours.

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

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 reference in the examination and test of the alarm. For this purpose, a printed edition is not required. The information is to 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 required for proper and safe installation, testing, maintenance, operation, and use of the alarm.

6 Nonfire Alarm Feature

6.1 A nonfire alarm feature, such as a burglar alarm, shall be used in common with a single or multiple station smoke alarm or both, or an accessory only when it does not degrade or interfere with operation of the smoke alarm or accessory and complies with all the requirements of this standard. See 4.3 and 34.1.9.

7 Alarm Silencing Means (When Provided)

7.1 It is not prohibited that each single and multiple station smoke alarm be provided with an automatically resettable alarm silencing means that has a fixed or variable time setting which desensitizes the alarm for a maximum of 15 minutes. Alarm silencing shall not disable the smoke alarm. Sensitivity shall not be reduced to more than 4 percent per foot of obscuration (37.5pA). Each alarm shall produce a distinctive audible or visible trouble signal while in the silence mode. Following the silenced period, the alarm shall restore automatically to its intended operation. Silencing of one alarm of a multiple station system shall not prevent an alarm operation from the other alarms in the system. See 34.2.1 and 34.2.2.

7.2 When a variable adjustment is provided on an alarm to vary the silenced period, the adjustment means shall be provided with a mechanical stop or the equivalent, so that the maximum 15-minute limitation is not exceeded.

7.3 Smoke alarms powered by a non-replaceable battery must be provided with a temporary alarm silencing means.

8 Battery Removal Indicator

8.1 Removal of a battery from a battery-operated (or AC with battery back-up) smoke alarm shall result in a readily apparent and prominent visual indication. The visual indication shall consist of:

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

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

c) An equivalent arrangement. (Such as an audible trouble signal on an AC with battery back-up).

8.2 Removal of a battery from a battery-operated (or AC with battery back-up) smoke alarm that is intended to be removed from its mounting location for battery replacement, shall render the unit resistant to reinstallation.

8.3 Deactivation of the battery of a smoke alarm that uses a non-replaceable battery with a 10-year minimum battery life shall result in a readily apparent and prominent visual indication. The visual indication shall consist of:

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

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

c) An equivalent arrangement (such as an audible trouble signal on an AC with battery backup).

8.4 Deactivation of a battery of a battery-operated (or AC with battery back-up) smoke alarm that is intended to be removed from its mounting location for battery deactivation, shall render the unit resistant to reinstallation.

8.5 When a warning flag, or equivalent, is employed to comply with the requirement of 8.1 or 8.3, it shall be marked as required in 92.6.

CONSTRUCTION

ASSEMBLY

9 General

9.1 Accessories

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

9.2 Sensitivity adjustment

9.2.1 When a field sensitivity adjustment is provided, it shall be accessible with the alarm 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 37.1.1. Removal of a snap-on cover to gain access to the sensitivity control is permissible only when no high-voltage parts are able to be contacted by the user.

9.3 Radioactive materials

9.3.1 The manufacture, importation, distribution, marking, and disposal of smoke alarms containing radioactive material are subject to the safety requirements of local or state radiation control agencies, the U. S. Nuclear Regulatory Commission, or both.

9.3.2 Verification of the compliance of such alarms with the requirements of the regulating agency involved is required prior to (or 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 alarm, is to be compatible with the device(s) with which it is intended to be employed, and the remote signaling device(s) shall be intended for fire alarm application.

9.5 Insect guards

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

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 accidental contact by persons performing service functions suitably performed with the equipment energized.

10.1.2 An electrical component which requires examination, replacement, adjustment, servicing, or maintenance with the alarm 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 identified as uninsulated live parts:

a) Coils of relays, solenoids, and transformer windings, when the coils and windings are provided with insulating overwraps capable of being used for this purpose;

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

c) Insulated wire.

10.2 Sharp edges

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

11 Enclosure

11.1 General

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

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

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

11.1.4 Nonfunctional rear openings (those that are not required for operation or installation of the detector) shall not permit the passage of any air current or debris which affects detector response to test smoke following installation as intended.

11.1.5 Following installation as intended there shall not be any openings between the intended mounting surface and the rear of the detector which allow for passage of air that affects detector response from test smoke.

11.1.6 To comply with 11.1.4 and 11.1.5, one of the following methods, or a method determined to be equivalent, shall be used:

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

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

11.1.7 To determine compliance with the requirements of 11.1.4 and 11.1.5, representative alarms shall be subjected to the Smoke Entry (Stack Effect) Test, Section 41.

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

11.1.9 When 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. When cast metal having a thickness 1/32 inch (0.8 mm) less than that indicated in Table 11.1 is employed, the surface under consideration is to be curved, ribbed, or otherwise reinforced, or the shape of the surface, size of the surface, or both, are such that equivalent mechanical strength is provided.

Table 11.1
Cast-metal enclosures

Use or dimensions of area involved	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	inch	(mm)	inch	(mm)
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) thick is obtained by the provision of reinforcing ribs subdividing a larger area.

11.2.2 When 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 is capable of being attached.

11.2.3 When 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 used for the enclosure of an alarm shall not be less than that indicated in Table 11.2. When sheet metal of up to two gage sizes lesser thickness is used, the surface under consideration shall be curved, ribbed, or otherwise reinforced, or the shape of the surface, size of the surface, or both shall be such that equivalent mechanical strength is provided.

Table 11.2
Sheet metal enclosures

Maximum dimensions of enclosure				Minimum thickness of sheet metal								
Length or width,		Area,		Steel, zinc-coated,			Steel, uncoated,			Brass or aluminum,		
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) when of uncoated steel, not less than 0.034 inch (0.86 mm) when of galvanized steel, and not less than 0.045 inch (1.14 mm) when 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 (0.69 mm) or 0.032 inch (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 and shall be able to be 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 located so that installation of a bushing at any knockout used during installation does not result in spacings between uninsulated live parts and the bushing of less than those indicated in Spacings, General, Section 32.

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 are protected against damage. The mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 11.2. See also the Tests of Thermoplastic Materials, Section 66.

11.4.2 The continuity of any grounding system to which an alarm is to be connected shall not rely on the dimensional integrity of the nonmetallic material.

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

a) Enclosures containing parts including a risk of fire – minimum flammability rating of V-0 and compliance with the Flame Test (5 inch) as described in 66.4.1 – 66.4.6.

b) Enclosures containing Class 2 and Class 3 circuits with a voltage not exceeding 30 volts AC, 42.4 volts-peak, or 60 volts DC – minimum flammability rating of HB and compliance with the Flame Test (3/4 inch), as described in 66.3.1 – 66.3.6.

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

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 permits 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 used to clean internal parts, shall be constructed to prevent damage to functional internal components during such cleaning operations.

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

11.5.3 When the indentation of the guard or enclosure does 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) when zinc coated], the following conditions shall be employed:

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 AWG 16 (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 when:

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

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

For the purpose of this requirement, intended operation is determined to be operation of a switch for testing or operation of any other component of an alarm that requires such action in connection with its intended performance. This requirement does not apply to a photoelectric type alarm where the lamp is intended to be periodically replaced, or to the battery replacement aspect of an alarm 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 shall be secured by any one of the following or equivalent means: positive snap catch, plug-in or twist action, snap tab with one screw, or two or more screws.

11.6.3 When an alarm cover is not intended to be removed for cleaning, maintenance, or both, and the alarm is intended to be returned to the factory for servicing, the cover shall be secured so that it is not readily removed. Exposed screw slots or nuts, other than a tamper-proof type, shall be sealed or covered. See 92.1 (s) for supplementary marking.

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

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 employed on a separate printed-wiring board or circuit subassembly, to prevent circuit damage resulting from a fault. The use of such a fuse(s) shall occur only when the word ″CAUTION ″ and the following or equivalent marking is located on the cover of a alarm 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 is not capable of being displaced in service and shall provide mechanical protection of the enclosed parts. The thickness of a glass cover shall not be less than that indicated in Table 11.3.

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, and

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

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	Over 305	Over 144	Over 929	See footnote a	See footnote a

[a] 1/8 inch (3.2 mm) or more, based upon the size, shape, and mounting of the glass panel. A glass panel for an opening having an area greater 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.

11.7.3 A lens, light filter, or similar part of a smoke alarm shall be constructed of a material whose transparency is not diminished by the conditions to which it is exposed in service, as represented by the Performance Tests of this standard. See Sections 34 – 76.

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 depends. It does not apply to minor parts, such as washers, screws, bolts, and other parts, when the failure of such unprotected parts does not result in a risk of fire or electric shock or injury to persons or impair the operation of the alarm. Parts made of stainless steel, polished or treated when required, do not require additional protection. Bearing surfaces shall be of materials that prevent binding due to corrosion.

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

12.4 Hinges and other attachments shall be resistant to corrosion.

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

POWER SUPPLY

13 Primary Power Supply

13.1 The primary power supply of a single station smoke alarm 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, when 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 When a separate power supply is provided, it shall have limited output energy consisting of an open circuit voltage not in excess of 30 volts rms, 42.4 volts peak or direct current (DC), and its output capacity shall be limited to a maximum of 100 volt-amperes. It is not prohibited for the energy to 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 not prohibited. When a secondary power supply, such as a battery, is provided it shall have the capacity to supply the maximum intended power to the detector for 7 days in the standby condition and thereafter be able to operate the detector for an alarm signal for at least 4 minutes continuously. This capacity shall be measured using a fully charged battery or other applicable rechargeable energy storage media, or a fresh non-rechargeable battery, as appropriate. Refer to 36.3.

14.1 effective August 25, 2008

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

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

14.4 The discharge condition of a non-rechargeable or rechargeable type battery shall be monitored where a trouble indication, as described in 36.1.3 is obtained. The monitoring shall take place whether the alarm is operating on the primary supply or on the standby supply.

15 Batteries

15.1 General

15.1.1 When a battery or set of batteries is used as the main source of power of a single or multiple station smoke alarm, it shall comply to the requirements of the Battery Tests, Section 63.

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

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 alarm components or disassembly of any part of the alarm, except for a cover or the equivalent. When the battery is capable of powering the alarm for a minimum of 10 years, the battery shall not be user replaceable.

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

15.1.6 A smoke alarm powered by a non-replaceable, ten-year life battery shall be provided with a means of activating the power prior to installation, and deactivating the battery at the end of useful battery life. The deactivation means shall require the use of a tool, or equivalent, and shall render the unit resistant to being reinstalled. The deactivation means shall also serve to completely discharge the battery(ies). Both the activation and deactivation means shall be designed to operate one time only. The installation instructions shall provide the user with information describing this one time operation. See 94.1 (o).

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. It is not prohibited for the polarity to 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 used as part of a battery operated alarm shall be a minimum of AWG 22 (0.32 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 alarm employing a supplementary signaling circuit which is energized from a separate source of supply, the source of energy shall not exceed the energy limits defined in 72.2.1 and 72.2.2.

16.2 For an alarm intended to be connected to a fixed wiring system and employing a separately energized signaling circuit, the source of energy shall not exceed the limits in 72.2.1 unless the connections are made as a Class 1 wiring system as defined in the National Electrical Code, ANSI/NFPA 70.

FIELD WIRING

17 Permanent Connection

17.1 General

17.1.1 A single station or multiple station smoke alarm intended for permanent connection shall be provided with wiring terminals or leads for the connection of conductors of at least the size required by the National Electrical Code, ANSI/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 sized for completing all field-wiring connections as specified by the installation wiring diagram. There shall be space within the compartment to permit the use of a standard conduit bushing on conduit connected to the compartment when a bushing is required for installation.

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 by protection that has been determined to be the equivalent.

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 when provided shall be found to be equivalent.

17.3.2 When 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 It is not prohibited for a terminal plate to have the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Other constructions, when employed, shall 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; shall be provided with strain relief; and shall not be smaller than AWG 18 (0.82 mm^2). The insulation, when of rubber or thermoplastic, shall not be less than 1/32 inch (0.8 mm) thick.

17.4.2 Leads provided for field connection to power limited fire protective signaling circuits, such as employed for multiple station interconnection or for connection to remote signaling devices, shall not be smaller than AWG 16 (1.3 mm^2), for a single conductor, AWG 19 (0.65 mm^2) for two or more conductors, and AWG 22 (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, shall be used only for AWG 18 (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 alarm 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 AWG 18 (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 when it is possible for such displacement to:

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

b) Reduce spacings below the minimum required values, or

c) Result in damage in internal components.

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 hazardous-voltage alarm provided with an overall nonmetallic enclosure and cover, that:

a) Is intended to be serviced internally and

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

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

a) An extra-low-voltage alarm;

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

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

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 alarm. The field-wiring terminal shall be located so that it shall not be removed during servicing of the alarm.

19.3 Cord connected units

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

20 Remote Power Supply

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

20.2 Where longer runs of interconnecting wiring are used in an installation, such as in a multiple station configuration, or where several alarms are supplied by a common power supply, the wiring is not required to be provided by the manufacturer. However, the installation wiring diagram or instructions shall be marked to specify that the wiring to be used shall be in accordance with the provisions of Articles 210 and 3003. (B) 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.

Revised 20.2 effective August 25, 2008

INTERNAL WIRING

21 General

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

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

21.3 When the use of a short length of insulated conductor is not possible, such as for a short coil lead, electrical insulating tubing shall be 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 comply 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 (0.43 mm).

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 shall 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 to avoid the possibility of 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.

21.8 A splice shall be provided with insulation equivalent to that of the wires involved, when 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 shall 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 when its deformation is readily accomplished so as to defeat its purpose. Any clearance between the edge of a barrier and a compartment wall shall not exceed 1/16 inch (1.6 mm).

22 Bonding for Grounding

22.1 An exposed dead metal part of a hazardous-voltage alarm that becomes energized shall be bonded to the point of connection of the field-equipment grounding terminal or lead, when 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 when there is a possibility that they be contacted by the user or by a serviceman servicing or operating the equipment.

22.3 Metal parts as described below are not required to comply with the requirement of 22.2.

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

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

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

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

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

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

22.6 A bolted or screwed connection, that incorporates a star washer under the screwhead, is capable of being used for penetrating nonconductive coatings.

22.7 When the bonding means relies upon screw threads, two or more screws, or two full threads of a single screw, engaging metal is appropriate for use.

22.8 Metal-to-metal hinge-bearing members for doors or covers shall not be used as a means for bonding the door or cover for grounding unless 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: It is not required that a switch be prevented from turning when all four of the following conditions are met:

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

b) The means for mounting the switch shall be such that the operation of the switch loosens it.

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

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

Exception No. 2: It is not required that a lampholder of the type in which the lamp is not capable of being replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel be prevented from turning when rotation does not reduce spacings below the minimum values required. See Spacings, General, Section 32.

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

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

23.2 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 the possibility of impaired operation due to dust or other material.

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

23.4.3 Polymeric materials shall not be used for the sole support of uninsulated live parts unless found to be equivalent to the materials indicated in 23.4.1.

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 (1.6 mm) thick shall not be employed unless the panel is supported or reinforced to provide equivalent rigidity.

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

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

24 Bushings

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

24.2 When 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 determined to be the equivalent of a bushing.

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

24.4 Fiber shall be employed only where:

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

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

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

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

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

25 Lampholders and Lamps

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

25.2 Where more than one lamp is provided on the alarm, 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. When the ″power-on″ lamp is of a different color it shall be marked to identify the function.

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

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

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

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

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

26 Light Emitting Diode (LED) Source Lamps

26.1 A LED used as a light source of a smoke alarm employing a photocell light assembly shall comply with electrical supervision requirements specified in 36.5.1 – 36.5.5, and the reliability prediction specified in 4.1.

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

29.3 An alarm silencing switch or equivalent means shall be provided on a single or multiple station smoke alarm only when 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 shall only be employed in an alarm intended for permanent connection only, when the terminal or lead connected to the autotransformer winding which is common to both input and output circuits is identified, and the output circuits are located within the enclosure containing the autotransformer. See 17.5.1 and 17.5.2.

30.2 The insulation of coil windings of relays, transformers and similar components 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 hazardous-voltage circuit of an alarm.

SPACINGS

32 General

32.1 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 32.1.

32.2 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 32.1.

32.3 The ″Through-Air″ and ″Over-Surface″ spacings of Table 32.1 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.

Table 32.1
Minimum spacings

Point of application	Voltage range	Minimum spacings[a,b]			
		Through-air,		Over-surface,	
		inch	(mm)	inch	(mm)
To walls of enclosure					
Cast metal enclosures	0 – 300	1/4	6.4	1/4	6.4
Sheet metal enclosures	0 – 300	1/2	12.7	1/2	12.7
Installation wiring terminals					
With barriers	0 – 30	1/8	3.2	3/16	4.8
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Without barriers	0 – 30	3/16	4.8	3/16	4.8
	31 – 150	1/4	6.4	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Rigidly clamped assemblies[c]					
100 volt-amperes maximum[d,e]	0 – 30	1/32	0.8	1/32	0.8
Over 100 volt-amperes[e]	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 are otherwise insufficient, shall not be less than 0.028 inch (0.71 mm) thick; except that a liner or barrier not less than 0.013 inch (0.33 mm) thick shall be used only in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it is not affected adversely by arcing. Insulating material having a thickness less than that specified shall be used only when it complies with the requirements for the particular application.

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

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

[d] Spacings less than those indicated, and not less than 1/64 inch (0.4 mm), are appropriate 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).

[e] When spacings between traces on a printed-wiring board are less than the minimum specified, the boards shall be covered with a conformal coating, and the combination shall be evaluated to the requirements in Conformal Coatings of Printed-Wiring Boards, Section 77.

32.4 The spacing requirements in Table 32.1 do not apply to the inherent spacings inside motors, except at wiring terminals, nor to the inherent spacings of a component provided as part of the alarm. Such spacings are 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 32.1.

32.5 The ″To Wall of Enclosure″ spacings of Table 32.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

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

32.7 Spacings on printed-wiring boards which are less than those indicated in Table 32.1 shall comply with the minimum spacings of Table 32.2 and shall be provided with a coating in compliance with Conformal Coatings on Printed-Wiring Boards, Section 77.

Table 32.2
Minimum over-surface spacings on printed-wiring boards

Voltage, volts[a]	Energy available, volt-amperes	Spacing,		Coating program
		inch	(mm)	
0 – 30	100 maximum	13/64	0.2	Section 77.1
0 – 30	Over 100	13/32	0.4	Section 77.1
31 – 300	Over 100	13/16	0.8	Section 77.2

NOTE – The minimum spacings are required between live parts of opposite polarity. Spacings between live parts and dead metal shall comply with Table 32.1.

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

PERFORMANCE

33 General

33.1 Test units and data

33.1.1 Alarms 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 DEFINES THE PRODUCTION SENSITIVITY.

33.1.2 The devices employed for testing are to be those specified by the wiring diagram of the alarm. Substitute devices shall produce functions and load conditions equivalent to those obtained with the devices intended to be used with the alarm in service.

33.2 Accessories

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

a) Normal Operation Test, Section 34;

b) Circuit Measurement Test, Section 35;

c) Temperature Test, Section 47;

d) Overload Test, Section 48;

e) Endurance Test, Section 49;

f) Variable Ambient Temperature Test, Section 50;

g) Humidity Test, Section 51;

h) Leakage Current Test, Section 52;

i) Transient Tests, Section 53;

j) Dielectric Voltage-Withstand Test, Section 54;

k) Overvoltage and Undervoltage Tests, Section 56;

l) Jarring Test, Section 60;

m) Audibility Test, Section 65;

n) Tests of Thermoplastic Materials, Section 66;

o) Drop Test, Section 76 (portable appliance only).

33.3 Test voltages

33.3.1 Unless otherwise specified, the test voltage for each test shall be as indicated in Table 33.1, at rated frequency.

Table 33.1
Test voltages

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

33.4 Test samples and data

33.4.1 The following samples and data are to be provided for testing:

a) At least 28 assembled alarms; 12 preset (as close as normal production calibration permits) to the nominal maximum anticipated production sensitivity (most sensitive setting), and 16 preset (as close as normal production calibration permits) 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 alarms are to be provided with means for monitoring each principle of operation during the Sensitivity Test, Section 37.

b) One additional unassembled alarm.

c) Three additional samples of alarms that operate on the photoelectric principle provided with means to reduce the light output as described in 62.2.

d) Installation and Operating Instructions, see 5.1 and 5.2 and Instructions, General, Section 94.

e) Where applicable, samples of conformal coated printed-wiring boards, as specified in Conformal Coatings on Printed-Wiring Boards, Section 77.

33.4.2 For alarms employing a battery as the main operating supply, 24 additional battery operated alarms 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 shall be provided. See the Battery Tests, Section 63.

33.4.3 Four battery test setups shall be provided for subjection to each of four environmental conditions. Each set up shall be representative of six alarms 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 is obtained from a complete alarm.

33.4.4 The batteries shall be connected in the test circuit with the same terminal arrangement employed in the alarm. Provision for connection of the actual sounding appliance used in the detector for novelty and weekly testing shall also be made. See the Battery Tests, Section 63.

33.5 Component reliability data

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

33.5.2 The data required by 33.5.1 shall include the following or equivalent information:

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

b) Component vendor's reliability and life expectancy data. This shall 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 alarm manufacturers quality assurance (QA) program. This data shall include incoming inspection, in-process QA, burn-in data and testing. This applies 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 an alarm.

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

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 47.1.

g) General calibration procedure of test instruments employed by the manufacturer in the calibration of an alarm.

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

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

34 Normal Operation Test

34.1 General

34.1.1 An alarm 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.

34.1.2 The test voltage is to be in accordance with 33.3.1. The alarm is to be in the standby condition and prepared for its intended signaling operation when it is connected to related devices and circuits.

34.1.3 The introduction of smoke into the detection chamber, such as from a smoldering cotton lamp wick, rope, or equivalent, shall result in the operation of the alarm in its intended manner. See 37.1.1. The alarm signal shall persist for at least 4 minutes under an abnormal level of smoke.

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

34.1.5 When single station smoke alarms are intended for multiple station connection, the operation for alarm of one station shall result in the alarm signal of all connected stations being energized and the station that initiated the alarm signal shall be identified. See 25.7. When the interconnection wiring is not supervised for opens, shorts, and grounds, no more than 12 smoke alarms, or 18 alarms [12 smoke and 6 other (heat, CO, or similar alarms)] shall be specified for interconnection. When the interconnection is supervised, no more than 64 alarms shall be specified for interconnection.

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

34.1.7 Neither principle of operation of a combination smoke alarm shall be rendered inoperative by any of the Performance Tests, Sections 34 – 76, of this standard. A circuit analysis shall be made, supplemented by electrical measurements when required, to determine that both principles of operation contribute to alarm actuation.

34.1.8 Operation for alarm of a smoke alarm with integral transmitter that is energized by an initial pulse(s) shall result in an alarm signal being locked in for at least 4 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 94.1 (m) for instructions to be provided. Lock-in of the receiver is not required when the receiving unit audible alarm signal is energized in time sequence and duration with the detector.

34.1.9 An alarm or accessory that employs one or more nonfire-alarm features shall operate as follows:

a) The smoke alarm 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) shall be used only when 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 appropriate. When an audible trouble signal is additionally provided it shall be distinctive from all alarm signals. It is not prohibited that the trouble signal is 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 alarm. See 36.1.5.

34.2 Alarm silenced period

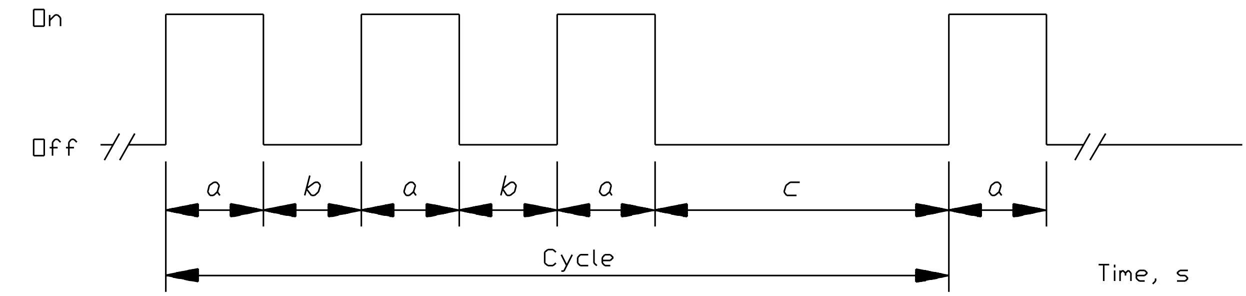
34.2.1 To determine the duration of the alarm silenced period each of four smoke alarms, in the normal standby condition, is to be placed in the sensitivity test chamber. See the Sensitivity Test, Section 37. The smoke is to be increased until the alarm goes into an alarm condition. The smoke is to be maintained at an abnormal amount for the duration of the test. After the alarm has been in an alarm condition for 1 minute, the silencing means is to be actuated and the time recorded between operation of the silencing means and reactivation of the alarm signal. The maximum time of silencing shall not exceed 15 minutes. See 7.1.

34.2.2 With the maximum number of alarms interconnected in a multiple station configuration as specified by the installation instructions, one alarm 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 34.2.1. 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 alarm. During the silenced period, the other alarms 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.

34.3 Standardized alarm signal

34.3.1 An alarm shall produce an audible signal in the form of the ″three pulse″ temporal pattern shown in Figure 34.1. Each ON phase shall last 0.5 second±10 percent, followed by an OFF phase of 0.5 second ±10 percent. After the third of these ON phases, there shall be an OFF phase that lasts 1.5 seconds ±10 percent.

Figure 34.1
Standardized alarm signal temporal pattern



Key

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

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34.4 Sensitivity shift criteria

34.4.1 During or immediately after performance tests, the sensitivity of the detectors shall not vary more than ±1 percent per foot obscuration (0.014 optical density per meter) from the value recorded prior to the test. In no circumstance shall the sensitivity of a detector shift outside the sensitivity limits as specified in 37.1.1.

35 Circuit Measurement Test

35.1 Current input

35.1.1 Except for a battery operated alarm, the input current of a smoke alarm shall not exceed the marked rating by more than 10 percent when the alarm is connected to a source of supply in accordance with 33.3.1 and operated under the conditions of intended use (standby and alarm).

35.2 Battery trouble voltage determination

35.2.1 An increase in the internal resistance, or a decrease in terminal voltage, of a battery employed as the primary source of power to an alarm shall not impair operation for an alarm signal before a trouble signal is obtained. In addition, any combination of voltage and resistance at which a trouble signal is obtained shall be greater than the battery voltage and resistance combination measured over the manufacturer's specified battery life (a minimum of 1 year) period in the room ambient condition of the Battery Tests, Section 63.

35.2.2 The trouble level of a battery operated smoke alarm shall be determined (using the test circuit in Figure 35.1 and the voltage-resistance curves of Figure 35.2) 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.

35.2.3 To determine compliance with 35.2.1 each of three alarms is to be connected in series with a variable regulated direct current power supply and a variable resistor as illustrated in Figure 35.1. The trouble level is to be determined by the following steps:

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

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

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

35.2.4 To determine that a battery is capable of supplying alarm and trouble signal power to the alarm for at least the manufacturer's specified battery life (1 year minimum) under the room ambient condition described in the Battery Tests, Section 63, Curve A of Figure 35.2 is to be plotted from the data obtained in the measurements described in 35.2.3 and compared to Curve B of Figure 35.2, which is plotted from data generated in the 1 year battery test. The intersection of Curves A and B shall not occur before the manufacture's specified battery life (1 year minimum) and all points of Curve B to the right of point F (extended to the base line), shall be below Curve A.

Figure 35.1
Test circuit

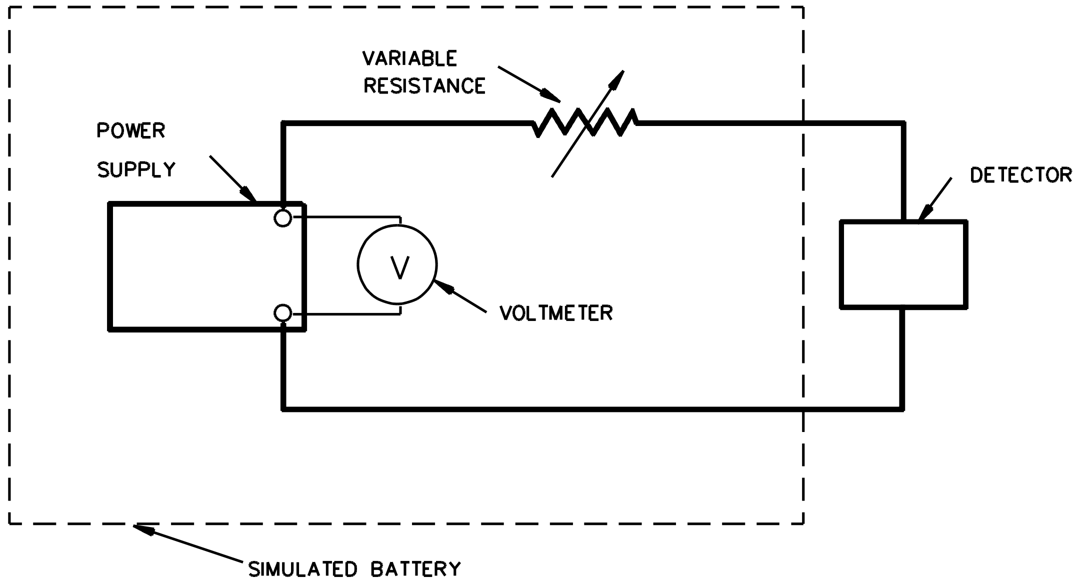

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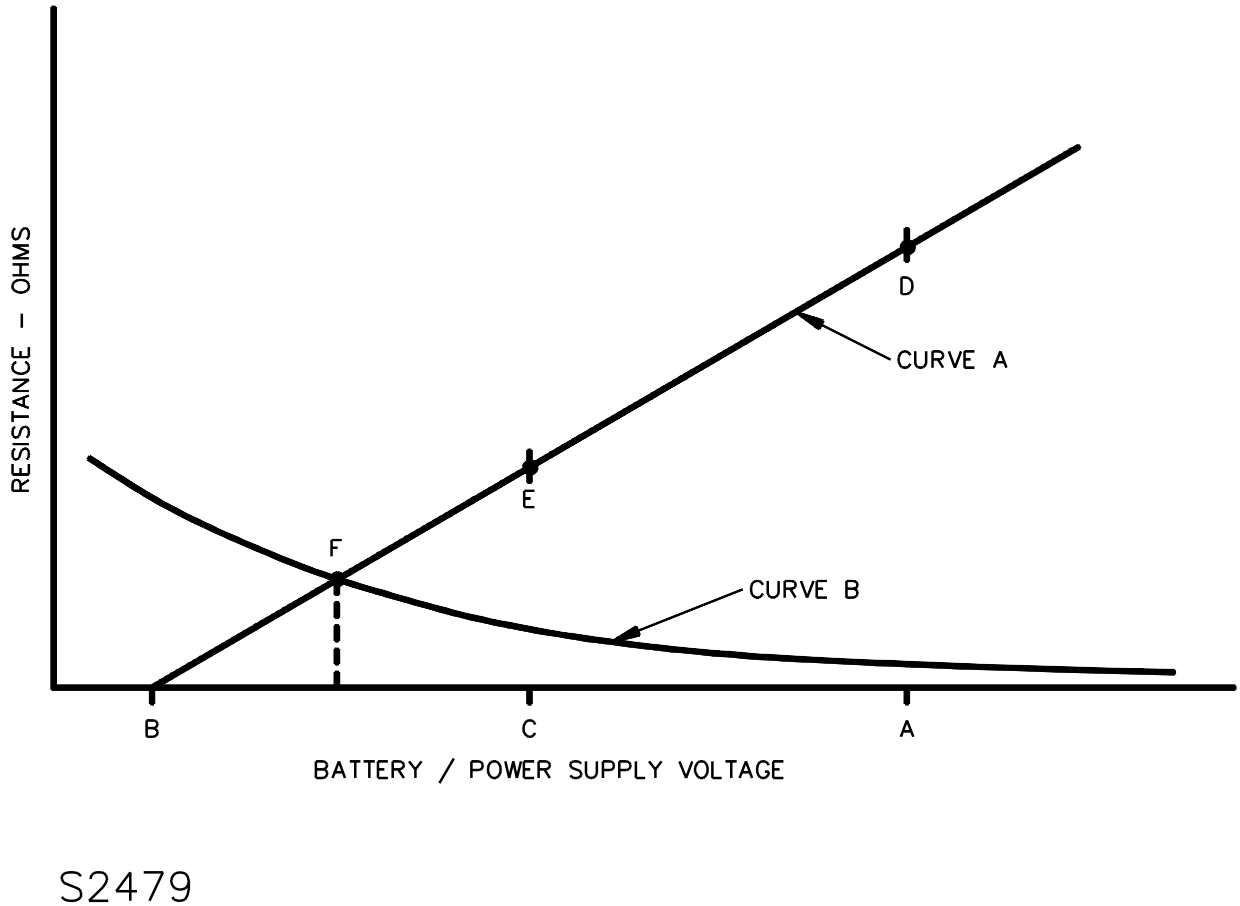
Figure 35.2
Trouble level determination



A – Rated battery voltage.

B – Trouble level voltage (assuming minimal resistance).

C – Voltage value between rated and trouble level.

D – Trouble level resistance at rated battery voltage.

E – Trouble level resistance at voltage value C.

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

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

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

36 Electrical Supervision Test

36.1 General

36.1.1 A single station smoke alarm 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 alarm shall result in an audible trouble signal.

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

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

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

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

36.2 AC powered units

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

36.2.2 Neither loss nor restoration of power shall result in an alarm signal under either momentary or extended (at least 1/2 hour) power outage conditions. Momentary energization of the alarm circuit (maximum of 1 second), and energization of the trouble circuit (maximum of 2 minutes), is appropriate. 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, nor energization of the trouble circuit for more than 2 minutes.

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

36.3 Battery powered (primary or secondary) units

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

36.3.2 An alarm which uses a battery (or other applicable rechargeable energy storage media) as the secondary source of supply shall be capable of supplying the alarm with a minimum of 7 days of power in the normal standby condition, and producing an alarm signal for at least 4 minutes at the battery voltage at which an audible trouble signal is obtained followed by 7 days of audible trouble signal indication.

36.3.2 effective August 25, 2008

36.3.3 To determine compliance with 36.3.1, three samples, powered from primary battery supplies, shall be equipped with batteries which have been depleted to the trouble signal level. The samples are then to be placed in alarm for 4 minutes. Following the 4 minutes of alarm the trouble signal shall persist for at least seven consecutive days. It is possible to deplete a fresh battery by applying a 1 percent or smaller loading factor based on the ampere hour rating of the battery. For example, a 1000 milliampere-hour rated battery is depleted by applying a 10 milliamperes (1 percent load) or less drain continuously until the battery voltage reaches the predetermined test level.

36.3.3 effective August 25, 2008

36.3.4 To determine compliance with 36.3.2 for alarms whose secondary supply is a battery or other applicable rechargeable energy storage media, three samples shall be powered from secondary sources of supply (with the primary source of supply disabled) which are fully charged, or in fresh condition (see 14.1) and allowed to remain in the normal standby condition for a minimum of 7 days. The samples shall not emit audible low battery trouble signals before the end of the 7 day period. Three samples shall also be equipped with secondary supplies (with the primary source of supply disabled) which have been depleted to the trouble signal level. The samples are then to be placed in alarm for 4 minutes. Following the 4 minutes of alarm the trouble signal shall persist for at least 7 consecutive days. It is possible to deplete a fresh battery by applying a 1 percent or smaller loading factor based on the ampere hour rating of the battery. For example, a 1000 milliampere-hour rated battery is depleted by applying a 10 milliampere (1 percent load) or less drain continuously until the battery voltage reaches the predetermined test level.

36.3.4 effective August 25, 2008

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

36.3.6 To determine compliance with 36.3.5, two samples of an alarm that locks-in on alarm shall be equipped with batteries which have been depleted and stabilized at just above the trouble signal level. The samples are then to be placed in alarm and the battery voltage monitored. The samples shall automatically transfer to audible trouble when the battery trouble voltage is reached. The trouble signal shall persist for seven consecutive days. In cases where the battery voltage recovers to a point where the trouble signal is no longer emitted, the unit shall be placed into alarm again until the trouble signal is reinstituted.

36.3.7 A decrease in the battery capacity of an alarm, 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.

36.4 Component failure

36.4.1 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 3.5.

36.4.2 Internal shorts between any two elements of an electronic tube which prevent operation of the unit shall be indicated by either an audible trouble signal or an alarm signal. Such failures shall not result in a risk of fire.

36.4.3 The heaters of all electronic tubes or other functional heating elements employed in an alarm shall be electrically supervised to indicate an open circuit fault by an audible trouble signal when the fault prevents operation of the unit or results in loss of sensitivity or response to the Fire Tests, Section 44, and the Smoldering Smoke Test, Section 45.

36.5 Photocell illuminating lamps

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

36.5.2 A limited life LED employed as the light source of an alarm shall be electrically supervised to indicate an audible trouble signal in the event of an open, short, or, except as exempted in 36.5.3, 50 percent or greater light degradation. Energization of the alarm signal for a maximum of 5 seconds prior to the trouble signal is appropriate.

36.5.3 An audible trouble signal for greater than 50 percent light degradation of a limited life LED is not required when light degradation data is supplied by the LED manufacturer to show that, for the conditions under which it is to be operated, the LED does not reach 50 percent light output at the end of the reliability prediction period. See 3.5.

36.5.4 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 alarm 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 the Reduction in Light Output Test, Section 62.

36.5.5 An LED employed as the light source of a photoelectric smoke alarm is required to be electrically supervised by means of an audible trouble signal unless it is reliable based on its use in the detector and supporting reliability data provided by the component manufacturer. It is possible for failure of the reliable LED at the end of the failure rate prediction described in 3.5, to result in an alarm signal.

36.6 External wiring

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

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

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

37 Sensitivity Test

37.1 General

37.1.1 A smoke alarm when calibrated to each end of its production window shall operate within the limits specified below when subjected to an aerosol buildup using the test equipment described in 37.3.1 – 37.3.3, and when subjected to a range of air velocities. For an alarm which 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 alarm located in the air stream in the least and most favorable horizontal positions for smoke entry as determined in the Directionality Test, Section 39.

a) Visible Smoke Obscuration Limits:

Percent per foot	Percent per meter	OD[a] per foot	OD per meter
4.0	12.5	0.0177	0.0581 maximum
0.5	1.6	0.0022	0.0072 minimum
[a] See 37.3			

b) Measuring Ionization Chamber (MIC) Measurement:

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

37.1.2 A smoke alarm employing a secondary power supply shall operate within the limits specified in 37.1.1 when operating from the secondary power supply.

37.2 Aerosol generation equipment

37.2.1 The equipment used shall generate the buildup rates specified in Figures 37.1 and 37.2. The aerosol shall be produced mechanically, or by the slow smoldering of a cotton wick, or similar item, only when the appropriate buildup rates are obtained.

Figure 37.1
Sensitivity test limits – aerosol – 32 fpm

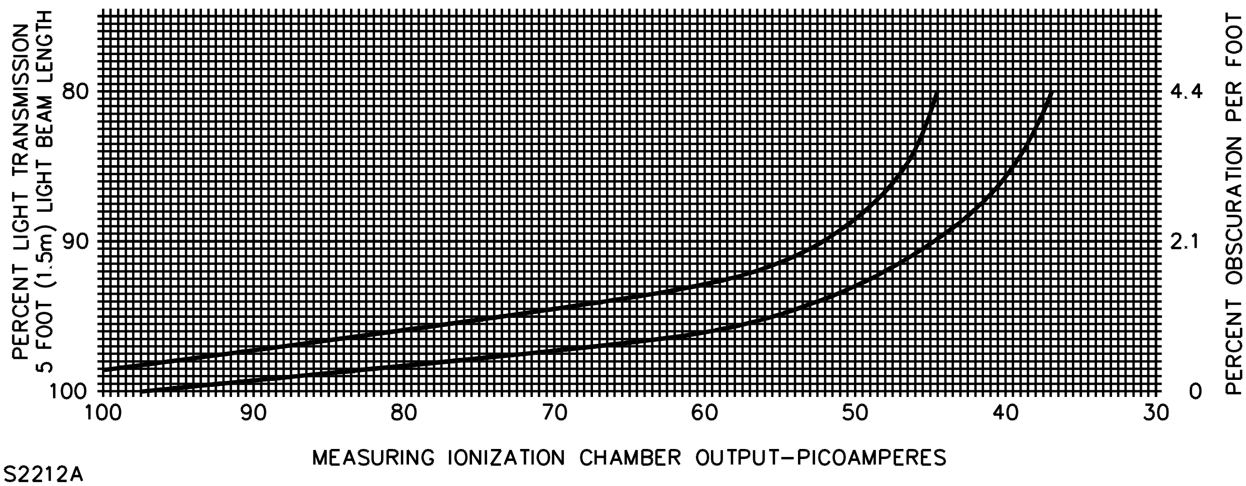


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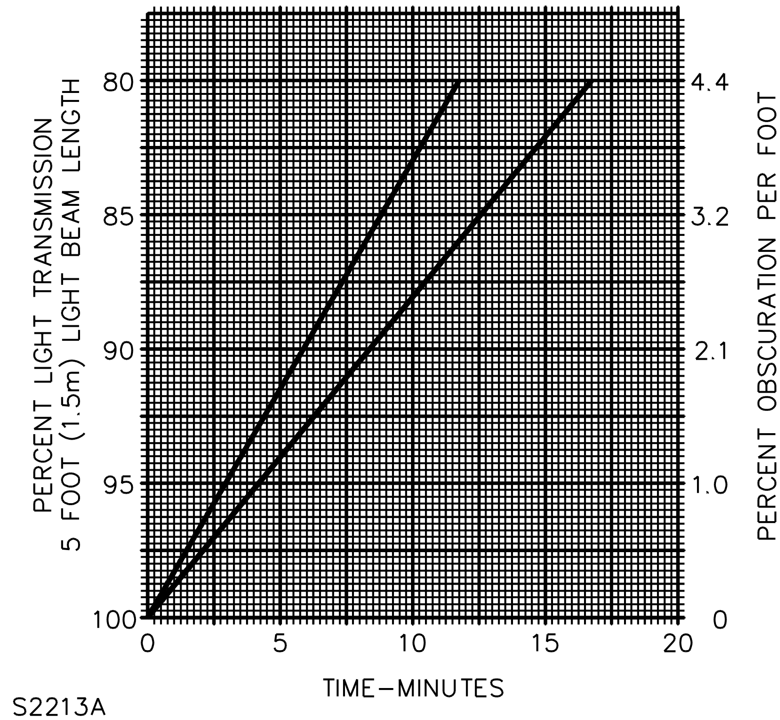
Figure 37.2
Smoke build-up rate – sensitivity test – aerosol – 32 fpm



37.3 Test equipment

37.3.1 The visible aerosol obscuration (optical density) in the test compartment is to be measured by means of a DC type micrometer 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 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 (Appendix B is provided for reference):

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

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

in which:

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

T_s is the aerosol density meter reading with smoke.

T_c is the aerosol 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 is:

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

in which:

O_d is the percent obscuration at distance d.

T_s is the aerosol density meter reading with smoke.

T_c is the aerosol density meter reading with clear air.

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

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

in which:

T_d is the percent transmission at distance d.

T_s is the aerosol density meter reading with smoke.

T_c is the aerosol density meter reading with clear air.

d) When the percent obscuration per foot (or per meter) is known, it is possible to determine the percent obscuration for the full length of any longer beam 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 is:

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

in which:

OD_t is the Optical Density.

T_c is the aerosol density meter reading with clear air.

T_s is the aerosol density meter reading with aerosol.

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

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

in which:

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

T_c is the aerosol density meter reading with clear air.

T_s is the aerosol density meter reading with smoke.

d is the distance in feet (or meters).

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

37.3.2 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.

37.3.3 A typical test chamber consists of the following items. It is not prohibited for different chamber configurations to be used as long as they provide a homogeneous aerosol mix and a laminar air flow across the alarm, 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 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 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 (19.1-mm) exterior grade plywood, 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 4-inch (102-mm) diameter hole for the 30 – 35 fpm circulating fan centered 4-1/2 inches (114 mm) from the side and 3-7/8 inches (98 mm) from the bottom near corner, a 5-3/4-inch (146-mm) diameter hole for the 150 fpm 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 (102-mm) diameter hole centered 3 inches (76.2 mm) 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] (30 – 35 fpm, not shown) – 110 cfm (0.05 m3/s); rated 8 – 28 volts DC (24 volts DC nominal), 6 watts (at 24 volts DC), 4.69 inches (119 mm) square. The fan is connected to a regulated DC power supply.

d) Circulating Fan[d] (150 fpm) – 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 shall be located on either side of the opening. The fan is connected to a motor controller (o) for variable speed adjustment.

Alternate Fan[e] (150 fpm) – 550 cfm (0.26 m^3 /s), rated 115 volts, 50/60 hertz, 10-inch (254-mm) diameter.

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

f) Photocell[f] – Selenium barrier layer type, 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 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 $\pm$0.3 microamperes per foot-candle (0.416 $\pm$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 10,000 ohm, ten turn potentiometer placed across the loaded photocell in a configuration which has negligible affect on the total photocell load regardless of the potentiometer setting, as shown in Figure 37.3 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 350 and 660 nanometer.

g) Airstream Deflector – Sheet aluminum, 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 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 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.

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

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

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

k) Detector Under Test – Located in center on inner compartment top. Positioned to rest on back (as illustrated) or 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 aerosol entry faces oncoming air flow.

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

m) 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 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 typically 2.40 volts which yields a lamp color temperature of 2373±50 Kelvin. At that level, the photocell current is to be 100 ±25 microamperes into 100 ohms. The lamp is not to result in random meter fluctuations.

n) Meter Assembly – Digital micrometer 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 (e). An analog direct current micrometer, having a maximum impedance of 100 ohms and a linearity of 1 percent or better over a range of 50 – 100 microamperes, is also appropriate for use.

o) Control Cabinet – Cabinet for mounting timers, switches, variable autotransformer for varying supply voltage to outlets (l), and potentiometer for speed control of circulating fan (c).

p) Monitor Head Meter[i] – High impedance meter 100 picoamperes full scale. Employed with (j) and (r).

q) Air Diffuser – Same type of screening material as described in (i). To be wedged between the underside of the air stream straightener and the deflector at a 45-degree angle with the horizontal.

r) Control Equipment (Monitoring Head) – Consists of a suction control unit employed with a vacuum pump and an amplifier with power supply. Employed with (j) and (p).

s) Recorder[j] – X-Y plotter. Records buildup of visible smoke versus MIC output.

t) Velometer[k] – Velocity measuring instrument with probe sensor. Probe inserted through hole in plastic window to measure air flow 1 inch (25.4 mm) above platform.

u) Power Supply (Not Shown) – Variable, regulated DC supply, 0 – 40 volt output. Employed with (c), 30 – 35 fpm circulating fan.

[c]Rotron, Model MD24B2, or equivalent.

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

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

[f]A photocell used for this purpose is Weston Instruments, Model 594 RR.

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

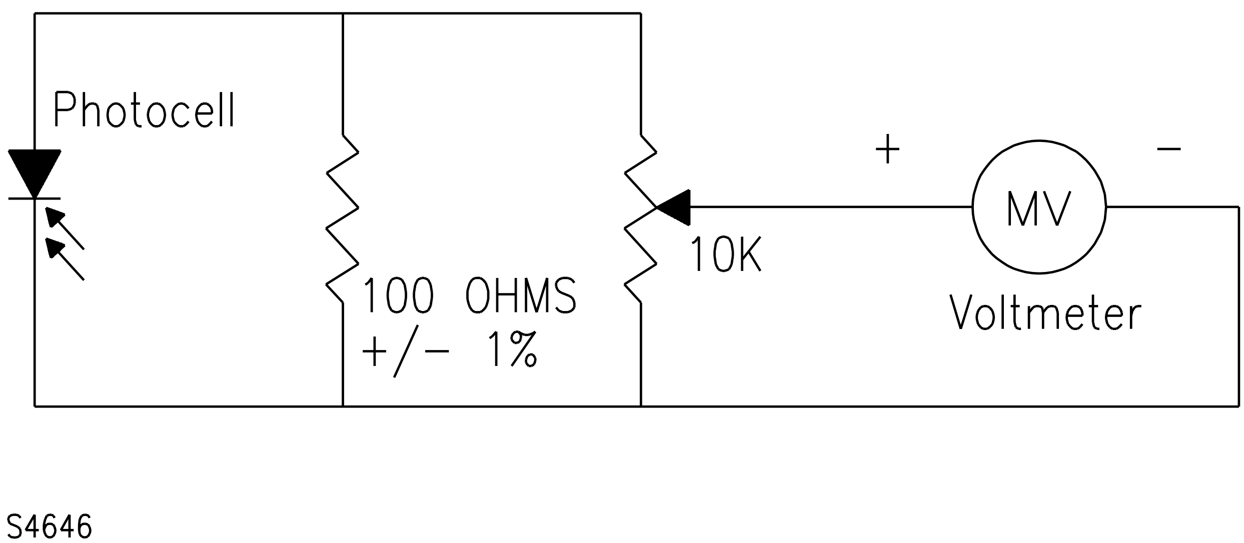
[h]An instrument used for this application is a Measuring Ionization Chamber (MIC), Type EC 23095, and control equipment manufactured by Electronikcentralen, Horsholm Denmark.

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

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

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

Figure 37.3
Potentiometer placement



37.4 Test method

37.4.1 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 (93.3 kPa) of mercury.

37.4.2 A minimum of 12 samples of the alarm, previously energized from a source of supply in accordance with 33.3.1 for at least 16 hours or for a time interval as specified by the manufacturer, are to be subjected to this test. The alarm under test is to be tested in the least and most favorable horizontal positions of aerosol entry. See 39.1.

37.4.3 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 alarm with a hot wire anemometer, or equivalent air velocity measuring instrument. The velocity measurement is to be made with the alarm removed.

37.4.4 The aerosol is to be admitted into the test chamber and operation is to be continued until the alarm is actuated in a continuous (steady or pulsing) alarm condition. For units whose alarm is nonpulsing and 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 37.1 and 37.2. When the trial-to-trial variation in percent light transmission at alarm is ±0.2 or less, only three trials are required to be conducted on each sample. When 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 let to stabilize for at least 30 seconds before each test trial.

37.4.5 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 Aerosol Obscuration (percent light transmission),

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

c) Time of test trial.

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

38 Velocity-Sensitivity Test

38.1 The sensitivity of an alarm shall not vary more than specified in 34.4.1, using aerosol, 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 37.1.1 for aerosol.

38.2 Two alarms, 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 aerosol buildup 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 38.1. The aerosol buildup rate is to be maintained within the limits of Figure 38.2.

38.3 For this test the alarms are to be oriented, in turn, in the least favorable and then the most favorable position for aerosol entry.

Figure 38.1
Smoke entry test limits – aerosol – 150 fpm

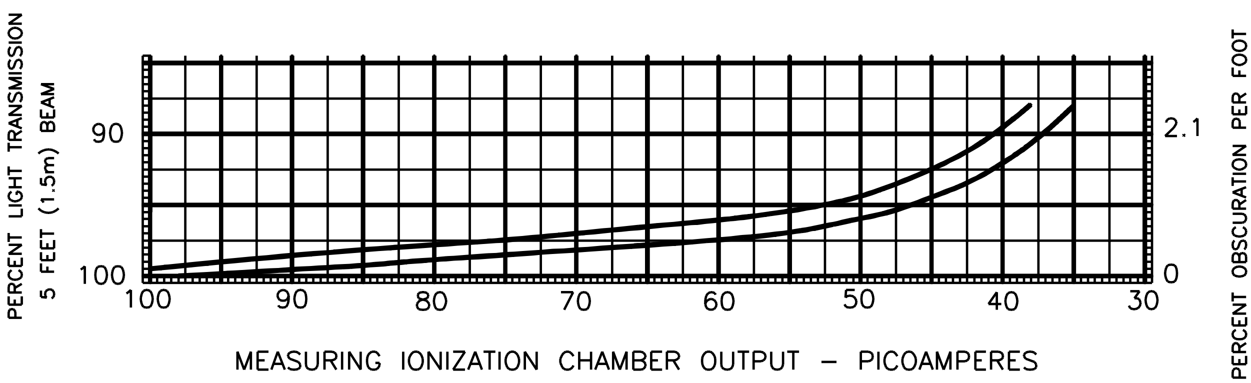


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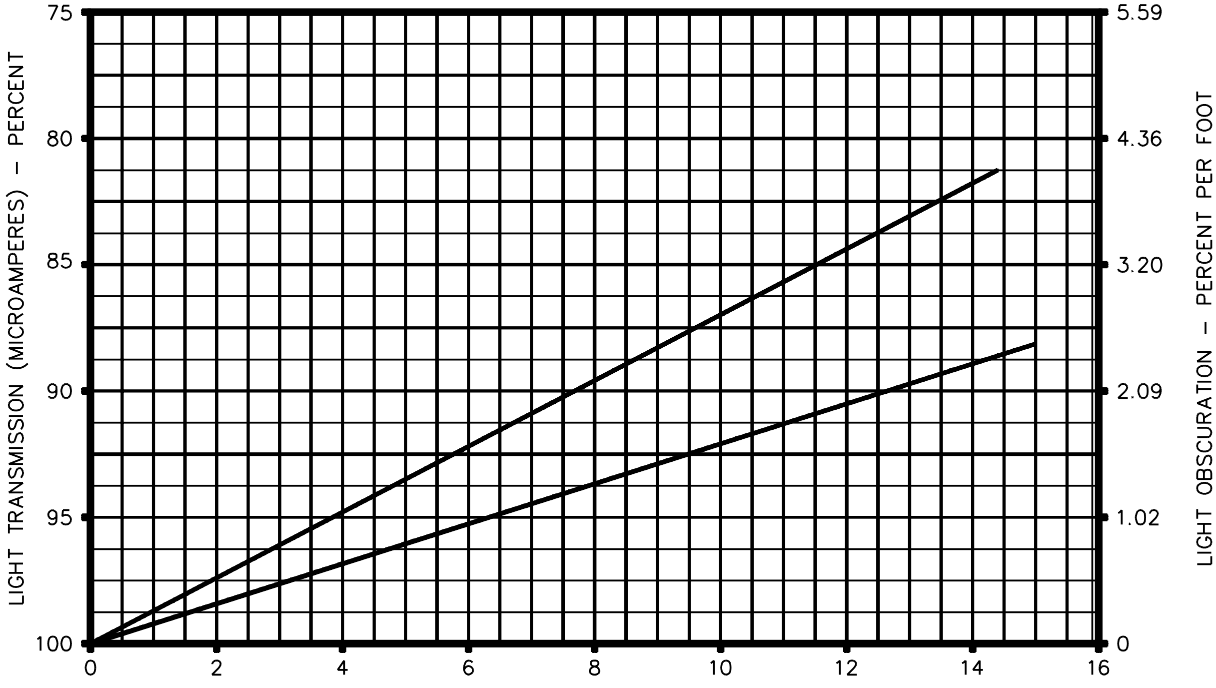
Figure 38.2
Smoke build-up rate – velocity-sensitivity test – aerosol – 150 fpm



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39 Directionality Test

39.1 The sensitivity of the alarm shall comply with the requirements of 37.1.1 for aerosol, in any orientation with the air flow in the chamber. The alarm 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 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 alarm front facing the oncoming air. The locations of the least and most favorable smoke entry positions are to be marked on all alarms to be used in subsequent Sensitivity Tests, Section 37; the Fire Tests, Section 44; and the Smoldering Smoke Test, Section 45.

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

39.3 When the height of an alarm 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 37.4.3.

40 Sensitivity Test Feature

40.1 A sensitivity test feature shall be provided on a smoke alarm, to simulate either mechanically or electrically a specified level of smoke in the sensing chamber. The test feature shall be accessible from outside the alarm, with the alarm 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 aerosol.

40.2 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 an alarm 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 obscuration versus an instrument (meter) reading, or equivalent.

41 Smoke Entry (Stack Effect) Test

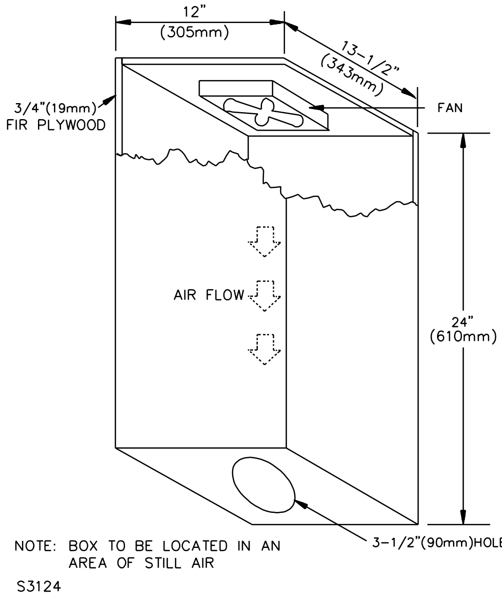
41.1 The sensitivity of a smoke alarm shall not vary by more than specified in 34.4.1 when subjected to the test conditions described in 41.2 – 41.4, which simulate air passing through an electrical conduit system that is connected to a smoke alarm.

41.2 The test box shown in Figure 41.1 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 (91.4 mpm) and with the hole covered, the fan shall produce a back pressure measuring between 0.012 – 0.015 inches (0.304 – 0.381 mm) of water. The fan is then to be turned off. A smoke alarm 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.

41.3 The entire test box smoke alarm assembly is to be placed (alarm side down) in an opening provided in a modified top door of the test chamber described in the Sensitivity Test, Section 37. The alarm shall then be tested for sensitivity while in this position. Two samples are to be tested, one at maximum, and one at minimum sensitivity.

41.4 The procedure described in 41.2 and 41.3 is to be repeated on both alarms, except the fan is to be turned on.

Figure 41.1
Test apparatus – smoke entry (stack effect) test



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

42 Lamp Interchangeability Test (Photoelectric)

42.1 The sensitivity of an alarm employing a replaceable light source shall vary not more than specified in 34.4.1 using aerosol and shall comply with the requirements of the Sensitivity Test, Section 37, when tested with the intended replacement lamps.

42.2 Three samples, set at the minimum sensitivity setting, are to be subjected to the Sensitivity Test, Section 37. The alarms then are to be de-energized, the photocell illuminating lamp replaced, reenergized, and again subjected to the Sensitivity Test.

43 Stability Tests

43.1 There shall be no false alarms of a smoke alarm set at the maximum sensitivity setting when two representative samples are subjected to the following test conditions. Different alarms are to be employed for each test. A test is not required when the principle of operation is such that conducting the test has no possible effect. Alarms whose sensitivity is affected by air velocity are to be tested in the horizontal position in which a false alarm is most probable. Momentary energization of the alarm (maximum of 1 second) is not prohibited during this test.

a) Operation for 90 days in a clean atmosphere in an air stream having a velocity of 300 ±25 fpm (1.5 ±0.13 m/s) in an ambient of 23 ±2°C (73.4 ±3°F) and 30 – 50 percent relative humidity.

b) Three plunges from an ambient humidity of 20 ±5 percent relative humidity to an ambient of 90 ±5 percent relative humidity at 40 ±2°C (73.4 ±4°F).

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

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

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

f) Fifty cycles of momentary (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 alarms are capable of being tested in conjunction with the Battery Replacement Test, Section 68.

g) 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.

43.2 Two alarms, employing a maximum sensitivity setting, are to be mounted in a position of normal use, energized from a source of supply in accordance with 33.3.1 and subjected to each of the above test conditions.

43.3 For 43.1 (b), the alarm 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.

43.4 For 43.1 (c), 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 (d) the air velocity is to be turned on and off abruptly with a maximum of 1 hour between applications. For (e), the time of change from one pressure to the other is to be 30 seconds. For (g), the alarm 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.

43.5 For 43.1 (g) the peak luminous intensity of the incandescent lamp test shall be 175 candela. The peak luminous intensity of the fluorescent fixture test shall be 424 candela.

43.6 The test samples subjected to (a) – (g) of 43.1 are to be tested for sensitivity, using aerosol (see the Sensitivity Test, Section 37), following the completion of each test. The response of any alarm, when tested in accordance with the Sensitivity Test, shall vary not more than specified in 34.4.1.

44 Fire Tests

44.1 General

44.1.1 Each alarm subjected to the tests specified in 44.2.1 – 44.4.1 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.

44.1.2 With reference to the requirements of 44.1.1, smoke alarms with precalibrated alarm settings are not required when alarms are employed which are equipped with a means to provide an analog output (electrical measurement) of the alarm sensitivity during the course of the test trials. The alarms then are to be subjected to the Sensitivity Test, Section 37, 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 is obtained without conducting repeat tests after recalibration. This method is also appropriate for the Soldering Smoke Test, Section 45.

44.2 Paper fire – Test A

44.2.1 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 1 inch in diameter until the paper level is 4 inches below the top edge of the receptacle. A hole 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 (102 mm) 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 alarm 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 alarm 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 alarm 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 alarm locations.

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

6) Length of test shall be 4 minutes.

44.3 Wood fire – Test B

44.3.1 The following materials and procedures shall be used for the wood fire test:

a) Combustible[l] – 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 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.

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 does 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 alarm location; and between 60 and 120 seconds at each sidewall alarm 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 alarm locations.

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

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

5) Length of test shall be 4 minutes.

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

44.4 Flammable liquid fire – Test C

44.4.1 The following materials and procedures shall be used for the gasoline fire test:

a) Combustible – Consists of a mixture of 25 percent toluene and 75 percent heptane which is to be burned in a metal receptacle in a large enough quantity to generate curves within the limits specified by Figure 44.1.

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 liquid is to be poured into the receptacle 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 liquid.

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

1) Maximum obscuration shall not exceed 13 percent per foot [0.061 OD/foot (0.199 OD/m)] or 17 percent per foot [0.081 OD/foot (0.265 OD/m)] at either side wall alarm location.

2) Length of test shall be 4 minutes.

44.5 Igniter assembly

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

a) Igniter Probes – The metal probes, 1/4 inch (6.4 mm) diameter and tapered at the ends to form a point and maintained 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, 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.

44.6 Test conditions

44.6.1 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 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. Where required, heating, humidity, and air conditioning are to be provided for maintaining the room ambient, and are to be shut down during the test trial. See Figure 44.2.

Figure 44.1
Flaming liquid fuel profile

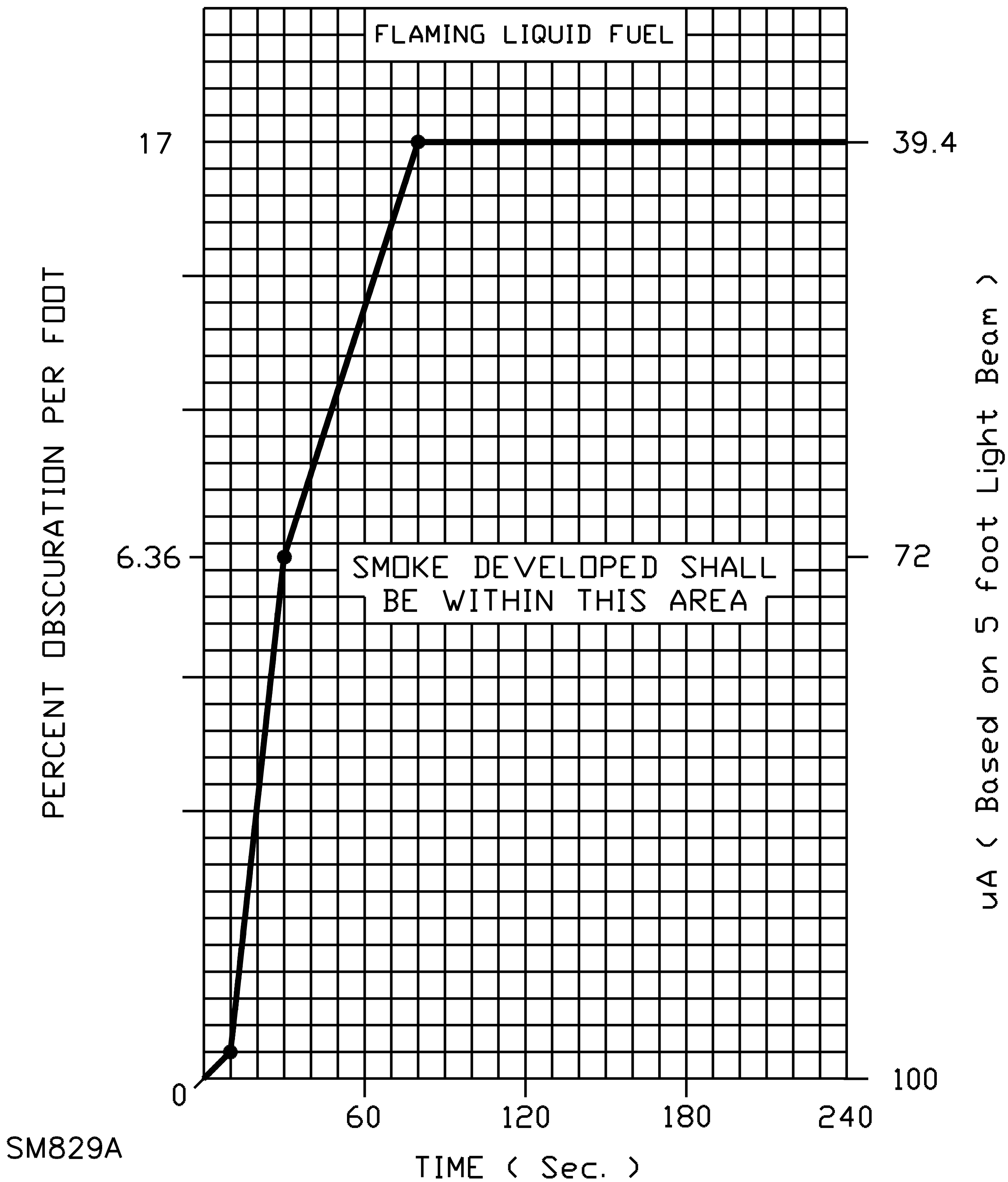
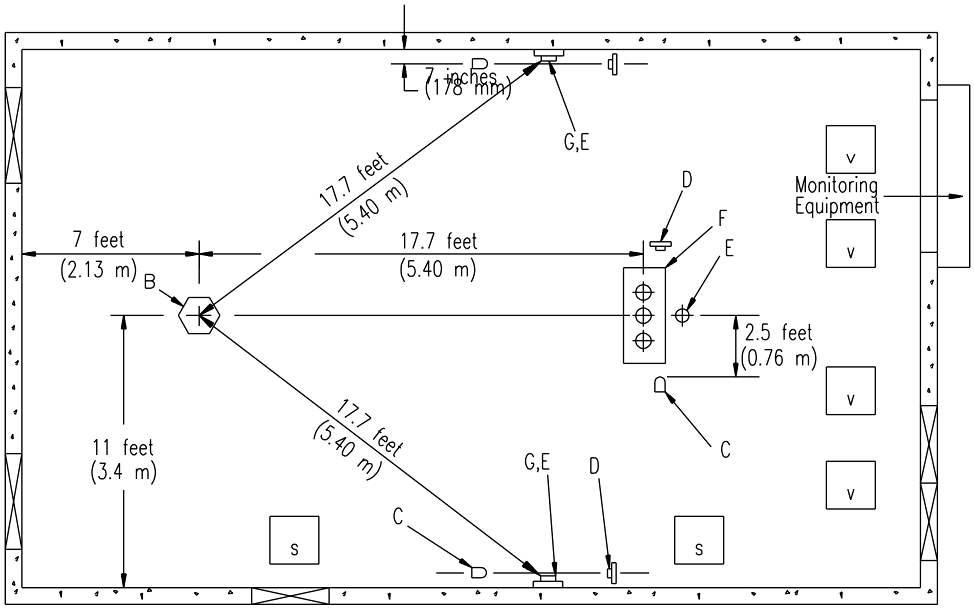


Figure 44.2
Fire test room



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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 the Fire Tests, Section 44

2. 8 inches (203 mm) above floor for the Smoldering Smoke Test, Section 45

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 45.8.

F. Test Panel, Ceiling Mounted Alarms – see Figures 44.3 and 44.5.

G. Test Panel, Sidewall Mounted Alarms – see Figures 44.4 and 44.5.

S. Air Supply

V. Exhaust Vents

44.6.2 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 alarm samples are to be energized from a source of supply in accordance with 33.3.1 except that alarms 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.

44.6.3 When intended for ceiling mounting only, three alarms are to be tested on a ceiling panel. See Figure 44.2. When intended for wall mounting only, two alarms are to be tested, one on each sidewall. See Figure 44.3. For detectors intended for both wall and ceiling mounting, five alarms are to be tested: three on the ceiling and one on each side wall. See Figure 44.5. For alarms 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 alarm. The ceiling mounted alarms are to be mounted such that the least favorable position of one sample faces the oncoming smoke flow, with the remaining two samples rotated 120 and 240 degrees, respectively.

44.6.4 All alarm samples, each adjusted to its minimum sensitivity setting, shall respond to each combustible. The test time is to start at ignition. Each alarm shall operate for continuous (steady or pulsing) alarm. For units whose alarm is nonpulsing and 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 alarm 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 37.3.3 (e) and (l) for a description of this assembly. Combination smoke alarms 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 45, or to both.

Figure 44.3
Ceiling panel size and sample location for ceiling mounting of alarms

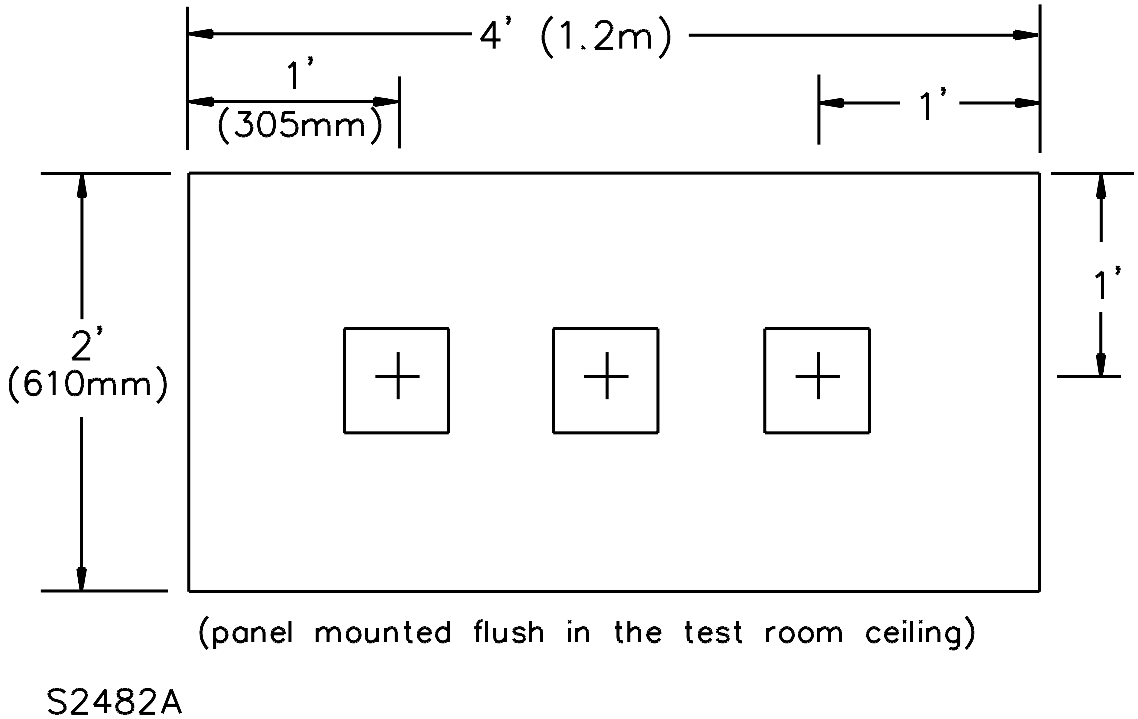
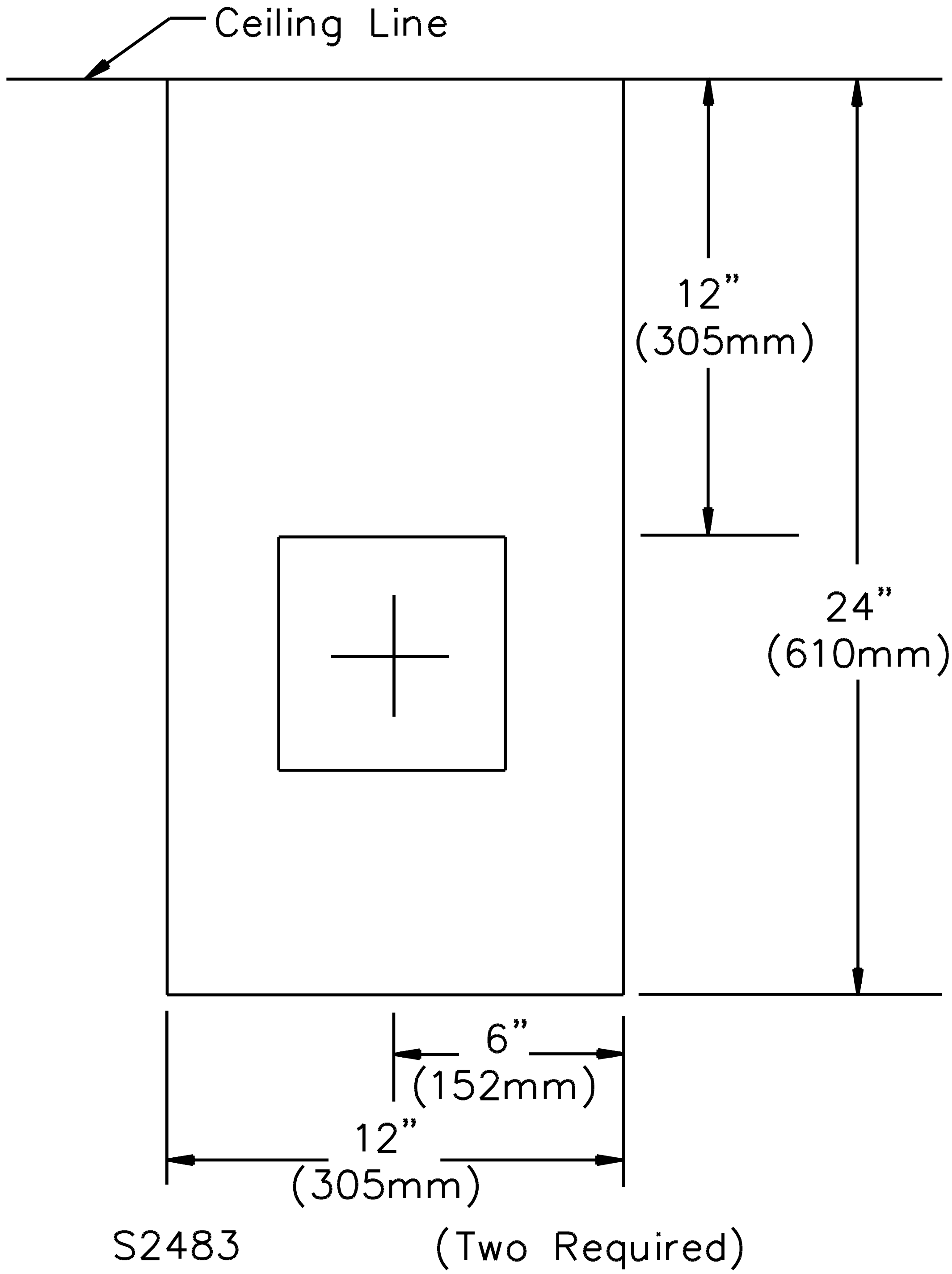


Figure 44.4
Sidewall panel size and sample location for wall mounting of alarms



NOTE – Distance less than 12 inches and not less than 4 inches to the top of the alarm shall be so specified in the installation instructions.

44.6.5 An alarm intended for flush mounting is to be mounted flush with the mounting base. Both wall and ceiling mounted alarms 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.

44.6.6 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 44.1, 44.6, and 44.7.

44.6.7 Measuring Ionization Chambers (MIC's) 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 alarm location as shown in Figure 44.2.

44.6.8 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 decreases.

44.6.9 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 44.8 – 44.11.

Figure 44.5
Panel mounting for fire tests

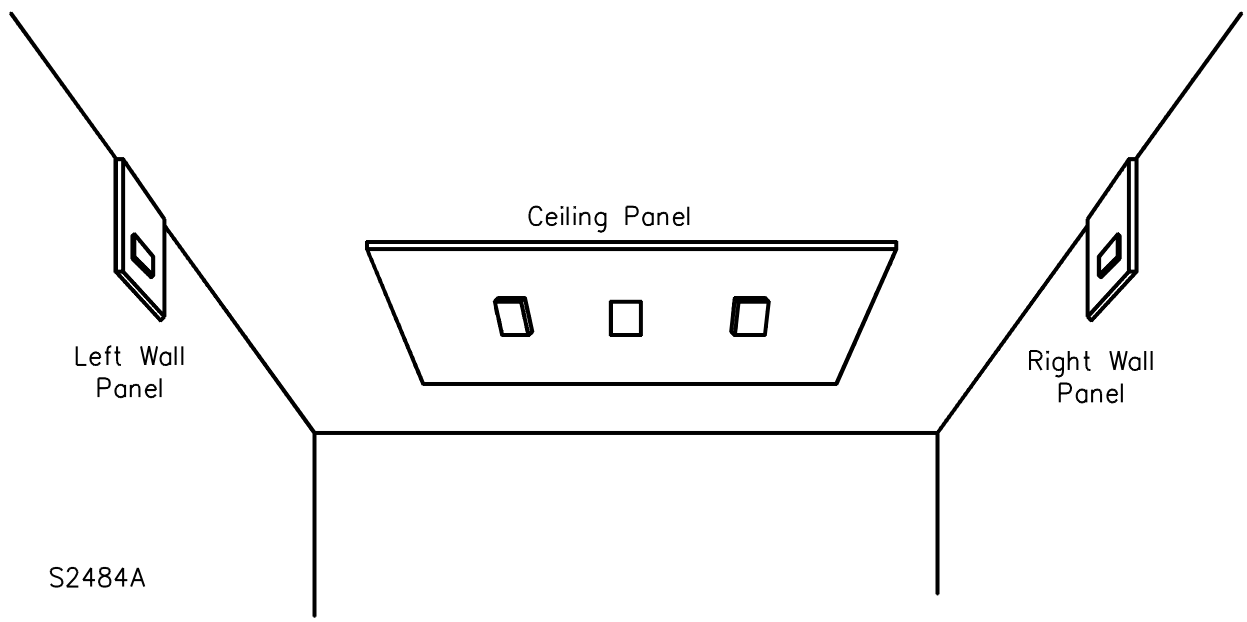


Figure 44.6
Shredded paper (newsprint) profile

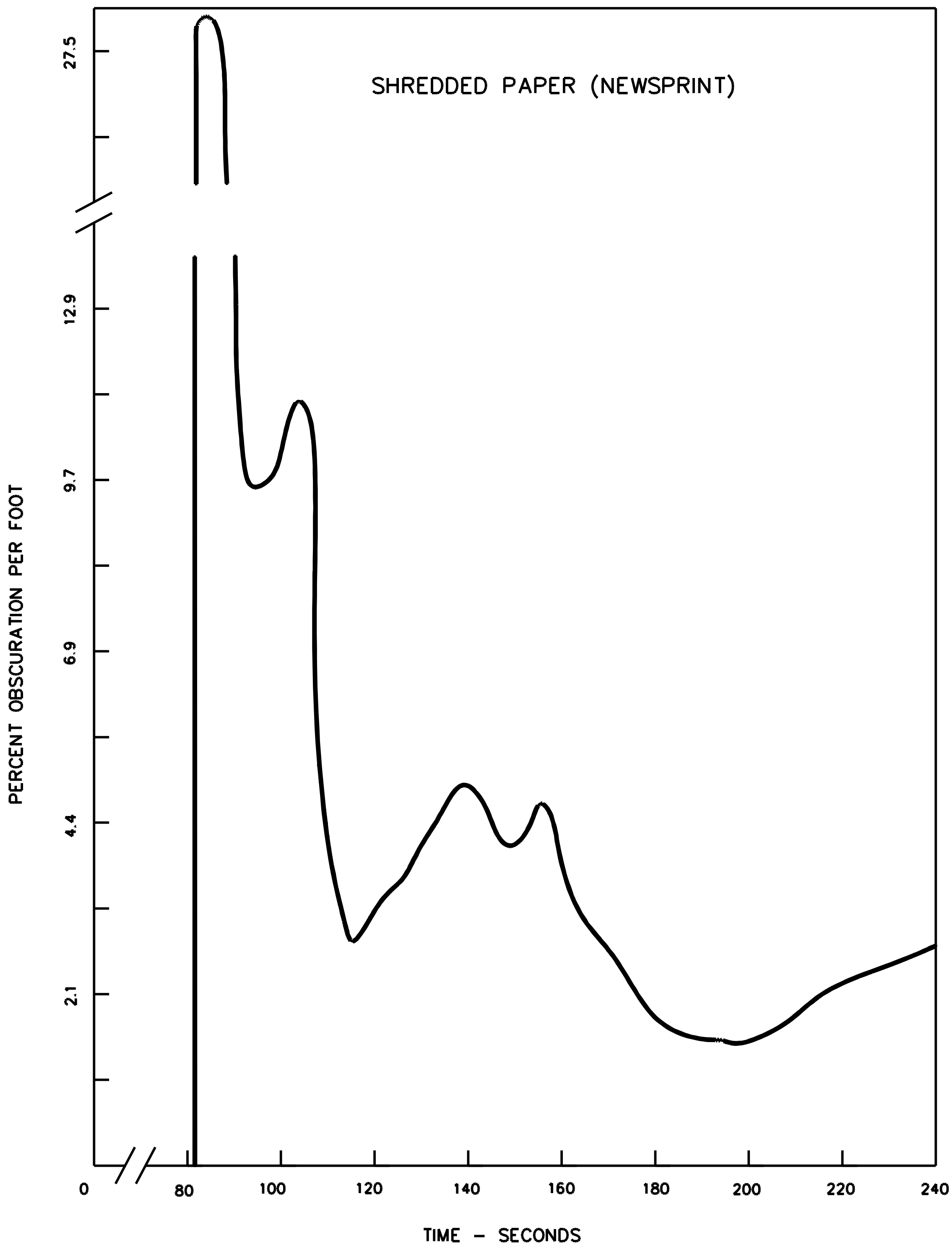


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Figure 44.7
Woodcrib profile

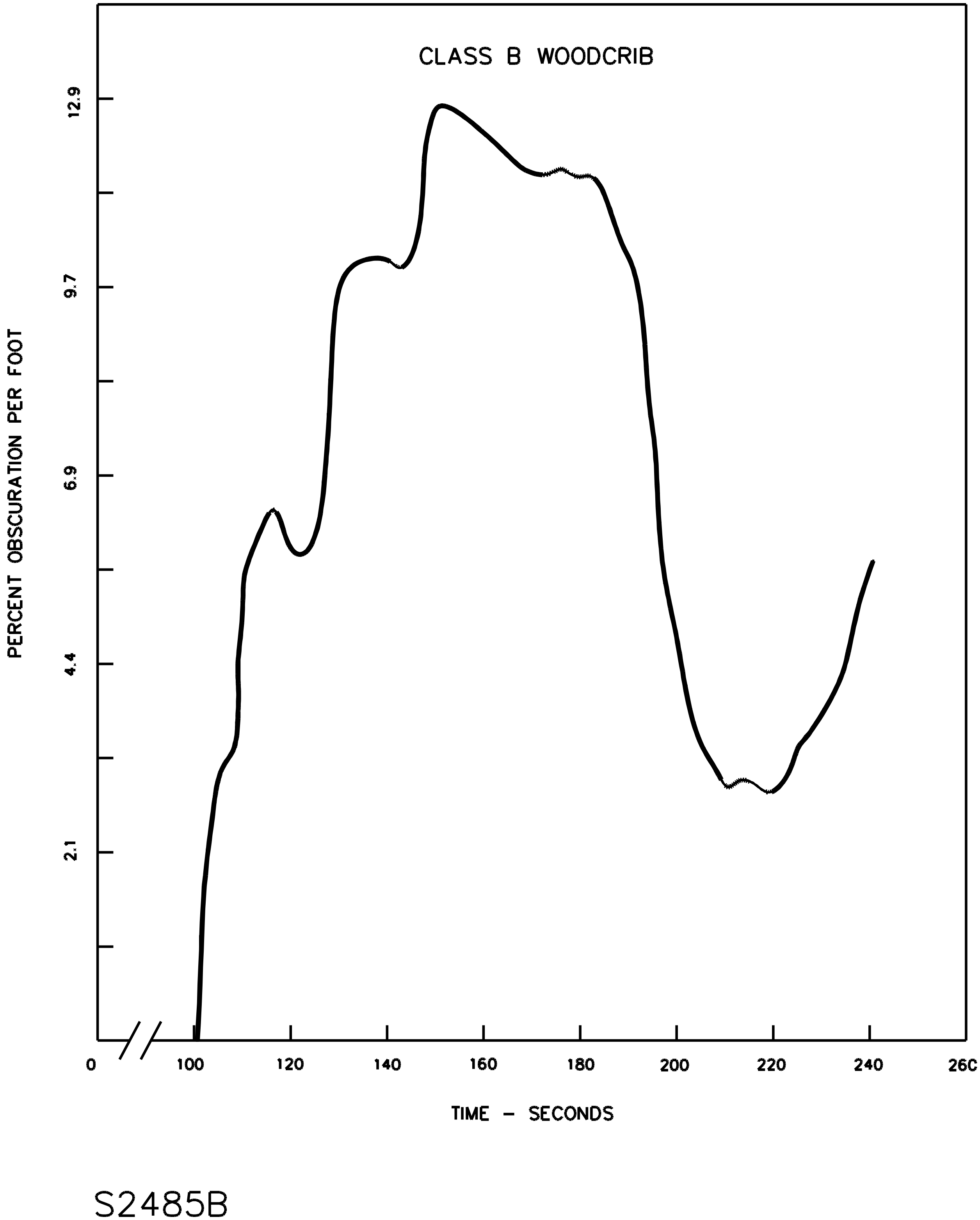


Figure 44.8
Paper fire – ceiling location

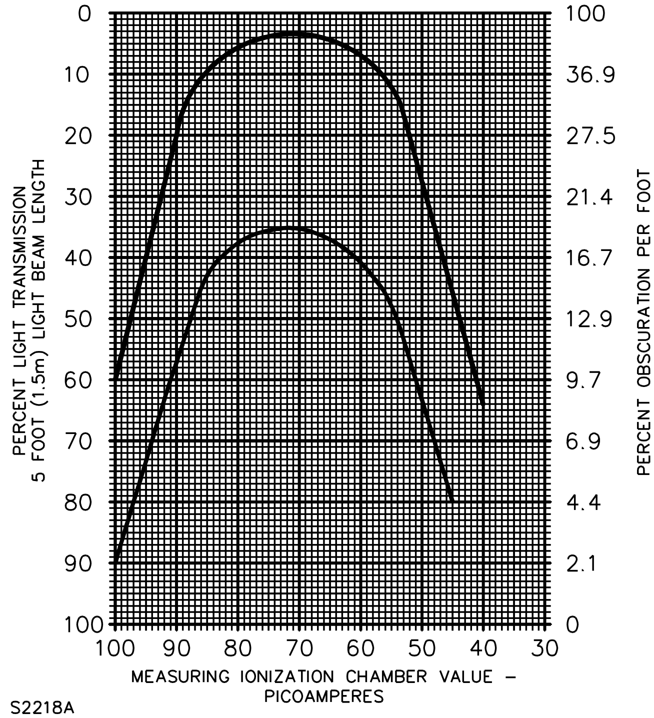


Figure 44.9
Paper fire – wall location

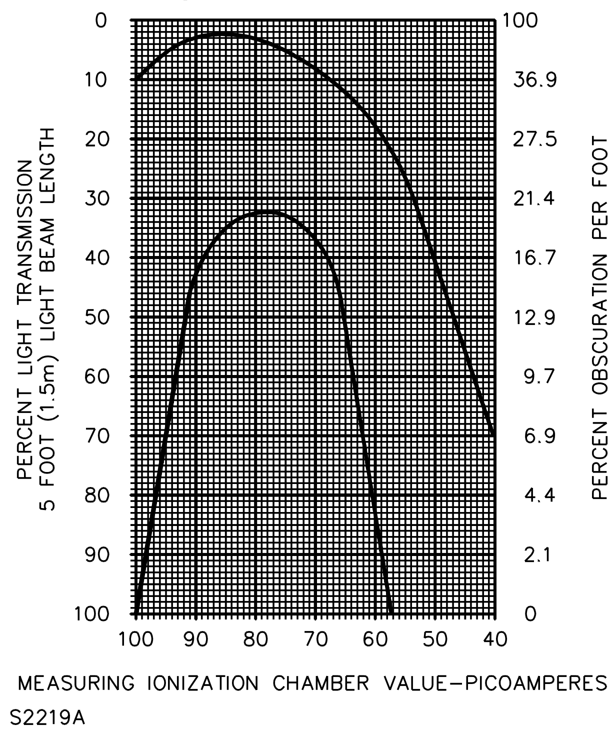


Figure 44.10
Wood fire – ceiling location

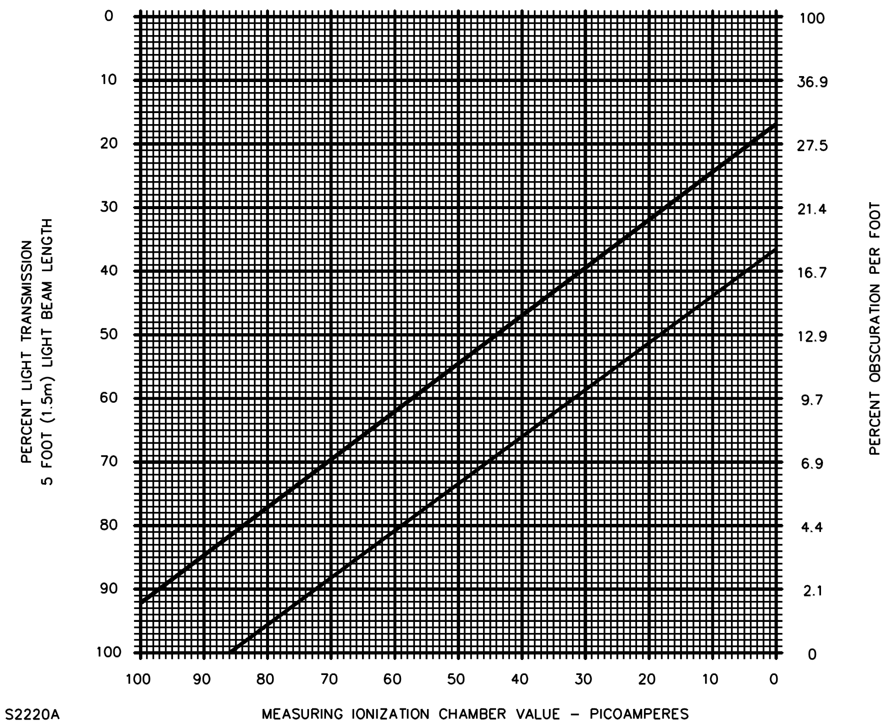
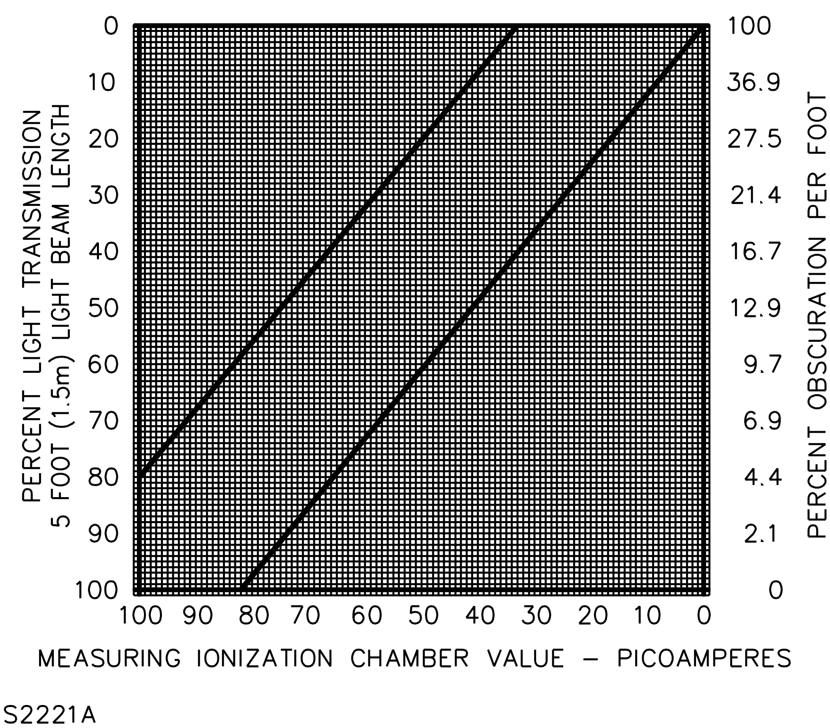


Figure 44.11
Wood fire – wall location



45 Smoldering Smoke Test

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

45.2 Unless specifically indicated otherwise in the alarm installation instructions, the alarms are to be installed in the least favorable position for smoke entry (except where noted in 44.6.3) with respect to the smoldering smoke source as determined by the Directionality Test, Section 39. Detectors adjusted to the minimum production sensitivity are to be employed for this test.

45.3 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 the sticks are 36 degrees (0.63 rad) 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 (19.1 by 76.2 mm) face in contact with the hotplate. All surfaces of each stick are to be smooth and free from burrs or holes. The grain of the wood is to be parallel to the stick length. Each stick is to be conditioned for not less than 48 hours at 52°C (125°F) in an air-circulating oven. The stick weight is to be 16 ±2 grams (0.56 ±0.07 oz) following the oven conditioning.

45.4 The heat source is to be a 240 volt, 1550 watt hotplate[m] 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 8 inches (200 mm) above the floor. The temperature of the hotplate is to be monitored by an iron-constantan AWG 30 (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 (6.4 mm) deep and peening over the opening to secure it. The thermocouple is to be connected to a proportioning temperature controller which is able to be precisely set for the specified 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 45.1 and Figure 45.1. (The hotplate temperature normally lags the controller setting by 2 minutes during incremental increases.)

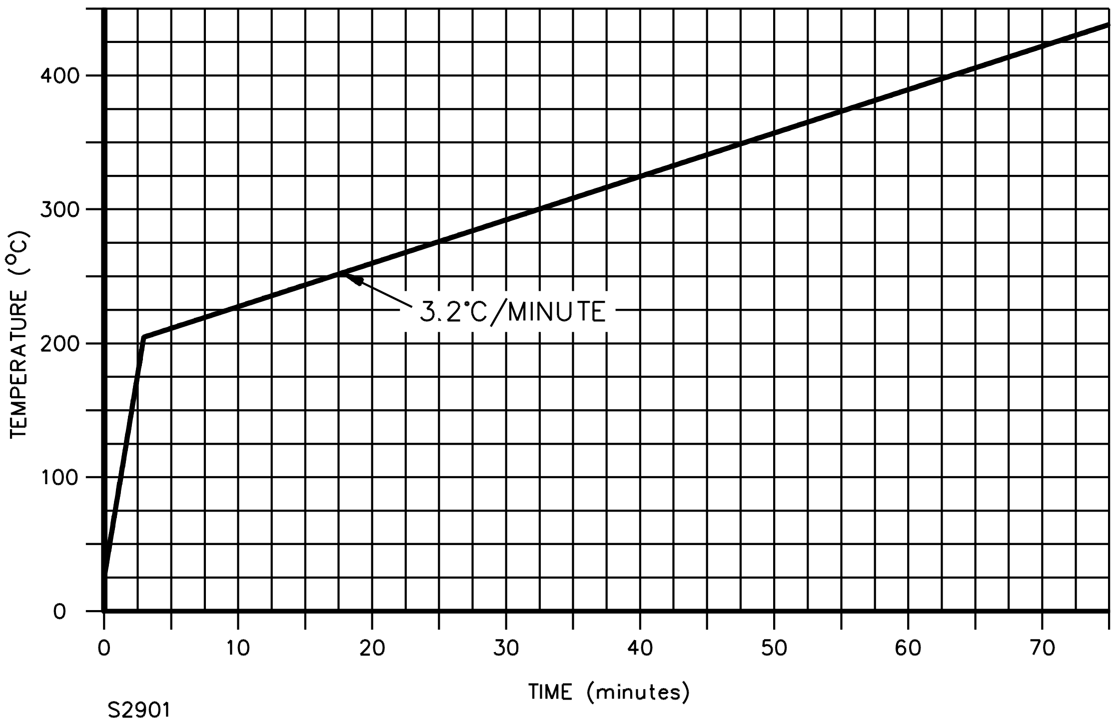
[m]A hotplate for this purpose is Emerson Electric Co., Series PH-400 Chromalox.

45.5 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 44.6.1 – 44.6.3 and 44.6.5. The alarm samples are to be energized from a source of supply in accordance with 33.3.1 except that alarms 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 45.1
Hotplate temperature

Time (minutes)	Hot plate 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 for remainder of test

Figure 45.1
Hotplate temperature profile



45.6 All alarms 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 alarm location as measured by the photocell-lamp assembly described in 37.3.3 (f) and (m). Flaming of the wood shall not occur before the obscuration level is reached.

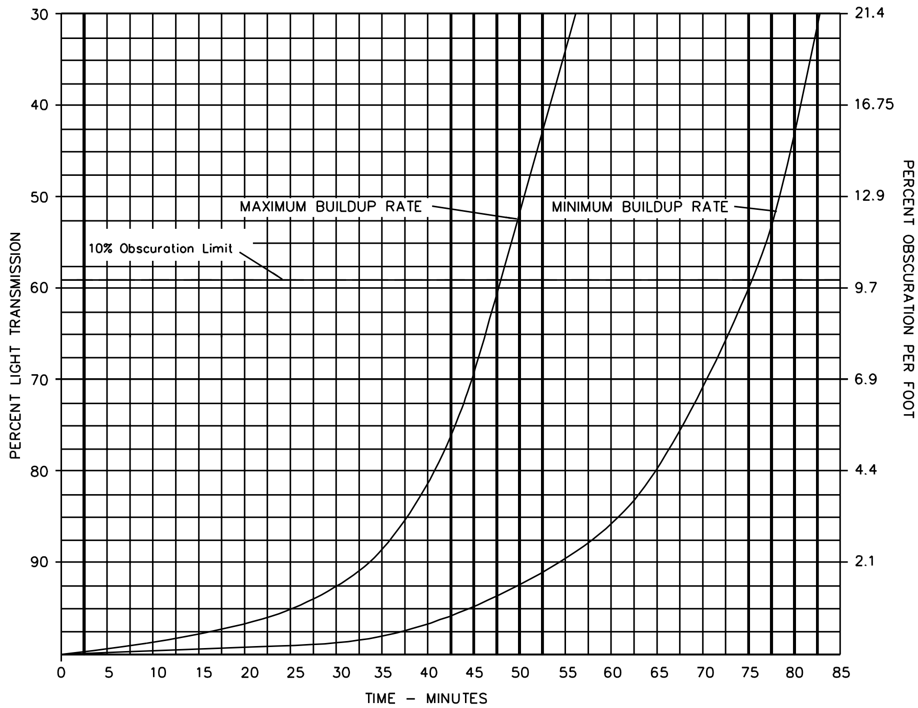
45.7 For this test, the visible smoke buildup rate is to be maintained within the limits illustrated in Figure 45.2. At no time during the test trial shall the buildup rate exceed 5 percent obscuration per minute as measured over the length of the 5 foot (1.5 m) light beam.

45.8 A Measuring Ionization Chamber (MIC)[n] 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 44.2.

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

45.9 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 decreases.

Figure 45.2
Smoldering test profile



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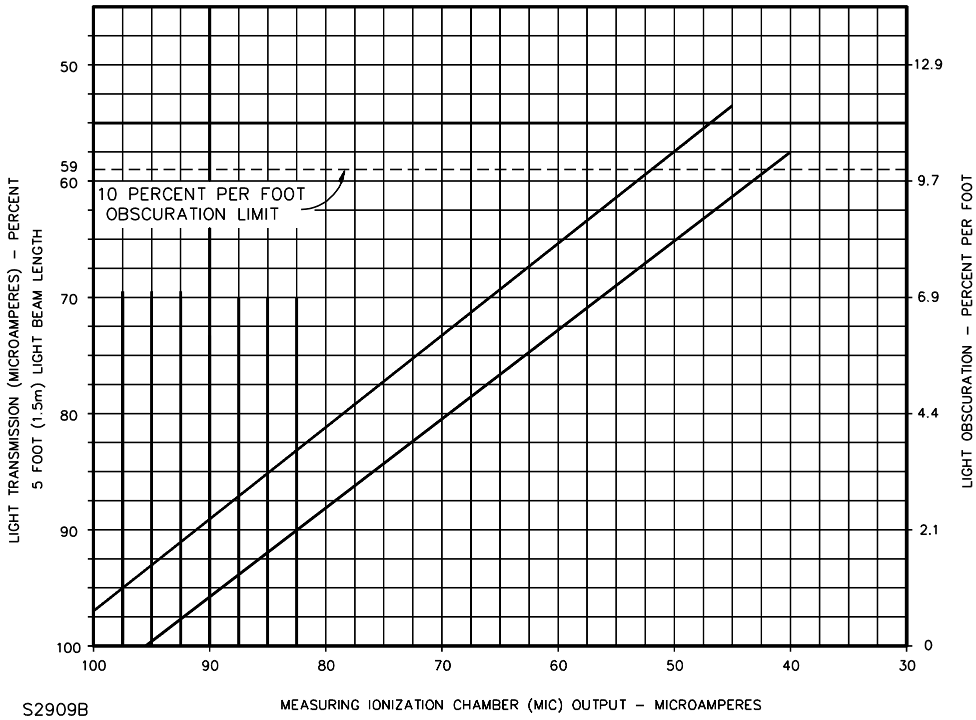
45.10 To determine the acceptability of the test trial, the relationship between the MIC output (ordinate) and the percent light transmission (abscissa) shall be plotted at 1 minute intervals during the test. The points generated shall remain within the curves illustrated in Figure 45.3.

Figure 45.3
Smoldering smoke test measuring ionization chamber/light beam limits



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46 Smoldering Smoke Test (Maximum Obscuration Without Alarm)

46.1 Each of four alarms, 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 alarm area when subjected to the Smoldering Smoke Test, Section 45.

46.2 All conditions for this test are to be as described for the Smoldering Smoke Test, Section 45, 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 39.

47 Temperature Test

47.1 The materials or components employed in an alarm shall not be subjected to a temperature rise greater than that indicated in Table 47.1, under any condition of operation.

Exception: When failure of a component results in an audible trouble signal resulting in the temperature rise of the component in the standby condition to exceed the limits in Table 47.1, in no case shall it be greater than the temperature permitted under an alarm condition.

47.2 Except as noted in 47.3, all values for temperature rises apply to equipment intended for use in prevailing ambient temperatures, usually not higher than 25°C (77°F).

47.3 When 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 temperature rises specified in Table 47.1 are to be reduced by the amount of the difference between that higher ambient temperature and 25°C (77°F).

47.4 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 smoke alarm cover.

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

47.6 Temperatures are to be measured by means of thermocouples consisting of wires not larger than AWG 24 (0.21 mm^2). The method of measuring the temperature of a coil shall be either the thermocouple or change-in-resistance method. The thermocouple method is not to be used for a temperature measurement at any point where supplementary thermal insulation is employed.

47.7 Thermocouples consisting of AWG 30 (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 required.

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

47.9 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,

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

r is the resistance in ohms at the known temperature,

t is the known temperature in degrees C.

Table 47.1
Maximum temperature rises

Device or material		Normal standby, °C	(°F)	Alarm condition, °C	(°F)
A. COMPONENTS					
1. Capacitors		25	45	40	72
2. Fuses		25	45	65	117
3. Rectifiers – At any point					
a. Germanium		25	45	50	90
b. Selenium		25	45	50	90
c. Silicon	(1) Maximum 60 percent of rated volts	50	75	75	135
	(2) 60 percent > rated volts	25	45	75	135
4. Relays and other coils with:					
a. Class 105 insulated windings					
Thermocouple method		25	45	65	117
Resistance method		35	63	75	135
b. Class 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 results in a risk of fire or electric shock		25	45	125	225

Table 47.1 Continued on Next Page

Table 47.1 Continued

Device or material	Normal standby,		Alarm condition,	
	°C	**(°F)**	**°C**	**(°F)**
3. Varnished cloth	25	45	60	108
D. GENERAL				
1. Mounting surfaces	25	45	65	117
2. Wood or other combustible material	25	45	65	117

[a] When the temperature rise of a resistor other than a line voltage dropping resistor exceeds the value shown, the power dissipation shall be 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 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 are 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 identified, reference shall be made to the National Electrical Code, ANSI/NFPA 70 : the maximum temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.

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

47.11 To determine compliance with this test, an alarm is to be connected to a source of supply in accordance with 33.3.1 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.

47.12 When the temperature limits for 47.11 (c) are exceeded there shall be no manifestation of a fire or approaching failure, and the alarm shall operate as intended following the test.

47.13 The alarm is to be subjected to the Dielectric Voltage-Withstand Test, Section 54, following 47.11 (b) or (c).

48 Overload Test

48.1 Detector

48.1.1 An alarm 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 alarm energized in the standby condition, initiation of an alarm by smoke or equivalent means, and restoration of the alarm to standby.

48.1.2 Rated test loads are to be connected to those output circuits of the alarm which are energized from the alarm power supply, such as remote indicators, relays, and other devices. The test loads shall be those devices, or the equivalent, normally intended for connection. When an equivalent load is employed for a device consisting of an inductive load, a power factor of 60 percent is to be employed. The rated loads are established initially with the alarm connected to a source of supply in accordance with 33.3.1 following which the voltage is increased to 115 percent of rating.

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

48.2 Separately energized circuits

48.2.1 Separately energized circuits of an alarm, such as dry contacts, shall be capable of operating as intended after being subjected for 50 cycles of signal operation at a rate of not more than 6 cycles per minute while connected to a source of supply in accordance with 33.3.1, with 150 percent rated loads at 60 percent power factor applied to output circuits which do not receive energy from the alarm. There shall be no electrical or mechanical failure of the switching circuit.

48.2.2 The test loads shall be set at 150 percent of rated current while connected to a separate power source of supply in accordance with 33.3.1.

49 Endurance Test

49.1 Smoke alarm

49.1.1 An alarm shall operate as intended after being subjected to 6000 cycles of 5 second alarm signal operation, at a rate of not more than 10 cycles per minute, with the alarm connected to a source of supply in accordance with 33.3.1 and with related devices or equivalent loads connected to the output circuits. There shall not be electrical or mechanical failure or evidence of failure of the alarm components. It is appropriate for battery operated units to be connected to an equivalent filtered DC power supply source for this test.

49.1.2 Sensitivity measurements, using aerosol, are to be recorded before and after the Endurance Test, in accordance with the Sensitivity Test, Section 37. The sensitivity values shall vary not more than specified in 34.4.1.

49.2 Separately energized circuits

49.2.1 Separately energized circuits of an alarm shall operate as intended, when operated for 6000 cycles at a rate of not more than 10 cycles per minute at a 50 percent duty cycle. When an electrical load is involved, the contacts of the device shall be made to make and break the normal current at the voltage specified by 33.3.1. The load is to represent that which the device is intended to control. The Endurance Tests of the separately energized circuits shall be conducted either separately or in conjunction with the Endurance Test of the alarm. There shall not be electrical or mechanical malfunction of the alarm nor malfunction or welding of any relay contacts.

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

49.3 Audible signaling appliance

49.3.1 The audible signaling appliance of each of two alarms shall operate as intended when the alarms are 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 alarms are to be connected to a source of rated voltage and frequency. For a battery operated alarm, a filtered DC supply is to be employed that has an output voltage equivalent to the fresh battery voltage.

49.4 Test means

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

50 Variable Ambient Temperature Test

50.1 Operation in high and low ambient

50.1.1 An alarm 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 alarms, 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 33.3.1.

50.1.2 Sensitivity measurements shall be recorded before and during exposure to each ambient temperature in accordance with the Sensitivity Test, Section 37, except that the relationship between the MIC output and the percent light transmission remains within the limits represented by the curves illustrated in Figures 50.1 and 50.2 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 50.3 and 50.4 for the 0 and 49°C ambients, respectively.

50.1.3 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 specified in 34.4.1 from the value recorded prior to the Variable Ambient Temperature Test, Section 50, and shall not, in any case, exceed the limits specified in 37.1.1.

Figure 50.1
Sensitivity test limits – 0°C ambient– aerosol – 32 fpm

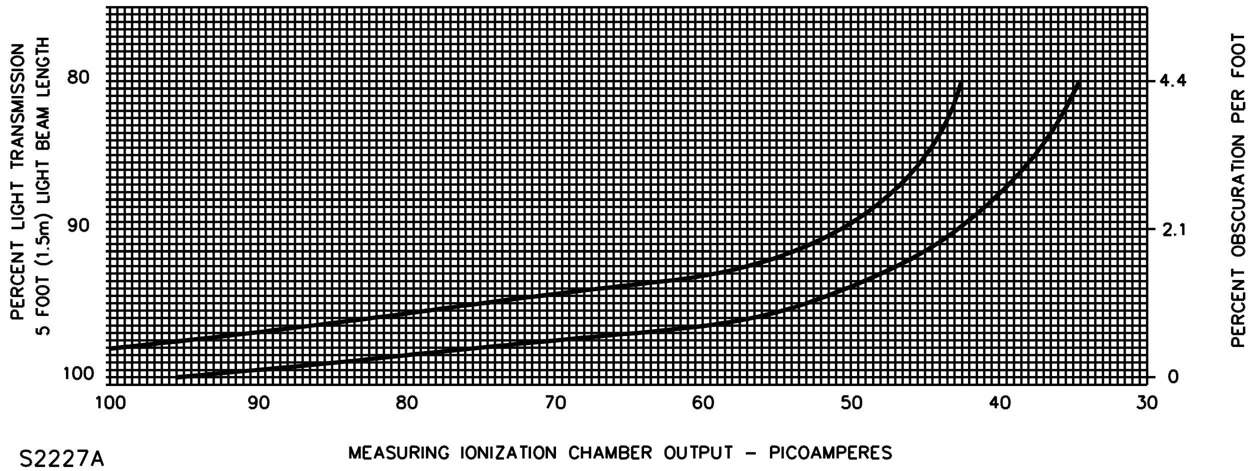

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Figure 50.2
Sensitivity test limits – 49°C ambient– aerosol – 32 fpm

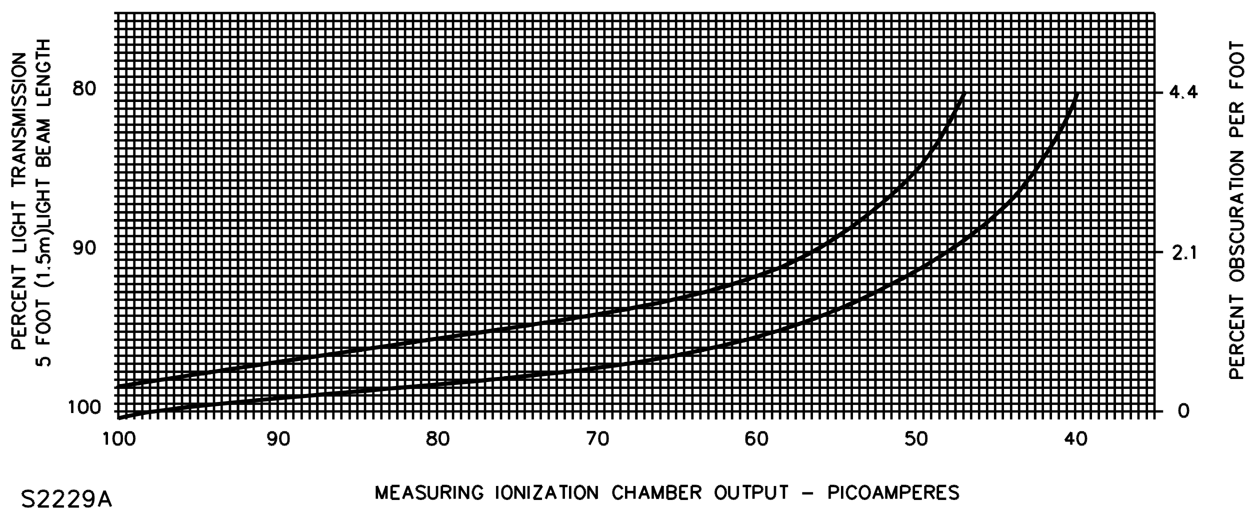

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Figure 50.3
Smoke build-up rate – sensitivity test – 0°C ambient – aerosol – 32 fpm

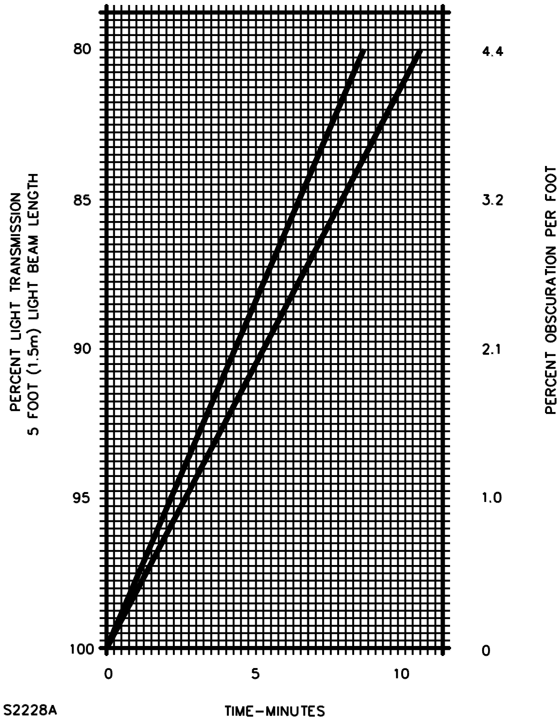

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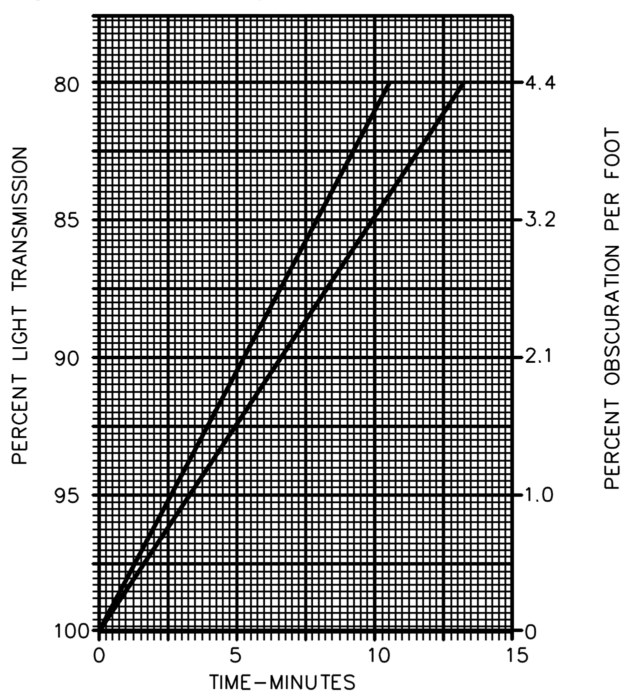
Figure 50.4
Smoke build-up rate – sensitivity test – 40°C ambient – aerosol – 32 fpm



S2230

50.2 Effect of shipping and storage

50.2.1 The sensitivity of an alarm shall not be impaired by exposure to high and low temperatures representative of shipping and storage.

50.2.2 Two alarms, 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, let to cool to room temperature for at least 1 hour, exposed to a temperature of minus 30°C (minus 22°F) for at least 3 hours, and then permitted to warm up to room temperature for at least 3 hours. The alarms then are to be tested for sensitivity using aerosol while connected to a source of supply in accordance with 33.3.1.

50.2.3 Sensitivity measurements are to be recorded, before and after exposure to both ambient conditions, in accordance with the Sensitivity Test, Section 37.

50.2.4 The sensitivity readings using aerosol measured after exposure shall vary not more than specified in 34.4.1.

51 Humidity Test

51.1 Two alarms, 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 33.3.1. There shall not be false alarms during the exposure.

51.2 Sensitivity measurements shall be recorded before and during exposure to the humidity condition in accordance with the Sensitivity Test, Section 37, except that the relationship between the MIC output and the percent light transmission remains within the limits represented by the curves illustrated in Figure 37.2. The buildup rate is to be maintained within the limits represented by the curves illustrated in Figure 37.1.

51.3 The sensitivity values shall not vary more than specified in 34.4.1 from the value recorded prior to the Humidity Test.

51.4 Following the Humidity Test, a detector other than that operating from a primary battery, shall be subjected to the Leakage Current Test, Section 52.

52 Leakage Current Test

52.1 The leakage current of an alarm not operating from a primary battery shall not exceed 0.5 milliampere, AC or DC, after being subjected to the Humidity Test, Section 51, when measured as follows:

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

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

All grounding connections to the unit being tested are to be disconnected prior to making the measurement. The leakage current measurement is to be made at the supply connection polarity indicated on the installation wiring diagram supplied with the alarm and also with the polarity reversed. See Figure 52.1.

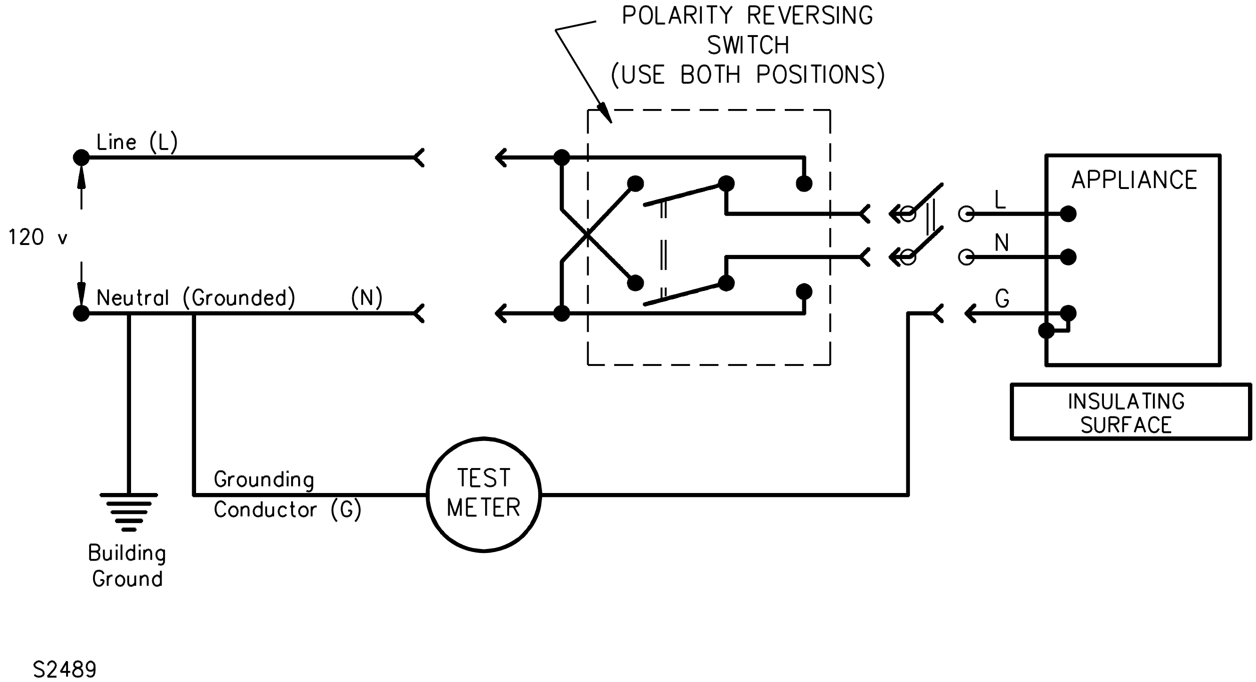
52.2 For this test the alarm is to be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately reenergized from a rated source of supply. The leakage measurement then is to be made within 5 minutes of energization while in the standby and alarm conditions.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

52.3 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.

52.4 When a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area of 10 by 20 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.

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

Figure 52.1
Leakage current measurement circuit



53 Transient Tests

53.1 General

53.1.1 An alarm shall operate for its intended signaling performance with 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 33.3.1 and connected to the device(s) intended to be used with the alarm.

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

53.1.3 Sensitivity measurements using aerosol, recorded before and after each transient condition, shall not vary more than specified in 34.4.1.

53.2 Supply line (high-voltage) transients

53.2.1 For this test, the alarm is to be connected to a transient generator, consisting of a 2 kilovolt-amperes isolating power transformer and control equipment capable of producing the transients described in 53.2.2. See Figure 53.1. The output impedance of the transient generator is to be 50 ohms.

53.2.2 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 50 percent of the value of the preceding peak. Each transient is to have a total duration of 20 microseconds.

53.2.3 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.

53.3 Internally induced transients

53.3.1 The alarm is to be energized in the standby condition while connected to a source of supply in accordance with 33.3.1. The supply is to be interrupted for 1 second at a rate of not more than 6 cycles per minute for a total of 500 cycles. Following the test the alarm is operated for its intended signaling performance.

53.4 Extraneous transients

53.4.1 Single or multiple station smoke alarms shall not false alarm and their intended operation shall not be impaired when subjected to extraneous transients generated by the devices and appliances described in 53.4.2. In addition, the alarm shall respond to smoke during application of the transient condition.

53.4.2 Two single and two sets of multiple station smoke alarms 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 alarm, 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 alarm chamber to determine whether the unit is operational for smoke with the transient applied.

a) Sequential arc (Jacob's ladder) generated between two 15 inch (381 mm) long, AWG 14 (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 five separate transmitter-receiver units (cellular phones) in turn, and operating in the following nominal frequencies:

1) 27 megahertz,

2) 150 megahertz,

3) 450 megahertz,

4) 866 megahertz, and

5) 910 megahertz.

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

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

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

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

[o]Edwards, Model 439D-6AW, vibrating bell rated 0.075 amperes, 20/24 volts DC or equivalent.

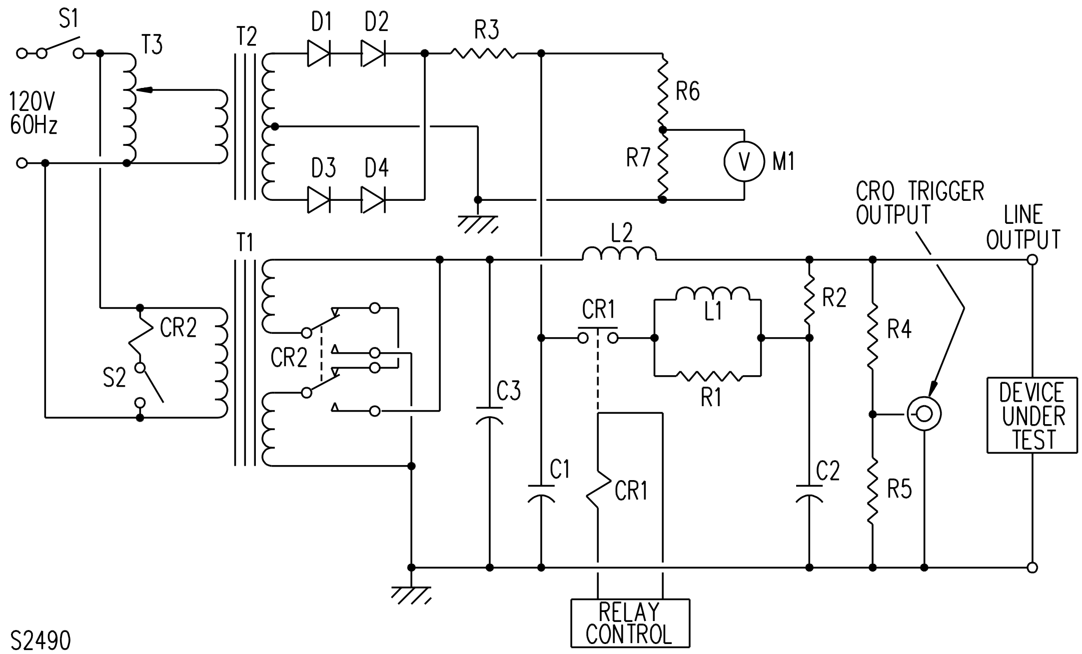
53.5 Supply line (low-voltage) circuit transients

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

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

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

Figure 53.1
Surge generator circuit



C1	– Capacitor, 0.025 µF, 10 kV
C2	– Capacitor, 0.006 µF, 10 kV
C3	– Capacitor, 10 µF, 400 V
CR1	– Relay, coil 24 VDC. Contacts, 3-pole, single throw, each contact rated 25 A, 600 VAC maximum, all three poles wired in series.
CR2	– Relay, coil 120 VAC. Contacts DPDT. Provides either 120 V or 240 V test circuit.
D1	– D4 – Diodes, 25 kV PIV each
L1	– Inductor 15 µH [33 turns, AWG 22 wire, wound on 0.835 inch (21.2 mm) diameter PVC tubing]
L2	– Inductor, 70 µH [45 turns, AWG 14 wire, wound on 2.375 inch (60.33 mm) diameter PVC tubing]
M1	– Meter, 0 – 20 VDC
R1	– Resistor, 22 Ohms, 1 W, composition
R2	– Resistor, 12 Ohms, 1 W, composition
R3	– Resistor, 1.3 megohms, (12 in series, 110K ohms each, 1/2 W)
R4	– Resistor, 47K ohms (10 in series, 4.7K ohms each, 1/2 W)
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 composition)
S1	– Switch, SPST
S2	– Switch, SPST, key-operated, 120 VAC, 1 A
T1	– Transformer, 2 kVA, 120 V primary, 1:1 (120 V or 240 V output)
T2	– Transformer, 90 VA, 120/15,000 V
T3	– Variable autotransformer, 2.5 A

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

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

a) Twenty pulses (two at each transient voltage level specified in 53.5.2) 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 53.5.2) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten of the opposite polarity.

53.5.4 At the conclusion of the test, the alarm shall comply with the requirements of the Normal Operation Test, Section 34, and the Sensitivity Test, Section 37.

54 Dielectric Voltage-Withstand Test

54.1 An alarm shall withstand for 1 minute, without breakdown, the application of a 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 an alarm rated 30 volts AC rms (42.4 volts DC or AC peak) or less – 500 volts (707 volts, when a DC potential is used).

b) For an alarm rated between 31 and 250 volts AC rms – 1000 volts (1414 volts, when a DC potential is used).

c) For an alarm 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, when a DC potential is used).

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

54.3 When the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is capable of preventing maintenance of the specified AC test potential, The capacitors and capacitor-type filters are to be tested using a DC potential in accordance with 54.1.

54.4 The test potential is obtained from any convenient source having the 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 200 volts per minute until the required test value is reached and is to be held at that value for 1 minute.

54.5 A printed-wiring assembly or other electronic-circuit component that short circuits or is damaged by application of the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. It is not prohibited for a representative subassembly be tested instead of an entire unit.

55 Abnormal Operation Test

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

55.2 To determine that an alarm complies with the requirement of 55.1, it is to be operated under the most severe circuit fault conditions to be encountered in service while connected to a source of supply in accordance with 33.3.1. There shall not be emission of flame or molten metal, or any other manifestation of a fire, or dielectric breakdown when tested in accordance with the Dielectric Voltage-Withstand Test, Section 54, after the abnormal test.

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

56 Overvoltage and Undervoltage Tests

56.1 Overvoltage test

56.1.1 An alarm other than one operating from a main battery power supply shall operate as intended in the standby condition at both maximum and minimum sensitivity settings and while performing its signaling function and connected to a supply source of 110 percent of rated value. When a nominal rated voltage value is specified, the overvoltage shall be 110 percent of the test voltage specified in 33.3.1. When 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 33.3.1, whichever is higher. Sensitivity measurements at the increased voltage shall vary not more than specified in 34.4.1.

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

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

56.2 Undervoltage test

56.2.1 An alarm 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 specified in 34.4.1 from the readings measured at rated voltage.

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

56.2.3 When the alarm is provided with a standby battery the test is to be conducted at 85 percent of the charged battery voltage. When 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.

56.2.4 For operation at the reduced voltage, three alarms are to be energized from a source of supply in accordance with 33.3.1, following which the voltage is to be reduced to 85 percent of the test voltage specified in 33.3.1 for AC operated alarms, or the battery trouble level voltage for battery operated alarms, and then tested for signaling operation and sensitivity.

57 Dust Test

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

57.2 To determine compliance with 57.1, 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).

57.3 Two ounces (0.06 kg) of cement dust, maintained in an ambient room temperature of 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 50 fpm (0.25 m/s).

57.4 Following the exposure to dust, the alarm is to be removed carefully, mounted in its intended position, energized from a source of supply in accordance with 33.3.1, and tested for sensitivity using gray smoke, unless a trouble signal or a false alarm is obtained. Sensitivity measurements following this test shall not vary by more than specified in 34.4.1. For those units whose sensitivity varies by more than 50 percent in the direction of high sensitivity, the unit shall be capable of being returned to its initial sensitivity value (plus or minus 0.25 percent per foot obscuration) after following the manufacturers specified cleaning procedure.

58 Static Discharge Test

58.1 The components of an alarm 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 a failure when the subsequent operation of the alarm is not impaired. During the test a 5 second or less false alarm is permitted. 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).

58.2 Each of two alarms is to be mounted in its intended mounting position and connected to a source of supply in accordance with 33.3.1. When an alarm is intended to be installed on a metal back box, the box is to be connected to earth ground. A 250 picofarad low leakage capacitor, rated 10,000 volts dc, is to be connected to two high-voltage 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 alarm and the other probe is then to be touched to earth ground.

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

58.4 Following the discharges, the alarm is to be tested for sensitivity. Sensitivity measurements shall be as specified in 34.4.1.

59 Vibration Test

59.1 An alarm shall withstand vibration without breakage or damage of parts. Following the vibration, the alarm shall operate for its intended signaling operation.

59.2 To determine compliance with 59.1, sensitivity measurements following the vibration shall vary not more than specified in 34.4.1.

59.3 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. In cases where no resonant frequency is obtained, the samples are to be vibrated at 35 cycles per second for a period of 4 hours.

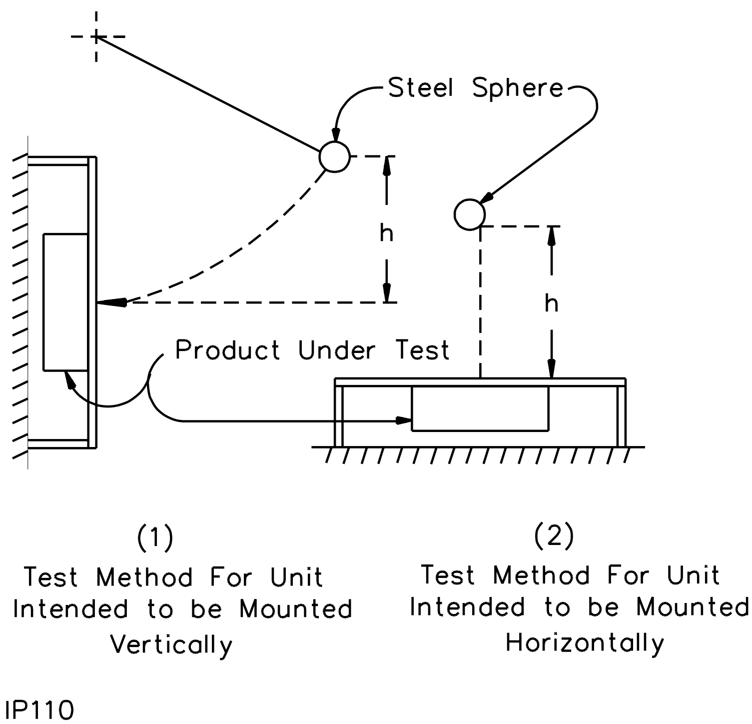
59.4 For tests, amplitude is defined as the maximum displacement of sinusoidal motion from a position of rest or one-half of the total table displacement. Resonance is defined as the maximum magnification of the applied vibration.

60 Jarring Test

60.1 An alarm shall withstand jarring resulting from impact and vibration such as 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 shall not occur unless the detector operation is not affected. Dislodgement of parts shall not occur unless 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.

60.2 The alarm and any associated equipment are to be mounted in a position of intended use, see Figure 60.1, 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.

Figure 60.1
Jarring test



60.3 During this test, the alarm is to be in the standby condition and connected to a rated source of supply in accordance with 33.3.1. Following the test, sensitivity measurements shall vary not more than specified in 34.4.1.

61 Corrosion Test

61.1 General

61.1.1 An alarm shall operate as intended after being subjected to the corrosive atmosphere tests described in 61.1.2 – 61.2.1. The samples are to be placed in the test chambers that are located in an ambient room temperature of 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 2 inches (50.8 mm) above the bottom of the exposure chamber. The relative humidity inside the chamber during the test is to be 95 percent.

61.1.2 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. The amount of hydrogen sulfide is to be equivalent of 0.1 percent of the volume 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.

61.1.3 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. The amount of carbon dioxide is to be the equivalent of 1.0 percent, and the amount of sulfur dioxide is to be the equivalent of 0.5 percent of the volume 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.

61.2 Test equipment

61.2.1 A typical test apparatus for the carbon dioxide-sulfur dioxide-moist air exposure test and the hydrogen sulfide-moist air exposure test consists 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, ten 3-1/2 inch (88.9 mm) 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 shall not be used unless the equivalent gas concentrations and water are maintained.

61.2.2 The alarms are to be tested for sensitivity using gray smoke prior to exposure to the corrosive atmospheres. Following the corrosive exposures described in 61.1.2 and 61.1.3, the alarms are to be dried in a circulating air oven at a temperature of 40°C (104°F) for a period of at least 24 hours, after which the alarms are to be tested again for sensitivity. When sensitivity measurements following the exposure to the corrosive atmospheres vary by more than the limits specified in 34.4.1 in the direction of high sensitivity there shall be no false alarm. The sensitivity shall not vary by more than the limits specified in 34.4.1 in the direction of low sensitivity. In no case, shall the sensitivity exceed the limits specified in the Sensitivity Test, Section 37.

61.2.3 Alarms are to be subjected to the corrosive atmospheres while de-energized so as not to produce an alarm signal. Battery operated alarms are to be tested with the batteries in place, and the leads to the clips disconnected for the same reason. After the exposure the leads are to be reconnected and the Sensitivity Test, Section 37, conducted.

62 Reduction in Light Output Test

62.1 The sensitivity of an alarm 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 Alarm Reliability Prediction, Section 4.

62.2 To determine compliance with 62.1, five samples calibrated to the minimum sensitivity, are to be subjected to the Sensitivity Test, Section 37, 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, when less than 50 percent, by reducing the supply voltage to the alarm, or an equivalent method. (The level of reduction of light is to be determined initially by means of a light meter, review of curve sheets, or the equivalent.) The samples shall then be subjected to the Fire Tests, Section 44, and the Smoldering Smoke Test, Section 45.

63 Battery Tests

63.1 Where a replaceable battery is employed as the main source of power of a smoke alarm, it shall provide power to the unit under intended ambient conditions for at least 1 year (or whatever longer period specified by the manufacturer) in the standby condition, including novelty and weekly alarm testing, and then operate the alarm for a minimum of 4 minutes of alarm, followed by 7 days of trouble signal. See 36.3.1. Where a nonreplaceable battery is employed as the main source of power, it shall provide power to the unit under intended ambient conditions for at least 10 years in the standby condition, including novelty and weekly testing, and then operate the alarm for a minimum of 4 minutes of alarm, followed by 7 days of trouble signal.

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

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

63.4 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.

63.5 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.

63.6 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 smoke alarm is to be placed into an alarm condition weekly. The duration of the weekly alarm test signal is to be 3 seconds.

63.7 For batteries rated longer than one year, at the end of the specified test period, all batteries shall have a capacity capable of operating the alarm signal for a minimum of 4 minutes, followed by 7 days of trouble signal. To obtain the trouble signal level it is sometimes required to continue the test with the standby current drain for longer than the test period. Batteries shall be subjected to the conditions described in 63.2 (b), (c), and (d) for the test period unless the alarm is marked to indicate the battery limitations for the condition involved. In no case shall the length of conditioning be less than one year.

63.8 For batteries rated for one year only, at the end of the specified test period (1 year) all batteries shall have a capacity capable of operating the alarm signal for a minimum of 4 minutes, followed by 7 days of trouble signal. To obtain the trouble signal level it is sometimes required to continue the test with the standby current drain for longer than 1 year. Batteries shall be subjected to the conditions described in 63.2 (b), (c), and (d) for a minimum of 1 year unless the alarm is marked to indicate the battery limitations for the condition involved. In no case shall the length of conditioning be less than 6 months.

64 Survivability Test

64.1 Two samples of the smoke alarm shall be exposed to a temperature of 121°C (250°F) for a period of 4 minutes. The units are to be removed from the test chamber and returned to room temperature. The units are then to be subjected to the Audibility Test, Section 65, and the Sensitivity Test, Section 37.

64.2 Following conditioning, the samples shall be capable of producing on audible output of 85 db (A), at 10 feet (3.05 m), and the sensitivity of each alarm shall not vary by more than specified in 34.4.1.

65 Audibility Test

65.1 General

65.1.1 Except as permitted in 65.2.1, the alarm sounding appliance, either integral with the smoke alarm 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. It is appropriate for alarms to be tested with the horn duty cycle specified in 34.3 defeated and emitting a continuous tone.

65.2 Sound output measurement

65.2.1 The sound power output of the alarm 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 alarm 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 alarm is to be energized from a source of rated voltage and frequency. A battery powered alarm is to be energized from batteries under each of the following conditions along the trouble signal level curve illustrated in Figure 35.2, or equivalent:

a) Nondischarged battery (a battery with some unknown shelf life, such as those purchased at a retail outlet) with enough added resistance to obtain a trouble signal (Point D of Figure 35.2), or the maximum resistance for the particular battery based on documented data, whichever is less.

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

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

The equivalent of a battery shall be identified as a voltage source with a series resistance adjusted to a level at which a trouble signal is obtained during the normal standby condition. The resistance and voltages used are to be those that were determined during the Circuit Measurement Test, Section 35.

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 56.2.2. 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 an alarm powered by a primary or secondary 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 65.3.1, 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 alarm is to be mounted 1 foot (302 mm) from the microphone placed in a direct line with the alarm. The alarm is then to be energized in the alarm condition and the sound output is to be measured at 1 minute intervals, using a sound level meter[p] 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 alarm that is providing a trouble signal.

[p]One 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 not be less than 85 db unless 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.″

Under no circumstances is the sound output to be less than 75 db.

66 Tests of Thermoplastic Materials

66.1 General

66.1.1 Polymeric materials intended for the sole support of current carrying parts or as an enclosure of an alarm shall be subjected to the tests specified in 66.2 and 66.3. When possible, a complete alarm is to be used.

66.2 Accelerated air-oven aging test

66.2.1 There shall not be 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 28 days at a temperature of 70°C (158°F), and 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 an alarm cover shall not occur during the test unless high-voltage parts are not exposed, operation for smoke is not affected, and the cover is replaceable as intended. Sensitivity measurements shall not vary by more than the limits specified in 34.4.1.

66.3 Flame test (3/4 inch)

66.3.1 When equipment is tested as described in 66.3.2 – 66.3.6, the material shall not flame for more than 1 minute after two 30-second applications of a test flame, with an interval of 1 minute between applications of the flame. The sample shall not be completely consumed.

Exception: Parts that are molded from materials that are classed as 5VA, 5VB, V-0, V-2, by the vertical burning test described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are not required to be subjected to the flammability test described in 66.3.2 – 66.3.6.

66.3.2 Three samples of the equipment are to be placed in a forced draft circulating air oven maintained at a uniform temperature not less than 10°C (18°F) higher than the maximum temperature of the material measured under normal operating conditions, and not less than 70°C (158°F) in any case. The samples are to remain in the oven for 7 days. After cooling to room temperature for a minimum of 4 hours, the samples are to be tested as described in 66.3.3 – 66.3.6.

Exception: Testing is required on only three unconditioned test samples when both of the following conditions are met:

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

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

66.3.3 Three samples of the part are to be subjected to the Flame Test described in 66.3.5. In the performance of the test, the equipment is to be supported in its normal operating position in a draft free location. Nonpolymeric portions are not to be removed and insofar as possible, the internal mechanism of the equipment is to be in place. The flame is to be applied to an inside surface of the sample at a location judged as capable of becoming ignited because of its proximity to a source of ignition. Each sample is to be tested with the flame applied to a different location.

Exception: Only three unconditioned test samples are required for testing when both of the following conditions are met:

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

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

66.3.4 With reference to 66.3.3, the sections judged capable of becoming ignited are to be those adjacent to coil windings, splices, open-type switches, or arcing parts.

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

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

66.3.6 When one sample from a set of three does not comply with 66.3.1, an additional set of three samples shall be tested. All samples from the second set shall comply with 66.3.1.

66.4 Flame test (5 inch)

66.4.1 When equipment is tested as described in 66.4.1 – 66.4.5, all of the following results shall be obtained:

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

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

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

Exception: Parts that are molded from materials that are classed as 5VA by the five inch burning test described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are not required to be subjected to the flammability tests described in 66.4.1 – 66.4.6.

66.4.2 Three samples of the complete equipment or three test specimens of the molded part shall be subjected to this test. Consideration is to be given to leaving in place components and other parts that influence the performance. The test samples are to be conditioned in a full draft circulating air oven for 7 days at 10°C (18°F) greater than the maximum use temperature and not less than 70°C (158°F) in any case. Prior to testing, the samples are to be conditioned for a minimum of 40 hours at 23.0 ±2.0°C (73.4 ±3.6°F) and 50 ±5 percent relative humidity. The flame is to be applied to an inside surface of the sample at a location judged as capable of becoming ignited because of its proximity to a source of ignition. When more than one part is near a source of ignition, each sample is to be tested with the flame applied to a different location.

Exception: Only three unconditioned test samples are required for testing when both of the following conditions are met:

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

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

66.4.3 The three samples shall perform as described in 66.4.1. When one sample does not comply, the test is to be repeated on a set of three new samples with the flame applied under the same conditions as for the unsuccessful sample. All the new specimens shall comply with 66.4.1.

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

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

Exception No. 1: The flame to shall be applied to the outside of an enclosure when the equipment is of the encapsulated type, or of a size that prohibits the flame being applied inside.

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

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

67 Replacement Test, Head and Cover

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

67.2 An alarm is to be installed as intended in service and the cover or head removed and replaced, or opened and closed, as specified by the manufacturer. The unit then is to be subjected to the Jarring Test, Section 60.

68 Battery Replacement Test

68.1 The battery clips and holders of a battery operated single station smoke alarm utilizing a battery that is intended to be periodically replaced 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 43.1 (f).]

68.2 For this test an alarm is to be installed as intended in service and the battery(s) removed and replaced as specified by the manufacturer. The unit shall then be tested for its intended operation.

69 Polarity Reversal Test

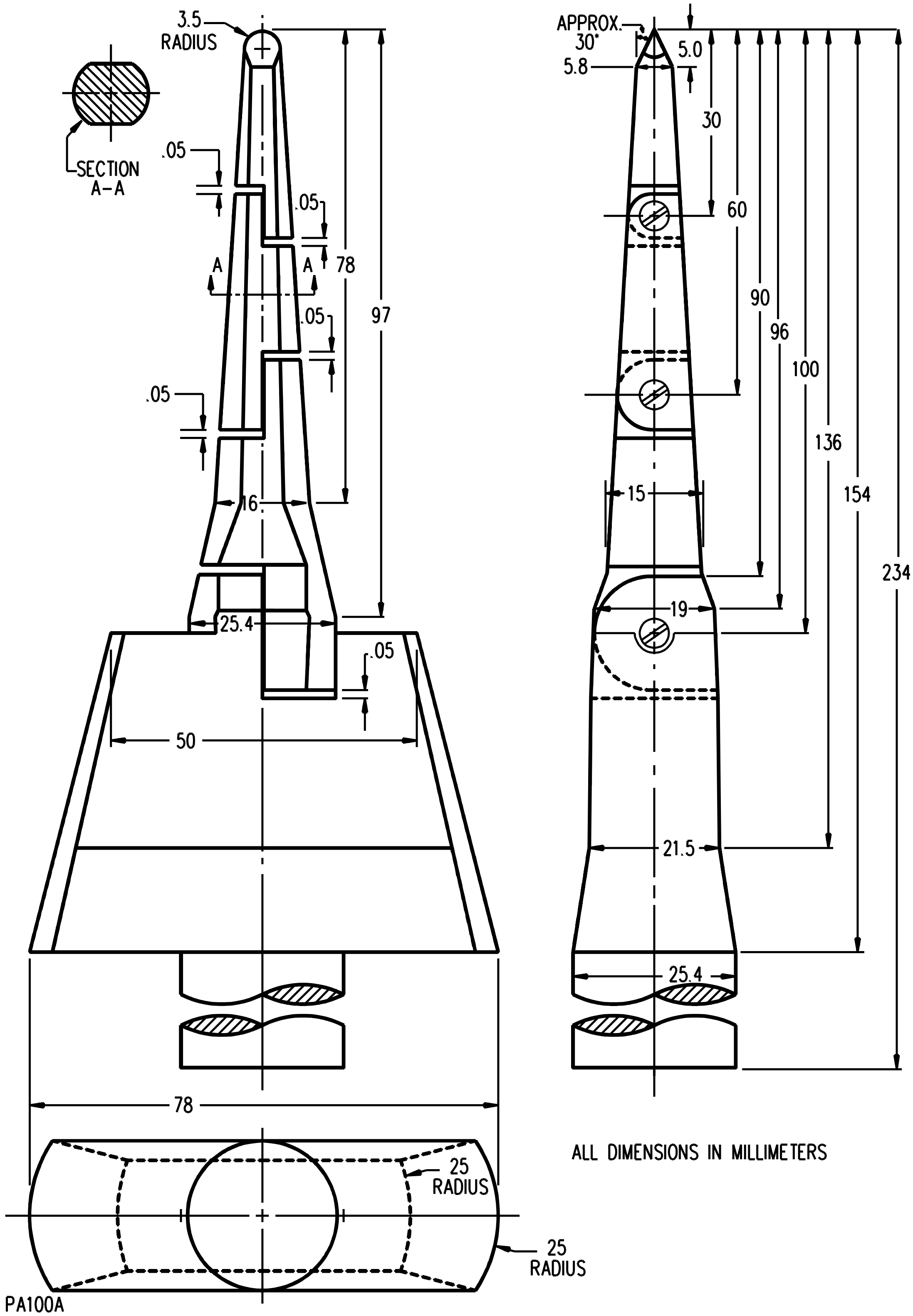
69.1 A smoke alarm shall operate as intended after being connected in each polarity. While energized under either polarity, the alarm shall comply with the requirements of the Electric Shock Current Test, Section 70. This includes high-voltage cord connected and fixed wiring (splice lead) types, battery 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 alarms intended to be connected by a polarized clip assembly the reverse polarity is to be applied for a minimum of 1 second. A trouble or alarm signal is to be permitted under any incorrect polarity applied. A maximum 1-second alarm is permitted when the correct polarity is connected.

69.2 Two samples are to be subjected to this test. Sensitivity measurements prior to and following the test are to be made in accordance with the Sensitivity Test, Section 37. Measurements following the polarity reversal shall vary not more than specified in 34.4.1.

70 Electric Shock Current Test

70.1 If the open circuit potential, between any part that may be contacted by the probe shown in Figure 70.1 either during normal operation or during operator servicing (servicing as defined in the operating or installation instruction) and either earth ground or any other exposed accessible part, exceeds 42.4 volts peak, the part shall comply with the requirements of 70.2 and 70.4.

Figure 70.1
Articulated probe



70.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 70.1 when the resistor is connected between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part.

Table 70.1
Maximum current during operator servicing

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

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

70.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 70.2 shall not exceed the following:

a) The value determined by the following equation:

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

in which:

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

I is the peak current in milliamperes; and

b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. Typical calculated values of maximum acceptable transient current duration are shown in Table 70.2.

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

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

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

in which:

C is the maximum capacitance of the capacitor in microfarads and

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

Typical calculated values of maximum capacitance are shown in Table 70.3.

70.5 With reference to the requirements in 70.2 and 70.3, the current is to be measured while the resistor is connected between ground and each accessible part individually or all accessible parts collectively if the parts are simultaneously accessible. The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, if the parts are simultaneously accessible.

Table 70.2
Maximum transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak, seconds
7.1	7.22
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	0.919
40.0	0.609
50.0	0.443
60.0	0.341

Table 70.2 Continued on Next Page

Table 70.2 Continued

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak, seconds
70.0	0.274
80.0	0.226
90.0	0.191
100.0	0.164
150.0	0.092
200.0	0.061
250.0	0.044
300.0	0.034
350.0	0.027
400.0	0.023
450.0	0.019
500.0	0.016
600.0	0.013
700.0	0.010
809.0	0.0083

70.6 With reference to the requirements in 70.5, parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is to be considered to be able to contact parts simultaneously if the parts are within a 4- by 8-inch (102- by 203-mm) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 6 feet (1.83 m) apart.

Table 70.3
Electric shock – stored energy

Potential across capacitance prior to discharge, volts	Maximum capacitance, microfarads
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.7
100	36.5

Table 70.3 Continued on Next Page

Table 70.3 Continued

Potential across capacitance prior to discharge, volts	Maximum capacitance, microfarads
90	43.8
80	53.8
70	68.0
60	89.4
50	124.00
45	150.00
42.4	169.00

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

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

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

71 Strain Relief Test

71.1 General

71.1.1 A cord or lead that relies upon a thermoplastic enclosure or part for strain relief is to be subjected to the applicable tests specified in 71.2.1 – 71.3.1 following exposure to the temperature conditioning test described in 66.2.1.

71.2 Power-supply cord

71.2.1 When tested in accordance with 71.2.2, 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 alarm disconnected.

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

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. A connector used in the lead assembly shall withstand a pull of 5 pounds-force (22.3 N) without any evidence of damage, transmittal of stress to internal connections, or separation.

72 Power Supply Tests

72.1 General

72.1.1 When a separate power supply is used to provide energy to one or more alarms, 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 alarms 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. When an overcurrent protective device is provided, it shall be shunted out during the test, when required.

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 52, and the Dielectric Voltage-Withstand Test, Section 54.

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. When accessible fuses are provided on the power supply, they are to be shunted out, and inaccessible fuses are to remain in the circuit.

73 Fire Test (Heat Detector)

73.1 A heat detector, provided as part of a single station smoke alarm assembly, shall comply with the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521. It shall be sensitive enough 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 alarm 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 Fire and Smoldering Smoke Tests

74.1 When the sensitivity of smoke alarms subjected to any one of the following tests exceeds the maximum value specified for that particular test then the same samples, adjusted to their minimum sensitivity setting, shall comply with the Fire Tests, Section 44, and the Smoldering Smoke Test, Section 45.

a) Undervoltage test, 56.1.1 – 56.1.3;

b) Overvoltage test, 56.2.1 – 56.2.4;

c) Jarring Test, Section 60;

d) Corrosion Test, Section 61;

e) Vibration Test, Section 59;

f) Dust Test, Section 57;

g) Lamp Interchangeability Test (Photoelectric), Section 42;

h) Reduction in Light Output Test, Section 62.

74.2 For 74.1 (a) and (b), the supply voltage to the alarms in the Fire Tests, Section 44, and the Smoldering Smoke Test, Section 45, shall be at the voltage indicated for the applicable test. For alarms 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 (Long-Term Stability Test)

75.1 This test is an alternate test method to the 90-day stability test requirements of 43.1 (a).

75.2 An alarm 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 recorded before and after the exposures shall be in compliance with the Sensitivity Test, Section 37, and shall not vary more than specified in 34.4.1.

75.4 Two samples, one at maximum and one at minimum sensitivity, or both at the sensitivity that is most affected by the test temperature (as determined during the Variable Ambient Temperature Test, Section 50) 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 43.1 (d) and then to the Sensitivity Test, Section 37. Batteries are not required to be subjected to the elevated ambient temperature.

76 Drop Test

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

76.2 An alarm 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 and without 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 alarm. Dislodgement of parts is not prohibited when:

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

b) The dislodged part is replaceable (such as a cover),

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

d) The condition is visually obvious.

76.3 Each of two alarms 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 specified in 34.4.1.

77 Conformal Coatings on Printed-Wiring Boards

77.1 Low voltage printed-wiring boards

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

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

77.1.3 Four specimens are to be conditioned to room ambient by exposure to ambient air at a temperature of 23 ±2°C (73, minus 3, +4°F) and 50 ±5 percent relative humidity for not less than 24 hours. Following the conditioning, the four samples shall be subjected to the Dielectric Voltage-Withstand Test, Section 54, for the 0 – 30 volt range. There shall not be indication of dielectric breakdown as a result of the test. All specimens shall be smooth, homogeneous, and free of heat deformation such as bubbles and pin holes, as determined by visual examination.

77.1.4 Four samples are to be exposed to ambient air at a temperature chosen from the applicable temperature index line shown in Figure 77.1 corresponding to the ″in service″ operating temperature of the coating. It is advised that the aging temperature chosen from index line correspond to not less than 1000 hours of exposure. However, any value of temperature chosen shall correspond to not less than 300 hours of exposure. The samples are then to be subjected to the Dielectric Voltage-Withstand Test, Section 54, for the 0 – 30 volts range. All specimens shall be smooth, homogeneous, and free of defects such as bubbles and pin holes, as determined by visual examination. There shall not be crazing, chipping, or other visual evidence of deterioration or separation of the coating from the board after conditioning. There shall not be indication of a dielectric breakdown.

77.1.5 As a permitted alternative to the use of conformal coating for circuits at a potential of 30 volts rms (42.4 volts DC or AC peak) or less, and less than 100 volt-amperes, four samples of the printed wiring board shall be subjected to the following tests. The samples shall be conditioned in the environment described in the Humidity test, see 51. Following the conditioning, the four samples shall be subjected to the Dielectric voltage-withstand test, see 54, for the 0 – 30 volt range. There shall not be indication of dielectric breakdown as a result of the test.

77.2 High voltage printed-wiring boards

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

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

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

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

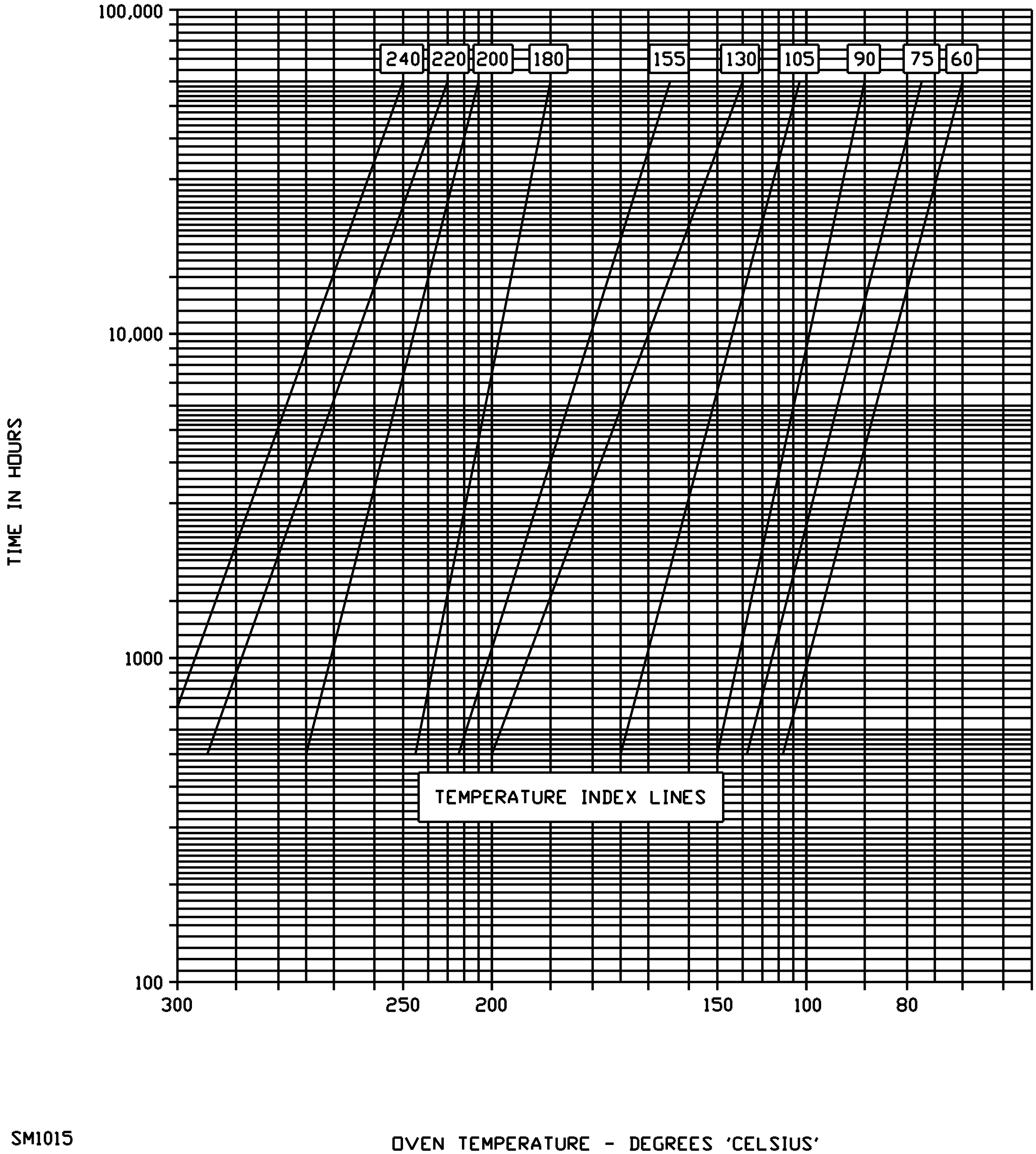
c) A 7 day oven conditioning period at 85 percent relative humidity at 65°C (149°F); and

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

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

77.2.3 A sample of the coated printed-wiring board, equipped with test leads, without electrical components installed, shall be subjected to this test. The sample shall be subjected to an atmosphere having a relative humidity of 93 ±2 percent at a temperature of 32±2°C (89°F, minus 3, +4°F) for a period of 24 hours, followed by a 500 volt dielectric voltage-withstand test with the sample maintained in the conditioning atmosphere. There shall not be indication of a dielectric breakdown.

Figure 77.1
Aging time versus aging temperature



SMOKE ALARMS FOR USE IN RECREATIONAL VEHICLES

78 General

78.1 A smoke alarm intended for use in recreational vehicles shall comply with the requirements specified in Sections 79 – 82, in addition to the requirements specified in Sections 1 – 77 and 86 – 94, inclusive.

79 Variable Ambient Temperature and Humidity Test

79.1 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).

79.2 Sensitivity measurements, recorded in the environmental chamber smoke box, shall not vary more than specified in 34.4.1. During the sensitivity measurement, the environmental chamber is to be as close as possible to the test conditions specified in 79.1 (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).

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

80 Corrosion (Salt Spray) Test

80.1 A smoke alarm 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.

80.2 Two alarms, one at maximum and one at minimum sensitivity, are to be subjected to the salt spray while in a de-energized condition. Following the exposure, the samples are to be removed, dried for at least 24 hours in an air circulating oven or air dried for at least 48 hours, and then subjected to the Sensitivity Test, Section 37.

80.3 It is not prohibited for sensitivity measurements following the exposure to vary by more than specified in 34.4.1 in the direction of high sensitivity under the following conditions:

1) the smoke alarm does not false alarm and

2) the sensitivity does not vary more than specified in 34.4.1 in the direction of low sensitivity.

In any case, the sensitivity shall not exceed the limits specified in the Sensitivity Test, Section 37.

81 Vibration Test

81.1 After vibration in accordance with 81.2, a smoke alarm shall not false alarm nor be adversely damaged. Sensitivity measurements shall not be greater than specified in 34.4.1 in the direction of low sensitivity, measurements greater than specified in 34.4.1 in the direction of high sensitivity are not prohibited. In no case shall the measurements exceed the limits specified in the Sensitivity Test, Section 37.

81.2 Two smoke alarms, one at maximum and one at minimum sensitivity, are to be subjected to vibration for 120 hours in accordance with the Vibration Test, Section 59. Sensitivity measurements are to be recorded before and after the test.

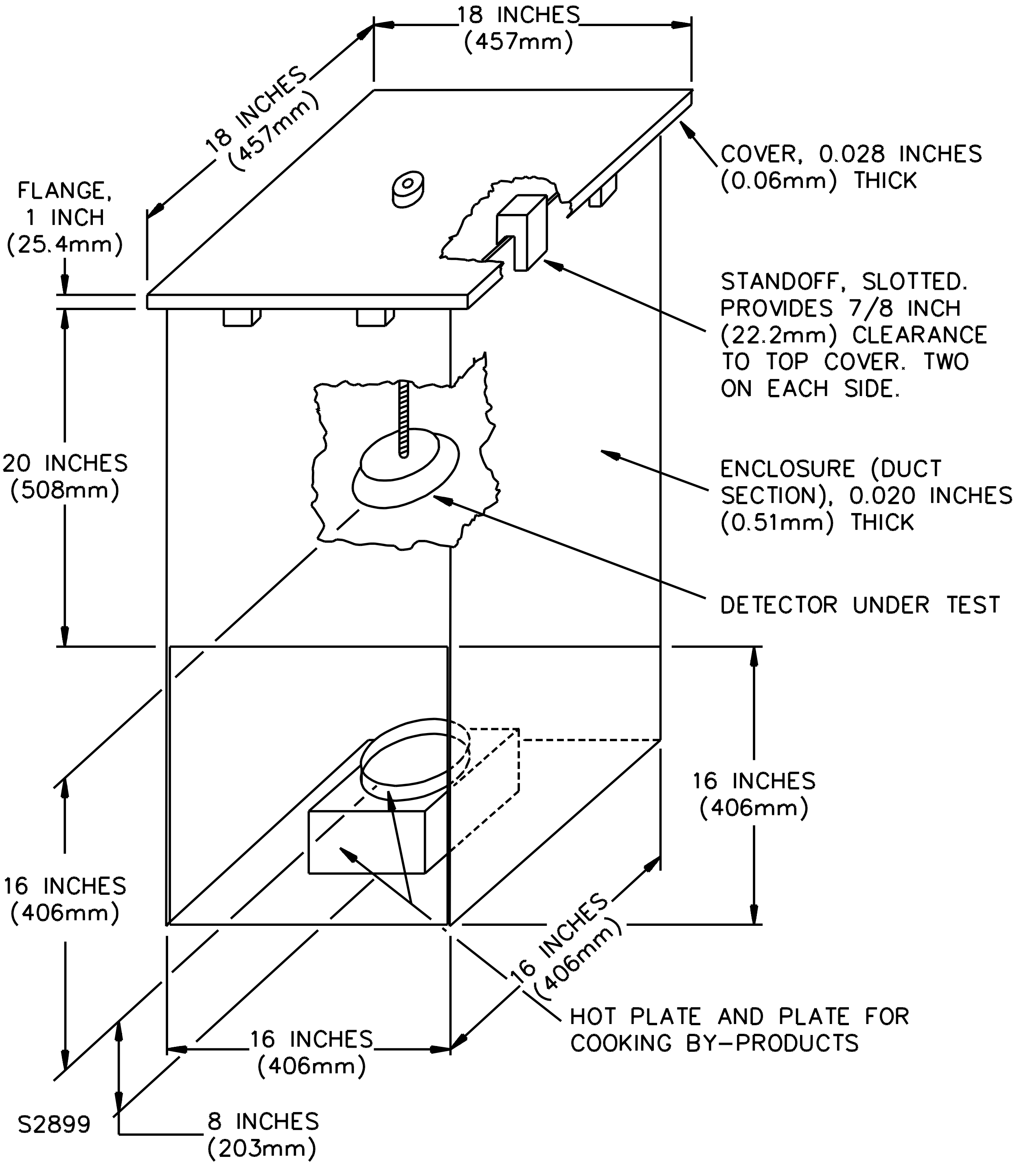
82 Contamination Test (Cooking By-Products)

82.1 After exposure in accordance with 82.2 – 82.5, a smoke alarm shall not false alarm or otherwise be adversely affected. Sensitivity measurements following the exposure shall not be greater than specified in 34.4.1 in the direction of low sensitivity, (measurements greater than specified in 34.4.1 in the direction of high sensitivity are not prohibited). In no case shall measurements exceed the limits of the Sensitivity Test, Section 37.

82.2 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.

82.3 The enclosure is to measure 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, 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 82.1.

Figure 82.1
Contamination test (cooking by-products)



82.4 The alarm 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 alarm is 12 inches (304 mm) below the enclosure cover and 16 inches (406 mm) above the aluminum plate. The alarm is not to be energized during the test.

82.5 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 37.

SMOKE ALARMS FOR USE ON RECREATIONAL BOATS

83 General

83.1 A smoke alarm intended for use in recreational boats shall comply with requirements specified in 83 – 85, in addition to the requirements specified in 1 – 77 and 86 – 94, inclusive.

83.2 These requirements apply to the construction and performance characteristics for single station self contained battery operated alarms as well as alarms powered by the vessels installed DC system. These alarms may be used in stand alone operation or as part of an integrated multiple device system when installed.

83.3 These smoke alarms are intended to be installed in enclosed accommodation compartments where smoke from undetected fire may accumulate. These devices shall be wired in accordance with Fire Protection Standard for Pleasure and Commercial Motor Craft , NFPA 302, and AC and DC Electrical Systems on Boats, ABYC E-11, and applicable regulations of the United States Coast Guard.

84 Sample Requirements

Table 84.1
Samples for performance tests

Number of samples[a]	Test
3	Sensitivity test, Section 37
3	Operation tests following conditioning, Section 85
3	Abnormal operation tests, Section 55
1	Salt-spray corrosion test, Section 80
3	Overvoltage and undervoltage tests, Section 56
3	Survivability test, Section 64
3	Audibility test, Section 65

[a] The same 3 samples are to be used for each test. When only 1 sample is required it shall be any one of the previously tested samples.

85 Operational Tests Following Conditioning

85.1 Immediately following each test condition, an alarm shall operate in accordance with the levels specified in Section 37. When specified by the manufacturer, it is not prohibited that the alarm be warmed up prior to a test or sensitivity check.

85.2 The same samples are to be used for each of the conditions in this section. The samples are to be energized (except for humidity) during each exposure. The three samples are to be placed in an air circulating oven maintained at 70 ±2°C (158 ±4°F) for 24 hours.

85.3 Immediately following the conditioning specified for high temperature and the sensitivity test, the same alarms are to be placed in a cold chamber maintained at minus 30 ±2°C (minus 22±4°F) for 24 hours.

85.4 The same three alarms used in the temperature tests are to be used in the vibration test as specified in section 81. The alarms, including all components, are to be mounted on a vibration table so as to simulate as closely as possible an actual installation on a boat in accordance with the device manufacturer's installation instructions. The means used for such mounting shall be rigid enough to reduce resonant frequencies of the mounting means. The vibration table is to produce vibration frequencies and amplitude specified as follows: The alarms are to be subjected to a variable frequency vibration along each of the three rectilinear orientation axes (horizontal, lateral, and vertical) for 4 hours in each plane (12 hours total) at peak to peak amplitude of 0.015 ±0.001 inches (0.40 ±0.05 mm). The frequency of vibration is to be continuously varied, at a uniform rate, from 10 to 60 to 10 hertz every 4 minutes.

85.5 For this test, peak to peak amplitude is defined as the maximum displacement of sinusoidal motion (total machine displacement).

85.6 The same three alarms are to be mounted on a shock machine in the same manner as described in the vibration conditioning. The samples are to be subjected to 5000 shock impacts of 10 g acceleration (98 m/s^2) and having a shock duration of 20 – 25 milliseconds as measured at the base of the half-sine shock envelope.

85.7 The machine used for this conditioning is to be of the automatic cycling type capable of producing a half sine shock pulse at the acceleration level and duration specified. The acceleration and shock pulse duration is to be measured by a piezoelectric accelerometer mounted on the test machine platform on an axis parallel to the axis of motion.

85.8 The test samples are to be mounted so that the center of gravity of the sample is as close as possible to the geometric center of the machine platform.

85.9 Following the vibration and shock conditioning, the same three alarms are to be used for the humidity conditioning. The alarms are to be subjected to air at a relative humidity of 90 ±5 percent and a temperature of 40 ±2°C (104 ±4°F) for 96 hours. The alarms are not to be energized during this condition.

85.10 Immediately following the above conditioning, the alarms are to be subjected to air at a relative humidity of 30 ±5 percent and a temperature of 23 ±3°C (73 ±5°F) for 96 hours. The alarms are not to be energized during this conditioning.

MANUFACTURING AND PRODUCTION TESTS

86 General

86.1 To verify compliance with these requirements in production, the manufacturer shall provide the required production control, inspection and tests. The program shall include at least the Sensitivity Calibration Tests, Section 87, and the Photocell Illuminating Lamp Test (Photoelectric Smoke Alarms), Section 88, conducted on 100 percent of the production.

87 Sensitivity Calibration Tests

87.1 The sensitivity of each smoke alarm is to be checked, following the warm-up period specified 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 alarm. The test equipment is to verify the value or range of sensitivities marked on the alarm. The value of indication is to be in the form of percent per foot obscuration.

87.2 For the warm-up period, the alarms are to be energized from a source of supply in accordance with 33.3.1. In situations where the smoke alarm sensitivity is not within the manufacturer's specifications, the unit is to be corrected and retested. When a retested sample is still outside the specification, it is to be rejected.

87.3 A warm-up period is required for those alarms employing components whose characteristics 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.

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

88 Photocell Illuminating Lamp Test (Photoelectric Smoke Alarms)

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

89 Production Line Dielectric Voltage-Withstand Tests

89.1 Each alarm 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 an alarm rated at 250 volts AC rms or less – either 1000 volts (1414 volts, when a DC potential is used) applied for 60 seconds or 1200 volts (1697 volts, when a DC potential is used) applied for 1 second or

b) For an alarm 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, when 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, when a DC potential is used) applied for 1 second.

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

89.2 When the alarm 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 is applied simultaneously between high-voltage live parts and low-voltage circuits.

89.3 A printed-wiring assembly or other electronic-circuit component that is damaged or short-circuited, by application of the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. It is not prohibited for a representative subassembly to be tested instead of an entire unit.

89.4 A 500 volt-amperes or larger transformer, the output voltage of which is able to be varied, is to be used to determine compliance with 89.1. A 500 volt-amperes or larger transformer is not required when 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.

89.5 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 are to be evaluated and accepted when found to achieve the results contemplated.

89.6 Where the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is enough to prevent maintaining the specified AC test potential, the alarm is to be tested using a DC test potential in accordance with 89.1.

90 Production Line Grounding Continuity Tests

90.1 The manufacturer shall test each alarm 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.

90.2 For this test, the manufacturer is to employ a resistance-indicating instrument with leads and terminals which determine the grounding circuit continuity.

90.3 When an investigation of the alarm has shown all exposed dead metal parts that 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 alarm, a test that determines the electrical continuity between the grounding blade and the frame or enclosure is satisfactory.

91 Smoke Alarm Shipment

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

91.2 A nonrechargeable standby battery of an AC operated accessory to a single- or multiple-station smoke alarm is not required to be shipped with the unit when 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

92 General

92.1 A smoke alarm shall be permanently marked with the following information unless specifically indicated that it appears 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 vendor.

b) Model number and date of manufacture. The date of manufacture shall be non-coded and in the format YEAR (in 4 digits), MONTH (in letters), DATE (in 2 digits) located on the outside of the smoke alarm.

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

d) Correct mounting position when a unit is intended to be mounted in a definite position. (It is not prohibited for this to appear in the installation instructions.)

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

f) Maximum rating of fuse in each fuseholder and temperature rating of supplementary heat detector, when 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 smoke alarm that employs a radioactive material, the following information shall be indicated directly on the exterior 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) An alarm 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 alarm is mounted in its intended manner.

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

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

Applicable wording shall be used.

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

m) For battery operated alarms employing replaceable batteries, reference to a source for battery replacement. (It is not prohibited for this to appear in the homeowner's manual.)

n) For a battery operated alarm employing replaceable batteries, the word ″WARNING ″ and the following or equivalent marking shall be included on the unit: ″Use Only Batteries Specified In Marking. Use Of A Different Battery Will Have A Detrimental Effect On Smoke Alarm Operation.″ The letter height shall be a minimum of 1/8 inch (3.2 mm) for ″WARNING″ and 3/64 inch (1.2 mm) for the rest of the notice.

o) For a smoke alarm 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 (3.2 mm) high.

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

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

r) Name and address of firm to whom alarm 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 alarm: ″RETURN TO (+) FOR SERVICING,″ or equivalent. It is not prohibited for units on which the cover is removable, and that are also intended to be returned to the manufacturer for servicing, to have the marking on the inside of the alarm.

(+) Name and address of manufacturer or supplier.

t) An AC operated alarm 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 (3.2 mm).

u) The sensitivity setting for a smoke alarm having a fixed setting. For an alarm which 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.

v) For a battery operated smoke alarm employing a non-replaceable 10 year battery, the words ″10 Year Battery. Replace Alarm After __________ ″ or equivalent marking shall be provided on the unit. The letter height shall be a minimum of 1/8 inch (3.2 mm) unless it is in a contrasting color, visible from 1.83 m (6 feet) after the unit has been installed as intended.

w) For a battery-operated smoke alarm employing a non-replaceable 10-year battery, a statement indicating that the unit is sealed, with no serviceable parts, and that the maintenance and testing specified elsewhere on the marking must be performed.

x) For a battery operated smoke alarm employing a non-replaceable 10-year battery, a description of how to use the deactivation feature and indication that once deactivated the smoke alarm is incapable of being reactivated and must be replaced.

y) A detector guard shall be permanently marked with the following information in a contrasting color, finish, or equivalent:

1) Name or identifying symbol of the manufacturer or private labeler,

2) Model number and

3) A statement indicating that the guard is only to be used with detectors specified in the installation instructions of the guard or detector.

92.2 Information required to appear directly on the alarm shall be readily visible after installation. Except for 92.1 (j), the removal or opening of an enclosure cover not requiring a tool, or an equivalent arrangement to view the marking is not prohibited.

92.3 When markings are placed on the base (bottom) of an alarm 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 alarm: ″Additional marking on back. Disconnect power.″

92.4 Additional marking requirements are specified by 9.2.1, 11.6.4, 14.1, 14.3, 14.4, 19.2.1, 25.2, and 94.2.

92.5 For manufacturers producing alarms at more than one factory, each such assembly shall have a distinctive marking to identify each subassembly as the product of a particular factory.

92.6 With regard to the requirement in 8.5, 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: ″Smoke Alarm is Non-Operational.″ The letter height shall be a minimum of 3/8 inch (9.5 mm) unless it is in a contrasting color, visible from 6 feet (1.83 m).

Exception: Not required for supervised RF detectors.

93 Packaging Marking

93.1 The point-of-sale carton, in which a smoke alarm 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 quantity (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 SMOKE ALARM 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.″

93.2 Smoke alarms with replaceable battery warranties exceeding one year shall:

a) Include a disclaimer that indicates that the battery warranty period is not a performance claim, or

b) Have the performance claims of the manufacturer verified per 63, Battery tests.

INSTRUCTIONS

94 General

94.1 Each single and multiple station smoke alarm 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 the National Fire Alarm Code (NFPA 72) Chapter 11. Locations where smoke alarm 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 72, Chapter 11.

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 is able to obtain the part.

d) The following text:

″For your information, the National Fire Protection Association's Standard 72, reads as follows:

″11.5.1 One- and Two-Family Dwelling Units. ″

″11.5.1.1 Smoke Detection. Where required by applicable laws, codes, or standards for the specified occupancy, approved single- and multiple-station smoke alarms shall be installed as follows: (1) In all sleeping rooms Exception: Smoke alarms shall not be required in sleeping rooms in existing one- and two-family dwelling units. (2) Outside of each separate sleeping area, in immediate vicinity of the sleeping rooms. (3) On each level of hte dwelling unit, including basements Exception: In existing one- and two-family dwelling units, approved smoke alarms powered by batteries are permitted.

″A.11.8.3 Are More Smoke Detectors Desirable? The required number of smoke detectors might not provide reliable early warning protection for those areas separated by a door from the areas protected by the required smoke detectors. For this reason, it is recommended that the householder consider the use of additional smoke detectors for those areas for increased protection. The additional areas include the basement, bedrooms, dining room, furnace room, utility room, and hallways not protected by the required smoke detectors. The installation of smoke detectors in kitchens, attics (finished or unfinished), or garages is not normally recommended, as these locations occasionally experience conditions that can result in improper operation. ″

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e) Description of the various situations against which the smoke alarm is 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 are 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 4.4°C (40°F) or exceeds 37.8°C (100°F), unless the alarm has been determined to be capable of being used at installation points with higher or lower ambient temperatures.

i) Reference to a source(s) of power limited 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. When 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 vendor.

2) Model number.

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

4) Temperature rating of heat detector, when 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 alarm 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 72 (National Fire Protection Association, Batterymarch Park, Quincy, MA 02269).

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

m) For alarms also recognized for installation in recreational vehicles, the word ″WARNING,″ and the following or equivalent text: ″TEST SMOKE ALARM 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 alarm.″

n) Smoke alarms are not to be used with detector guards unless the combination has been evaluated and found suitable for that purpose.

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

p) An indication that current studies have shown smoke alarms may not awaken all sleeping individuals, and that it is the responsibility of individuals in the household that are capable of assisting others to provide assistance to those who may not be awakened by the alarm sound, or to those who may be incapable of safely evacuating the area unassisted.

94.1 revised May 22, 2007

94.2 It is not prohibited that the instructions be incorporated on the outside of the unit, on a separate sheet, or as part of a manual. When not included directly on the device, the instructions or manual shall be referenced in the marking information on the unit.

94.3 The material shipped with the alarm, including the package, instructions, or user’s manual, shall not include information other than that specified in 94.1, such as manufacturer’s claims on the operation of the alarm 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 of the National Fire Protection Association.

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SUPPLEMENT SA - SMOKE ALARM RELIABILITY PREDICTION

SA1 Instructions for Determining a Reliability Prediction for Smoke Alarms

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

SA1.2 By circuit analysis or experimentation, determine the effect of any failure mode (short or open) of each component on the smoke alarm operation and the rationale for the decision. This determines that a component is to be identified as critical, conditionally critical, or noncritical.

SA1.3 A component is identified as noncritical when all failure modes of the component result in a trouble signal[a], or have no effect on the intended operation of the smoke alarm for alarm and trouble signals, and do not affect the alarm sensitivity.

[a] A trouble signal is indicated by energization of an audible signal, energization of a separate visual indication (amber or orange), or de-energization of a power-on light. When a visual indication is relied 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 identified as critical when two or more failure modes of the component, which affect the intended operation or the sensitivity of the smoke alarm, do not result in a trouble signal[a].

SA1.5 A component is identified as conditionally critical when only one failure mode of the component affects the intended operation or the sensitivity of the smoke alarm, and does not result in a trouble signal[a].

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

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

SA1.8 For each conditionally critical component, the expected failure rate shall 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 SA2.7 – 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 alarm.

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/10^6 hrs) shall be assigned only when 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			Failure rate
Construction	Style	Mil-R-Spec. (reference only)	
Composition	RCR	39008	0.002
Composition	RC	11	0.01
Film	RLR	39017	0.015
Film	RL	22684	0.075
Film	RNR	55182	0.017
Film	RN	10509	0.017
Film, power	RD	11804	0.96
Wire wound, accurate	RBR	39005	0.056
Wire wound, accurate	RB	93	0.28
Wire wound, power	RWR	39007	0.033
Wire wound, power	RW	26	0.17
Wire wound, chassis mount	RER	39009	0.062
Wire wound, chassis mount	RE	18546	0.31
Resistors, variable			
Wire wound, trimmer	RTR	39015	0.066
Wire wound, trimmer	RT	27208	0.33
Wire wound, precision	RR	12934	2.7
Wire wound, semi-precision	RA	19	2.3
Wire wound, semi-precision	RK	39002	2.3
Wire wound, power	RP	22	2.3
Non-wire wound, trimmer	RJ	22097	4.6

Table SA2.4 Continued on Next Page

Table SA2.4 Continued

Resistors, fixed			Failure rate
Construction	Style	Mil-R-Spec. (reference only)	
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. (reference 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 transformers	0.0027
Audio transformers	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
crimps	0.0073
welds	0.002
wirewraps	0.0000037
Coaxial connectors	0.63
Toggle switches	0.57

Table SA2.6 Continued on Next Page

Table SA2.6 Continued

Part type	Failure rate
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	
beads	0.10
discs	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. 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

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 are required for review. See also Table SA2.11 and Figure SA2.1 for equations and tabulation sheets.

[b] When a Mil-Spec component is required in a smoke alarm and it does not employ a specific marking to that effect, it is required that the alarm manufacturer provide documentation to verify that the component is Mil-Spec graded. The documentation shall 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 is also able to be applied to any other component of an alarm, 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 – It is appropriate to employ this method for the evaluation of generic integrated circuit ″chips″ as well as any other component of an alarm, 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 comply to the identification program in SA4.3, and minimum screening program of Table SA5.1.

SA2.6 It is not prohibited for the overall failure rate of the components of an alarm to 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.

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 SI/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	$\lambda_p = \pi_L\ \pi_Q\ (C_1\ \pi_{T2} + C2\pi_E)$	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
RV composition potentiometers	$\lambda_p = \pi_b \times \pi_{TAPS}\ (\pi_R \times \pi_V \times \pi_Q \times \pi_E)$	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

Table SA2.11 Continued on Next Page

Table SA2.11 Continued

Type device	Applicable equation	MIL-HDBK-217B 9/20/74 page reference
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	$\lambda_p = {}_b (\pi_E)(\pi_Q)$	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 when Table SA5.1 screening is conducted		

SA3 Maximum Smoke Alarm Failure Rates

SA3.1 The overall failure rates for the alarm shall not be greater than as indicated in Table SA3.1.

Table SA3.1
Smoke alarm failure rates

Method of failure rate computation	Maximum alarm 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

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.

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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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 is also applied for other microelectronic devices.

SA4.3 Components that comply to 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 alarms and ″chips″ so that a comparison of the tally of alarms shipped to the quantity of screened devices procured from the component vendor is able to be performed.

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 alarm manufacturer. When the screening program is conducted by the component manufacturer, each lot or shipment to the alarm 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, minus 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	AQL 1.5 percent per MIL-STD 105 Level II
a) Functional electrical, 25°C [Run last, after b), c), and d)]	
b) Temperature cycling (Method 1010C, minus 55°C to 150°C, 10 cycles)	
c) Seal (Fine leak, Method 1040B, 5x10^{-8} CC/sec)[c]	
d) External visual, Method 2009	
Plastic packages	
1. Internal visual (Method 2010.1, condition B modified)	100 percent[a]
2. Bond strength (Method 2011)	Sample basis[a]
3. Temperature cycling (Method 1010C, minus 55°C to 150°C, 10 cycles)	100 percent[c,f]

Table SA5.1 Continued on Next Page

Table SA5.1 Continued

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

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

[b] Stabilization bake is not required when the production process includes equivalent conditioning.

[c] Thermal Shock, Method 1011.1, Condition B or C, is not prohibited as a substitute.

[d] Reduced to 1.5 percent AQL when vendor's first lot of 25,000 units shows statistical justification.

[e] Not required when justified by the reject rate in item 5.

[f] Not required when 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. A method of performing This audit is by choosing 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 alarm. 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 alarm).

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.

b) Choose test temperature for acceptance test.

c) Using chosen 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. When a different temperature is employed, lot sizes are derived from a table of Summation of Terms of Poisson's Exponential Binomial Limit[d] a 60 percent confidence level.

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

[d]Reliability Handbook by W. Grant Ireson

Figure SA6.1
Time-temperature regression and time limits for test condition

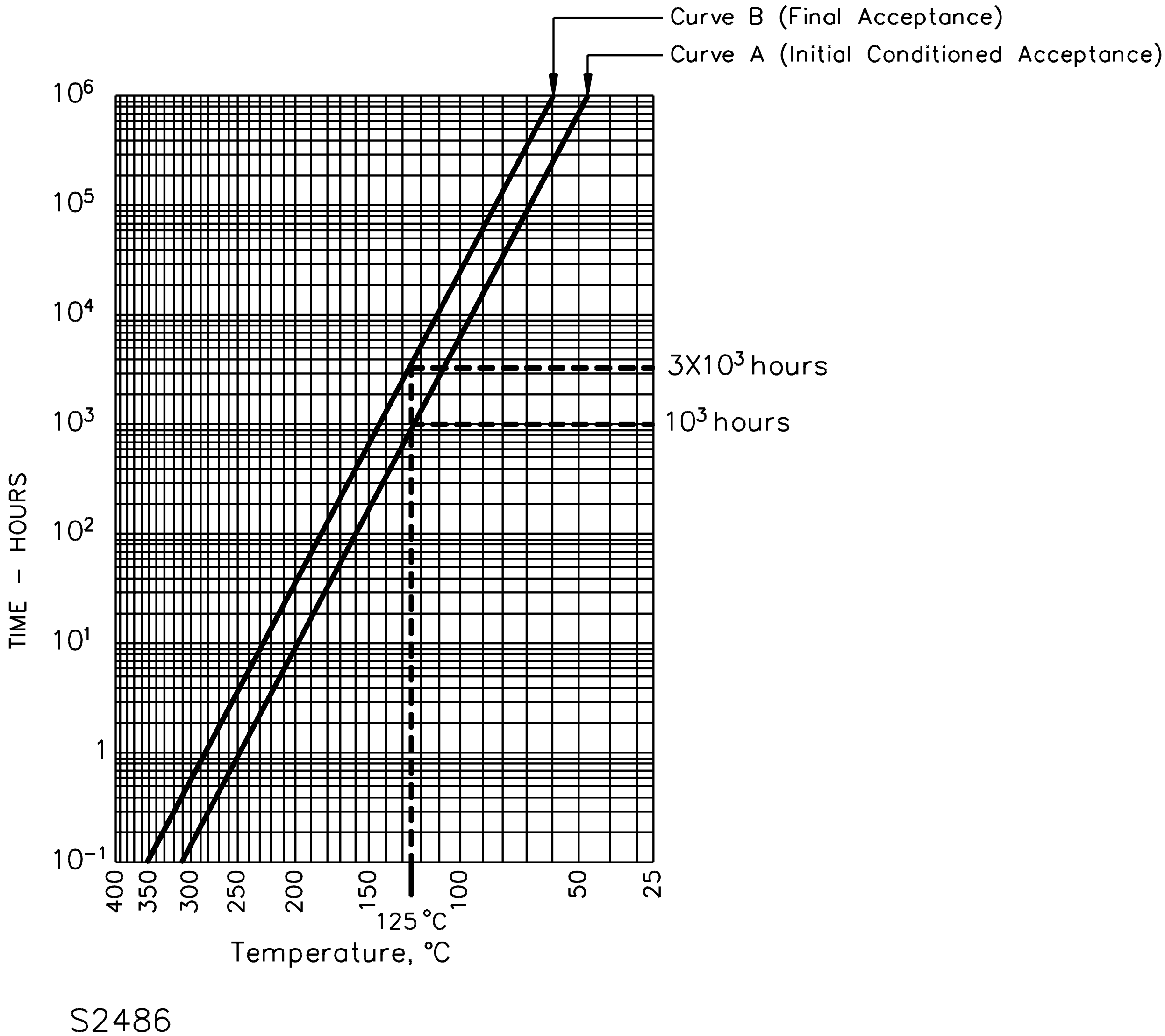

Table SA6.1
Sample lot size for burn-in test

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

SA6.3 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 It is not prohibited that the elevated test temperature and related time periods (using the illustrated curves) be increased or decreased except the minimum chosen temperature for the burn-in test shall not be 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).

SA6.4 Test conditions

SA6.4.1 Appropriate sockets or other mounting means shall be provided to make firm electrical contact to the terminals of devices under test in the specified circuit configuration. The mounting means shall be constructed so that they do not remove internally dissipated heat from the device by conduction, other than that removed through the device terminals and the required electrical contacts, which shall be maintained at or above the specified ambient temperature. The apparatus is to provide for maintaining the specified biases at the terminal of the device under test and, when specified, monitoring of the input excitation. When the device incorporates on board elements which directly drive such things as the smoke alarm horn, battery pulse test or beacon LED of a photoelectric smoke alarm, 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,and ambient temperatures. The test equipment is preferably to be arranged so that only natural convection cooling of the devices occurs. When test conditions result in significant power dissipation, the test apparatus is to be arranged so as to result in the average power dissipation for each device whether devices are tested individually or in a group. The test circuits are not required to compensate for normal variations in individual device characteristics and shall be arranged so that the existence of failed or abnormal (for example open, or short) 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 chosen elevated test temperature to the 38°C (100°F) 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. When 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) Numerical failure rate λ_2 = 0.1 Failure per 10^6 hours.

b) Test ambient temperature is 125°C (257°F).

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:

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

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

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

K is 8.62×10^{-5} *ev/°K*

T_1 *is 398°K*

T_2 *is 311°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* 20×10^{-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), is usable at the conditional acceptance point (1000 hours). For 2.0 percent/1000 hours:

C = 0 N = 47

C = 1 N = 109

C = 2 N = 155

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. It is possible for the failure rate to be less at the final acceptance point of 3000 hours.

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APPENDIX A

Standards for Components

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

Title of Standard − UL Standard Designation

Control Units for Fire-Protective Signaling Systems – UL 864
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Motors, Overheating Protection for – UL 2111
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape – UL 510
Printed-Wiring Boards – UL 796
Switches, Snap, General-Use – UL 20
Transformers, Specialty – UL 506
Tubing, Extruded Insulating – UL 224
Wire Connectors – UL 486A-486B
Wires and Cables, Thermoplastic-Insulated – UL 83
Wires and Cables, Thermoset-Insulated – UL 44

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APPENDIX B

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

Obscuration – optical density chart Based on a 5-foot (1.52-m) light beam Continued on Next Page

Obscuration – optical density chart Based on a 5-foot (1.52-m) light beam Continued

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	
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
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 37.3.1.

Superseded requirements for
the Standard for
Single and Multiple Station Smoke Alarms

UL 217, Sixth Edition

The requirements shown are the current requirements that have been superseded by requirements in this edition. The numbers in parentheses refer to the new requirements with future effective dates that have superseded these requirements. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

14.1 The use of a secondary power supply is not prohibited. When a secondary power supply, such as a battery, is provided, it shall 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: When the battery capacity is such that it is not capable of providing 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.

20.2 Where longer runs of interconnecting wiring are used in an installation, such as in a multiple station configuration, or where several alarms are supplied by a common power supply, the wiring is not required to be provided by the manufacturer. However, the installation wiring diagram or instructions shall be marked to specify that the wiring to be used shall be in accordance with the provision of Article 210 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.

36.3.2 (36.3.3) To determine compliance with 36.3.1, 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. It is possible to deplete a fresh battery 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 is depleted by applying a 10 milliamperes (1 percent load) or less drain continuously until the battery voltage reaches the predetermined test level.

89.1 (93.1) The point-of-sale carton, in which a smoke alarm 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 quantity (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 SMOKE ALARM 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.″

d) A disclaimer for those units employing a long warranty specifying that the warranty is not a performance claim.