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Single and Multiple Station Smoke Alarms

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FOREWORD

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

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

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

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

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

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

INTRODUCTION

1 Scope

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

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

c) Heat detectors [except for the requirements in the Fire Test (Heat Detector), Section 72] 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.

1.6 Deleted October 12, 2001

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.

2.1.2 revised October 12, 2001

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.

2.1.4 revised October 12, 2001

2.2 Units of measurement

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

2.2.1 revised October 12, 2001

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.

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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 silences the alarm for a maximum of 15 minutes. 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.

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

CONSTRUCTION

ASSEMBLY

9 General

9.1 Accessories

9.1.1 Unless specifically indicated otherwise, the construction requirements specified for 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.

11.4.3 revised January 4, 1999

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 No. 16 AWG (1.3 mm^2) and the screen openings shall not be greater than 1/2 square inch (3.2 cm^2) in area.

11.6 Covers

11.6.1 An enclosure cover, other than the type usually employed over the sensing chamber, shall be hinged, sliding, pivoted, or similarly attached 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 tamperproof type, shall be sealed or covered. See 88.1(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 – 75.

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 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.

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

14.3 When a nonrechargeable 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 nonrechargeable 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 is not required to be 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.

15.2 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 No. 22 AWG (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 71.2.1 and 71.2.2.

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 71.2.1 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 No. 18 AWG (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 No. 16 AWG (1.3 mm^2), for a single conductor, No. 19 AWG (0.65 mm^2) for two or more conductors, and No. 22 AWG (0.32 mm^2) for four or more conductors of a multiconductor cable. The conductor shall be solid, bunch tinned stranded, or stranded copper. Stranded copper wire, consisting of not more than seven strands, shall be used only for No. 18 AWG (0.82 mm^2) and larger conductors.

17.5 Grounded supply terminals and leads

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

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

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

18 Power Supply Cord

18.1 A cord-connected single station smoke 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 No. 18 AWG (0.82 mm^2). It shall be rated for use at the voltage and ampacity rating of the detector, in accordance with the National Electrical Code, ANSI/NFPA 70.

18.3 Means shall be provided to prevent the flexible cord from being pushed into the enclosure through the cord-entry hole 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 No. 18 AWG (0.82 mm^2) and shall not be longer than 20 feet (6.1 m). The interconnecting wiring is to be provided with the 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 Article 760 of the National Electrical Code, ANSI/NFPA 70. In addition, the resistance of the interconnecting wiring shall be a maximum of 10 ohms, unless otherwise specified by the manufacturer.

INTERNAL WIRING

21 General

21.1 The internal wiring of 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 No. 16 AWG (1.3 mm^2).

[c] Rigidly clamped assemblies include such parts as contact springs on relays or cam switches, printed-wiring boards, and 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 81.

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 81.

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

Voltage, volts[a]	Energy available, volt-amperes	Spacing, inch	(mm)	Coating program
0 – 30	100 maximum	13/64	0.2	Section 81.1
0 – 30	Over 100	13/32	0.4	Section 81.1
31 – 300	Over 100	13/16	0.8	Section 81.2

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 75 (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 90.

e) Where applicable, samples of conformal coated printed-wiring boards, as specified in Conformal Coatings on Printed-Wiring Boards, Section 81.

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.

Effective date for 34.1.5 changed from August 21, 1998 to August 21, 1999

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 – 75, 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 90.1(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.

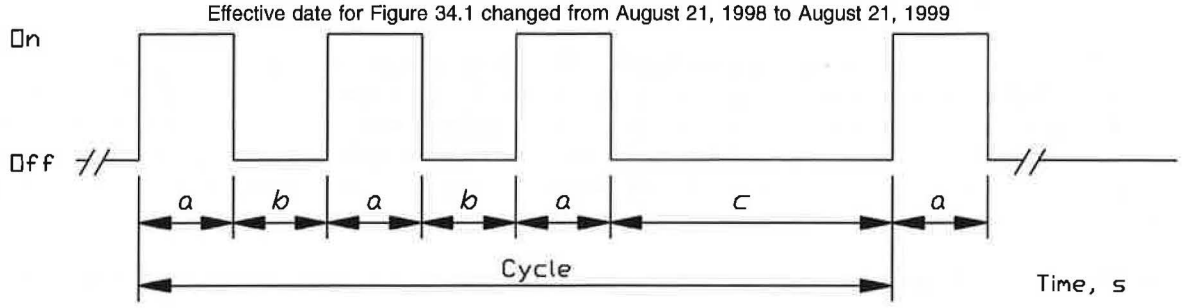
34.3 Standardized alarm signal

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.

Effective date for 34.3.1 changed from August 21, 1998 to August 21, 1999

Figure 34.1
Standardized alarm signal temporal pattern

Effective date for Figure 34.1 changed from August 21, 1998 to August 21, 1999



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.

34.4.1 added August 10, 1998

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 a 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.

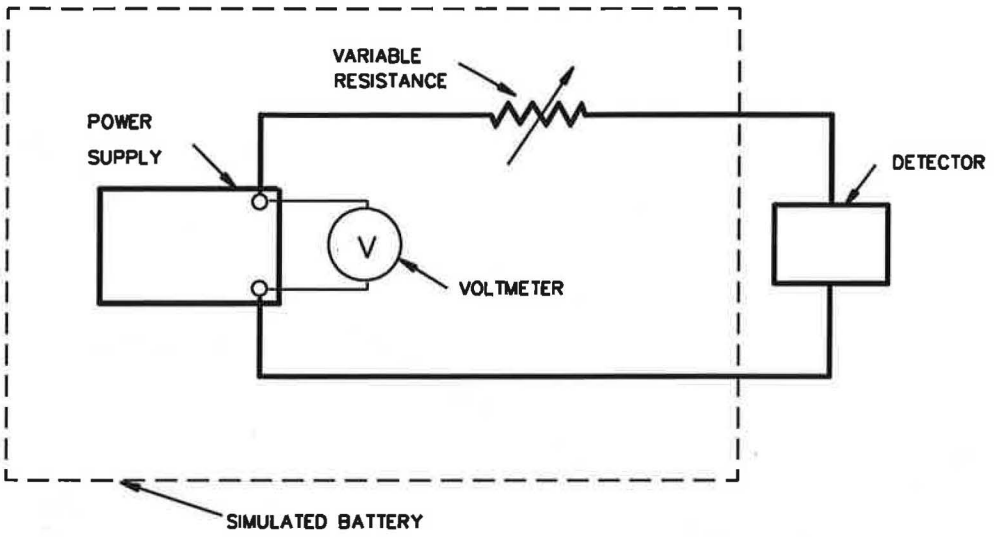
c) Voltage Values Between Rated and Trouble Level Voltages – The voltage of the power supply is to be set at prespecified voltages between the rated battery voltage and the trouble level voltage. The series resistor is then to be increased in increments of 0.1 – 10 ohms, at a rate of not more than one 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 1 year 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 1 year and all points of Curve B to the right of point F (extended to the base line), shall be below Curve A.

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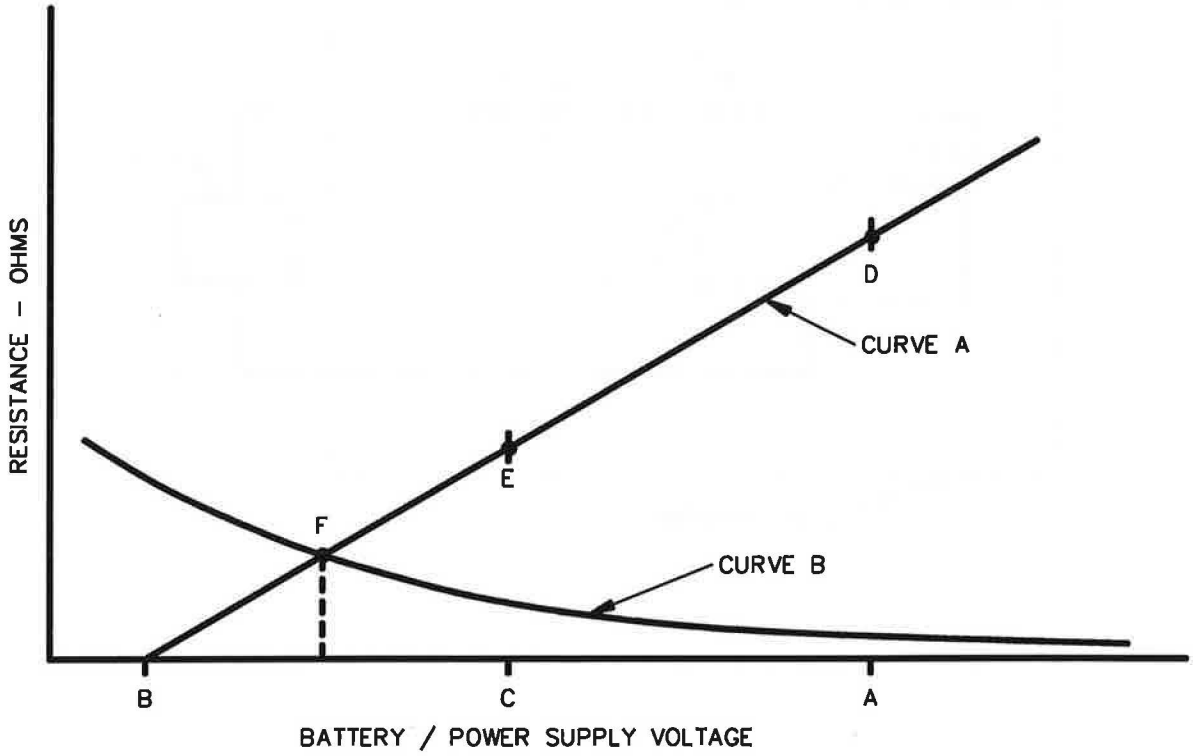
Figure 35.1
Test circuit

Figure 35.1 revised January 4, 1999



S2478

Figure 35.2
Trouble level determination
Figure 35.2 revised January 4, 1999



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A – Rated battery voltage.

B – Trouble level voltage (assuming minimal resistance).

C – Voltage value between rated and trouble level.

D – Trouble level resistance at rated battery voltage.

E – Trouble level resistance at voltage value C.

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

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

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

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.

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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 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 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.

36.3.3 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.

36.3.4 To determine compliance with 36.3.3, 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.

36.3.5 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

Figure 37.1 revised January 4, 1999

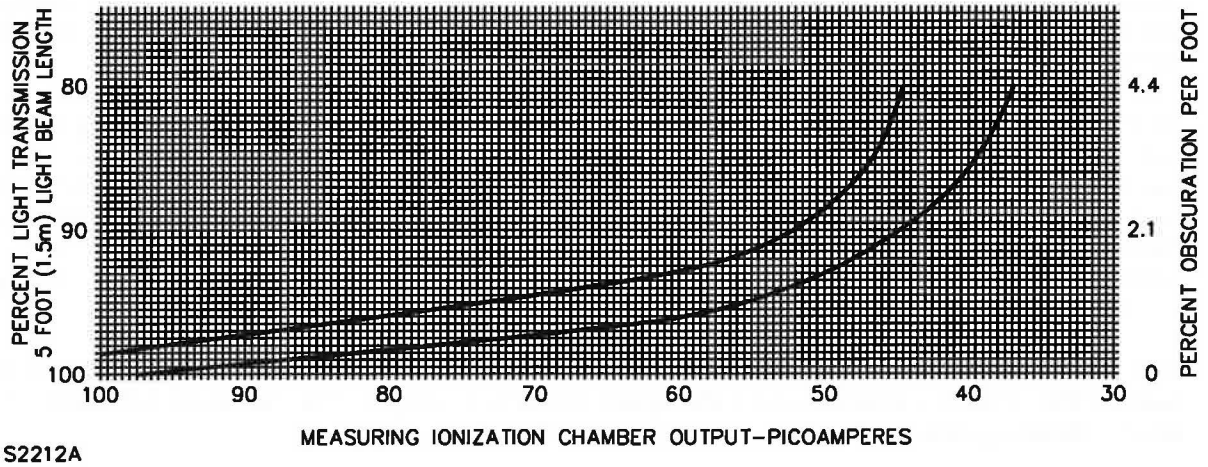


Figure 37.2
Smoke build-up rate – sensitivity test – aerosol – 32 fpm

