UL 268

ISBN 0-7629-1189-1

Smoke Detectors for Fire Alarm Signaling Systems

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Smoke Detectors for Fire Alarm Signaling Systems, UL 268

Fifth Edition, Dated September 8, 2006

Summary of Topics

This new edition of UL 268 includes the following changes in requirements:

Change in Photocell Loading;

Performance Testing Alternative to Conformal Coating Requirements for Low Voltage, Power Limited Circuits;

Requirements for Same Smoke Generation Method used in Sensitivity Testing as Used in Production Testing;

Use of Two Color LEDs; and

Various Editorial Changes

UL Standards for Safety are developed and maintained in the Standard Generalized Markup Language (SGML). SGML -- an international standard (ISO 8879-1986) -- is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Due to formatting differences resulting from the use of UL's new electronic publishing system, please note that additional pages (on which no requirements have been changed) may be included in revision pages due to relocation of existing text and reformatting of the Standard.

The revisions are substantially in accordance with UL's Bulletin(s) on this subject dated March 11, 2005, November 18, 2005, and May 12, 2006. The bulletin(s) is now obsolete and may be discarded.

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

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL provides this Standard ″as is″ without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

UL will attempt to answer support requests concerning electronic versions of its Standards. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports the electronic versions of its Standards only if they are used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Purchasers of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

If a single-user version electronic Standard was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access.

If a multiple-user version electronic Standard was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer, or on an Intranet server. The number of concurrent users shall not exceed the number of users authorized.

Electronic Standards are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of an electronic Standard. Only one copy of the Standard may be printed for each authorized user of a multiple-user version of an electronic Standard. Because of differences in the computer/software/printer setup used by UL and those of electronic Standards purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

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

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

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

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

Page	Date
1-124	September 8, 2006
SA1-SA16	September 8, 2006
A1-A2	September 8, 2006
B1-B2	September 8, 2006

No Text on This Page

UL 268

Standard for Smoke Detectors for Fire Alarm Signaling Systems

Products covered by this standard were previously tested under the Standards for Combustion Products Type Smoke Detectors for Fire Protective Signaling Systems, UL 167, and Photoelectric Type Smoke Detectors for Fire Protective Signaling Systems, UL 168. The First, Second, Third and Fourth Editions were titled Standard for Smoke Detectors for Fire Protective Signaling Systems.

First Edition – September, 1979
Second Edition – June, 1981
Third Edition – May, 1989
Fourth Edition – December, 1996

Fifth Edition

September 8, 2006

The most recent designation of ANSI/UL 268 as an American National Standard (ANSI) occurred on September 8, 2006.

This ANSI/UL Standard for Safety, which consists of the Fifth Edition with revisions through September 8, 2006, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

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

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

ISBN 0-7629-1189-1

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

ASSEMBLY

COMPONENTS

SPACINGS

PERFORMANCE

MANUFACTURING AND PRODUCTION TESTS

MARKING

SUPPLEMENT SA - RELIABILITY PREDICTION AND CRITERIA FOR ACCEPTANCE

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

CRITERIA FOR ACCEPTANCE OF MICROELECTRONIC DEVICES

APPENDIX A

APPENDIX B – OBSCURATION – OPTICAL DENSITY CHART

INTRODUCTION

1 Scope

1.1 These requirements cover smoke detectors intended to be employed in indoor locations in accordance with the National Fire Alarm Code, NFPA 72. These requirements also cover mechanical guards used to provide physical protection to installed smoke detectors.

1.2 A smoke detector, as covered by these requirements, consists of an assembly of electrical components coupled with a sensing means inside of a chamber, or by separate components, to detect smoke. The detector includes provision for the connection to a source of power, signaling, and remote control circuits. A heat detector, or audible signaling appliance, or both, are not prohibited from being incorporated as part of the smoke detector assembly.

1.3 These requirements cover the following types of detectors:

a) Detectors intended for open area protection and for connection to a compatible power supply or control unit for operation as part of a fire alarm system.

b) Detectors intended solely for control of releasing devices such as electromagnetic door holders, fire dampers or smoke dampers.

c) Detectors intended for both the applications described in (a) and (b) above.

1.4 This standard does not cover the following:

a) Control units to which the detectors are intended to be connected that are covered by the Standard for Control Units for Fire-Protective Signaling Systems, UL 864.

b) Self-contained single and multiple station smoke detectors, not intended for connection to a system control unit, that are covered by the Standard for Single and Multiple Station Smoke Alarms, UL 217.

c) A heat detector incorporated as a part of a smoke detector assembly, and covered by the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521; except for the requirements of the Fire Test (Heat Detector).

d) Fire tests for smoke detectors integral with combination door closers and holders that are covered by the Standard for Door Closers-Holders, With or Without Integral Smoke Detectors, UL 228.

e) Commercial-residential detectors not intended for connection to a system control unit that are covered by the Standard for Smoke Detector Monitors and Accessories for Individual Living Units of Multifamily Residences and Hotel/Motel Rooms, UL 1730.

1.5 These requirements also cover all remote accessories that are intended to be connected to a smoke detector.

1.6 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, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined essential to maintain the intended level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific provisions of this standard cannot be judged to comply with this standard. Where identified as appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix 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 statement or

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

2.2.1 When a value for measurement is followed by a value in other units in parentheses, the first stated value is the requirement.

2.3 Undated references

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

3 Glossary

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

3.2 ALARM SIGNAL – A signal indicating an emergency that requires immediate action, such as a signal indicative of fire.

3.3 ALARM VERIFICATION – A feature of automatic fire detection and alarm systems to reduce unwanted alarms wherein smoke detectors report alarm conditions for a minimum period of time, or confirm alarm conditions within a given time period after being reset, in order to be accepted as a valid alarm initiation signal.

3.4 ANNUNCIATOR – A unit containing one or more indicator lamps, alphanumeric displays, or other equivalent means in which each indication provides status information about a circuit, condition, or location.

3.5 COMBINATION SMOKE AND HEAT DETECTOR – A detector that responds to excessive concentrations of smoke or heat.

3.6 COMBINATION SMOKE DETECTOR – A smoke detector that employs more than one smoke detecting principle in one unit. To qualify as a combination smoke detector it is required that each principle either predominate or contribute in response to at least one of the Fire Tests, Section 39, or the Smoldering Smoke Test, Section 40.

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

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

3.9 RISK OF ELECTRIC SHOCK – A risk of electric shock exists at any part when:

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

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

3.10 RISK OF FIRE – A risk of fire exists at any point in a circuit where:

a) The open circuit voltage is more than 42.4 volts 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 shall only be delivered in an external resistor connected between the two points.

3.11 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.

3.12 SMOKE DETECTOR – PROJECTED BEAM TYPE – A type of photoelectric light obscuration smoke detector wherein the beam spans the protected area.

3.13 SMOKE DETECTOR – SAMPLING TYPE – A detector that consists of a piping or tubing distribution network that runs from the detector to the area(s) to be protected. An aspiration fan in the detector housing draws air from the protected area back to the detector through air sampling ports, piping, or tubing. At the detector, the air is analyzed for fire products.

3.14 SMOKE DETECTOR – SPOT TYPE – A device whose detecting element is concentrated at a particular location. Example: chamber of a detector that encloses a radioactive source or light source and photocell assembly.

3.15 SMOKE DETECTOR – TWO-WIRE TYPE – A detector that signals over and obtains its power from the initiating device circuit of a fire alarm system control unit. It is not prohibited to provide additional terminals or leads for annunciation or control of supplementary functions.

3.16 TROUBLE SIGNAL – A signal initiated by the fire alarm system or device indicative of a fault in a monitored circuit or components.

3.17 VOLTAGE CLASSIFICATION – Unless otherwise indicated, all voltage and current values specified in this standard are root-mean-square (rms).

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

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

4 Detector Reliability Prediction

4.1 The maximum failure rate for a detector unit shall be 4.0 failures per million hours as calculated by a full part stress analysis prediction as described in MIL-HDBK 217 or 3.5 failures per million hours as calculated by a simplified parts count reliability prediction as described in MIL-HDBK 217, or equivalent. A ″Ground Fixed″ (GF) environment is to be used for all calculations. When actual equivalent data is available from the manufacturer, it is not prohibited that it 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), or 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,

is not required to be included in the failure rate calculation. Examples include the audible signal appliance, non-compulsory 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 detector.

4.4 A reliable light emitting diode (LED) of a single station smoke detector employing a photocell-light assembly shall have a predicted failure rate of not greater than 2.5 failures per million hours. See 18.1 – 18.3.

4.5 A custom integrated circuit (CHIP) employed in a detector shall have a predicted failure rate of not greater than 2.5 failures per million hours. The failure rate is to be determined through 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 detector. For this purpose, a printed edition is not required. It is not prohibited that the information be included in a manual or technical bulletin.

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

CONSTRUCTION

ASSEMBLY

6 General

6.1 Remote accessories

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

6.2 Sensitivity indicating means

6.2.1 Each detector shall be provided with a means for measuring or indicating the nominal sensitivity or sensitivity range of the detector, as described in 6.2.2, or a sensitivity test feature, as described in 6.2.3, after it has been installed as intended. Removal of a snap-on cover to gain access to the sensitivity control is permissible, only when no high-voltage parts are exposed or are able to be contacted by the user.

6.2.2 Measuring or indicating means include the use of jacks or terminals for connection of a meter, visual indicators (such as a change in frequency of a pulsing light visible with the detector installed), operation of a mechanical device (such as described in 6.2.3), or any arrangement determined to be equivalent.

6.2.3 The test feature is to verify that the sensitivity of the detector is within its marked range. Unless it is employed on a detector that has other means of measuring its sensitivity, the test feature shall consist of either an electrical means or a mechanical device which simulates a specified level of smoke in the sensing chamber or smoke obscuration of a beam.

6.2.4 The use of a plug-in type detector assembly that is removed readily for insertion of an adapter connected to metering equipment is appropriate. A plug-in type detector that is removed readily and connected to metering equipment is also appropriate.

6.2.5 A detector that incorporates a variable sensitivity setting intended to be field adjusted shall have a mechanical stop on the adjusting means for the maximum and minimum settings.

6.3 Radioactive materials

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

6.3.2 Verification of the compliance of such detectors with the requirements of the regulating agency involved shall be obtained prior to, or concurrently with, the establishment of the requirements of this standard.

6.4 Insect guards

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

6.4.2 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).

6.5 Supplementary heat detector

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

6.6 Alarm verification feature

6.6.1 To reduce the effect of electrical and migratory smoke transients, it is not prohibited that a smoke detector to have provision for alarm verification. The alarm verification time shall be 10 to 30 seconds. See 31.8.1, 39.1.3, 40.2, and 74.1 (s).

Exception: It is appropriate for the alarm verification to be included in the related control unit circuit of a smoke detector whose sensitivity is preset at the specific control unit with which it is intended to be employed.

6.6.2 When an alarm verification feature is employed in a detector, a bypass arrangement, readily accessible after installation, shall be provided and shall be resettable after field testing is completed. It is appropriate to include the bypass as part of the sensitivity indicating means described in 6.2.1 – 6.2.4.

Exception: The bypass is not required when the detector complies with the Fire Tests, Section 39, and the Smoldering Smoke Test, Section 40.

6.7 Maintenance (cleanability)

6.7.1 A detector shall be capable of being cleaned without degradation of performance or disturbance of field wiring.

7 Compatibility Information

7.1 General

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

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

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

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

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

7.2 Method of evaluation

7.2.1 In accordance with 7.1.1 – 7.1.5, to determine whether any combination of control unit and smoke detector or detectors is compatible, whether the detectors are the same model or a mixture of one or more models or types, the tests indicated in (a) and (b) are to be conducted:

a) The Dynamic Load Immunity Test in the Standard for Control Units for Fire-Protective Signaling Systems, UL 864.

b) The Two-Wire Smoke Detector Compatibility Tests in UL 864.

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

7.3 Changes affecting compatibility

7.3.1 In the event of modifications to either detectors or control units which result in the possibility of incompatibility with previously installed compatible combinations, the modified product shall be assigned a different model number or the compatibility identification marking of the product shall be changed.

8 Servicing and Maintenance Protection

8.1 General

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

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

8.1.3 The following are not identified as uninsulated live parts:

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

b) Enclosed motor windings;

c) Terminals and splices with insulation determined to be appropriate; and

d) Insulated wire.

8.2 Sharp edges

8.2.1 An enclosure, a frame, a guard, a handle, or similar parts of the construction shall not be sharp enough to constitute a risk of injury to persons in normal maintenance and use.

9 Enclosure

9.1 General

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

9.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two are to be evaluated in determining compliance with the requirement specified in 9.1.1.

9.1.3 All electrical parts of a detector shall be enclosed to reduce the risk of contact with uninsulated live parts. A separate enclosure for field-wiring terminals that are to be enclosed by a back box is not required.

9.1.4 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.

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

9.1.6 To comply with 9.1.4 and 9.1.5, one of the following methods, or their equivalent, shall be used:

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

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

c) An arrangement determined to be equivalent to (a) or (b).

9.1.7 To determine compliance with the requirements of 9.1.4 – 9.1.6 representative detectors shall be subjected to the Smoke Entry (Stack Effect) Test, Section 34.

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

9.1.9 An enclosure shall have provision for the connection of metal-clad cable, conduit, or nonmetallic sheathed cable. An enclosure without such provision shall be used only when the enclosure is furnished with definite instructions indicating the sections of the enclosure that are intended to be drilled in the field for the connection of raceways, or when the detector is intended for mounting on an outlet box.

9.2 Cast metal enclosures

9.2.1 The thickness of cast metal used for an enclosure shall be as indicated in Table 9.1. Cast metal having a thickness 1/32 inch (0.8 mm) less than that indicated in Table 9.1 shall be employed only when the surface under consideration is curved, ribbed, or otherwise reinforced, or when the shape of the surface, size of the surface, or both, are such that equivalent mechanical strength is determined to be provided.

Table 9.1
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.

9.2.2 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 5 threads in the metal, and the construction shall be such that a standard conduit bushing is capable of being attached.

9.2.3 When threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

9.3 Sheet metal enclosures

9.3.1 The thickness of sheet metal employed for the enclosure of a detector shall not be less than that indicated in Table 9.2, except that sheet metal of two gage sizes lesser thickness shall be employed only when the surface under consideration is curved, ribbed, or otherwise reinforced, or when the shape of the surface, the size of the surface, or both, are such that equivalent mechanical strength is determined to be provided.

9.3.2 At any point where conduit or metal-clad cable is to be attached, sheet metal shall have a thickness 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.

Table 9.2
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)	GSG	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

9.3.3 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 inch (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.

9.3.4 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 detector or a standard knockout seal shall be used.

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

9.3.6 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 27.

9.4 Nonmetallic enclosures

9.4.1 An enclosure or parts of an enclosure of nonmetallic material shall 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 9.2. See also the Tests on Polymeric Materials, Section 61.

9.4.2 The continuity of any grounding system intended for a detector connection shall not rely on the dimensional integrity of the nonmetallic material.

9.4.3 Polymeric material 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 successful completion of the Flame Test (5 inch), Section 61.4.

b) Enclosures containing power limited 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 successful completion of the Flame Test (3/4 inch), Section 61.3.

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

9.5 Ventilating openings

9.5.1 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 33/64 inch (13.1 mm). An enclosure for a fuse(s) or other overload protective device and provided with ventilating openings shall not permit the emission of flame or molten metal. Openings provided which permit cleaning of internal parts shall not permit damage to functional internal components during such cleaning operations.

9.5.2 Perforated sheet metal and sheet metal employed for expanded metal mesh shall be not less than 0.042 inch (1.07 mm) in average thickness, 0.046 inch (1.17 mm) when zinc coated.

9.5.3 When the indentation of the guard of enclosure does not alter the clearance between uninsulated live parts and grounded metal so as to reduce spacings below the minimum values required, it is appropriate for 0.021 inch (0.53 mm) expanded metal mesh or perforated sheet metal, 0.024 inch (0.61 mm) when zinc coated, to be employed under the following conditions:

a) The exposed area on any one side or surface of the product is not greater than 72 square inches (464 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).

9.5.4 The wires forming a screen protecting 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.

9.6 Covers

9.6.1 An enclosure cover of a detector 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 to periodically open the cover in connection with the intended operation of the detector.

For the purpose of this requirement, intended operation is identified as operation of a switch for testing or for silencing an audible signal appliance or operation of any other component of a detector that requires such action in connection with its intended performance.

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

9.6.3 When a detector cover is not intended to be removed for cleaning, maintenance, or both, and the detector is intended to be returned to the factory for servicing, the cover shall be secured so that it cannot be readily removed. Exposed screw slots or nuts, other than a tamperproof type, shall be sealed or covered. See 74.1 (q) for supplementary marking.

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

9.6.4 A hinged cover is not required where the only fuse(s) enclosed is intended to provide protection to portions of internal circuits, such as a fuse on a separate printed wiring board or circuit subassembly, to prevent excessive circuit damage resulting from a fault. The use of such a fuse(s) shall be used only when the word ″CAUTION ″ and the following or equivalent marking is indicated on the cover of a detector employing high-voltage circuits: ″Circuit Fuse(s) Inside – Disconnect Power Prior To Servicing. ″ This marking is not required where only low-voltage circuits are involved.

9.6.5 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.

9.7 Glass panels

9.7.1 Glass covering an enclosure opening shall be held securely in place so that it cannot be displaced in service and shall provide mechanical protection of the enclosed parts. The thickness of a glass cover shall not be less than the applicable value indicated in Table 9.3.

Table 9.3
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.

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

a) Have mechanical strength determined to be equivalent to that of glass,

b) Not distort, or

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

9.7.3 A lens, light filter, or similar part of a smoke detector shall be constructed of a material the transparency of which is not impaired by the conditions to which it is exposed in service as represented by the performance tests described in Sections 29 – 69.

10 Corrosion Protection

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

Exception: Parts made of stainless steel, polished or treated when required, do not require additional protection.

10.2 The requirement of 10.1 applies to all enclosures, whether of sheet steel or cast iron, and to all springs and other parts upon which operation depends. It does not apply to minor parts such as washers, screws, and bolts, when the deterioration of such unprotected parts does not result in noncompliance with this standard or impair the operation of the detector.

10.3 Bearing surfaces shall be of such materials that reduce the risk of binding due to corrosion.

10.4 Metal shall not be used in combinations such as to result in galvanic action that results in deterioration of cabinets or enclosures.

10.5 Hinges and other attachments shall be resistant to corrosion.

10.6 Nonferrous cabinets and enclosures do not require special corrosion protection.

11 Field Wiring Connections

11.1 General

11.1.1 A detector 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 electrical rating of the detector. Duplicate terminals or leads, or an equivalent arrangement, shall be provided for circuits supplying operating power to the detector (where the operating power is monitored by an end-of-line device) and for circuits transmitting alarm signals from the detector to the control unit, one for each incoming and one for each outgoing wire. It is not prohibited that a common terminal be used in lieu of duplicate terminals when it is intended to prevent the looping of an unbroken wire around or under a terminal screw in a manner that permits the looped wire to remain unbroken during installation, thereby precluding monitoring in the event the wire becomes dislodged from under the terminal. A notched clamping plate under a single securing screw, where separate conductors are intended to be inserted in each notch, is an equivalent arrangement. When duplicate terminals or leads are used and there is no provision to prevent looping an unbroken wire around or under one terminal, the marking in 76.1.2 (c) shall be provided.

11.2 Field wiring compartment

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

11.2.2 Protection for internal components and wire insulation from sharp edges shall be provided by insulating barriers or metal barriers having smooth rounded edges.

11.2.3 The location of an outlet box or compartment in which field wiring connections are to be made shall be such that inspection of the connections, following installation of the detector as intended, is possible.

11.3 Field wiring terminals

11.3.1 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 shall be provided only when found to be equivalent.

11.3.2 When a wire-binding screw is employed at a field wiring terminal, the screw shall be not smaller than a No. 6 (3.5 mm diameter). It is not prohibited that the screw be plated steel.

11.3.3 A terminal plate tapped for a wire-binding screw shall be of a nonferrous metal not less than 0.030 inch (0.76 mm) thick and shall have not less than two full threads in the metal. See 11.3.4.

11.3.4 It is not prohibited that a terminal plate have the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Other constructions shall be employed only when they are identified as providing equivalent security.

11.3.5 When more than one conductor is to be connected to the same terminal, a nonferrous intervening washer shall be provided for each additional conductor. When the conductors are separated and secured under a common clamping plate, a separate washer is not required.

11.4 Field wiring leads

11.4.1 Leads provided for field connections shall not be less than 6 inches (152 mm) long; shall be provided with strain relief; shall not be smaller than No. 18 AWG (0.82 mm^2); and the insulation, when of rubber or thermoplastic, shall not be less than 1/32 inch (0.8 mm) thick.

11.5 Grounding terminals and leads

11.5.1 A high-voltage detector which is provided with an overall nonmetallic enclosure and cover, is intended to be serviced internally, and employs internal dead metal parts which become energized under fault conditions, requires an equipment grounding terminal or lead, or the equivalent.

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

a) A low-voltage detector;

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

c) A high-voltage detector provided with an overall nonmetallic enclosure and cover, and:

1) That does not employ internal dead-metal parts which are energized under a fault condition and be contacted during servicing, or

2) Having internal dead metal parts that are insulated; or

d) A high-voltage detector provided with an overall nonmetallic enclosure and cover that includes internal dead metal parts which are contacted during servicing, and employs a 2-pole disconnect switch which de-energizes both legs of the supply circuit upon removal of the cover.

11.5.3 The grounding means shall be connected to all exposed dead metal parts that become energized and all dead metal parts within the enclosure that are exposed to contact during servicing and maintenance. See Bonding for Grounding, Section 13.

11.5.4 The surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be green, with or without one or more yellow stripes, and no other leads visible to the installer, other than grounding conductors, shall be so identified. A field wiring terminal intended for connection of an equipment grounding conductor shall be plainly identified, such as by being marked ″G,″ ″GR,″ ″Ground,″ ″Grounding,″ or the equivalent, or by a marking on a wiring diagram provided on the detector. The field wiring terminal shall be located so that it won’t to be removed during servicing of the detector.

11.6 Grounded supply terminals and leads

11.6.1 A field wiring terminal for the connection of the grounded supply conductor of a high-voltage circuit shall be identified by means of a metallic plated coating substantially white in color and shall be readily distinguishable from the other terminals, or 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.

11.6.2 A field wiring lead provided for connection of the grounded supply conductor of a high-voltage circuit shall be finished to show a white or natural gray color and shall be readily distinguishable from other leads and no other leads visible to the installer, other than grounded conductors, shall be so identified.

11.6.3 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 which has an OFF position or to a single-pole overcurrent (not thermal) protective device.

11.7 Isolated (nongrounded) detectors

11.7.1 When a detector is constructed such that the exposed metal enclosure serves as a current-carrying part of the circuit, an insulated (nonmetallic) mounting plate, or a metal mounting plate with insulated bushed holes through which metal mounting screws are employed, or an equivalent arrangement shall be provided for installation between the detector current-carrying parts and metal back box.

11.7.2 The arrangement described in 11.7.1 is permitted only on a detector intended for connection to a low-voltage circuit. In addition, the word ″CAUTION″ and the following or equivalent marking is to be displayed in letters at least 1/8 inch (3.2 mm) high adjacent to the detector wiring area: ″INSTALL ENCLOSURE ISOLATED FROM GROUND PER MANUFACTURER'S INSTRUCTIONS AND HARDWARE PROVIDED. GROUNDING COULD RESULT IN A FALSE ALARM.″

12 Internal Wiring

12.1 General

12.1.1 The internal wiring of a detector shall consist of conductors having:

a) Insulation rated for the potential involved,

b) Insulation rated for the temperatures to which they are subjected, and

c) The current-carrying capacity for the service.

The wiring shall be routed away from the moving parts and sharp projections and held in place with clamps, string, ties, or the equivalent, unless the wiring is determined to be rigid enough to retain a shaped form.

12.1.2 Leads, or a cable assembly, connected to parts mounted on a hinged cover, shall 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 reduce the risk of insulation abrasion and jamming between parts of the enclosure.

12.1.3 When the use of a short length of insulated conductor is not feasible, such as for a short coil lead, it is not prohibited for electrical insulating tubing to 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 with 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).

12.1.4 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 is to be accomplished by clamping, routing, or equivalent means that provide permanent separation.

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

12.2 Wireways

12.2.1 Wireways shall be smooth and free from sharp edges, burrs, fins, and moving parts that result in the abrasion the conductor insulation.

12.3 Splices

12.3.1 All splices and connections shall be mechanically secured to preclude shorting to adjacent uninsulated current carrying parts in the event that an improper connection such as a cold solder joint is made. Tack soldering is permitted where the construction precludes mechanical security only when 5 samples resist a pull-force of 2 lbs (8.9 N) applied for 3 seconds and the connection is subjected to 100 percent inspection and testing with the same pull force by the manufacturer.

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

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

12.4 Barriers

12.4.1 A metal barrier shall have a thickness at least equal to that required by Table 9.2 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 it is possible for deformation which defeats its purpose to be easily accomplished. Any clearance between the edge of a barrier and a compartment wall shall not be more than 1/16 inch (1.6 mm).

12.5 Strain relief

12.5.1 A strain relief means shall be provided for the field supply leads and all internally connected wires or cords that are subject to movement in conjunction with the installation, operation, or servicing of a detector to reduce the risk of any mechanical stress being transmitted to internal connections and terminals. Inward movement of the cord or leads provided with a ring-type cord grip shall not damage internal connections or components, or result in a reduction of the electrical spacings required. See the Strain Relief Test, Section 62.

13 Bonding for Grounding

13.1 An exposed noncurrent-carrying metal part of a high-voltage detector 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. See 11.5.1.

13.2 Uninsulated metal parts of electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors, and other electrical components shall be bonded for grounding when it is possible that they be contacted by the user or by a serviceman in servicing or operating the equipment.

13.3 Metal parts as described below are not required to comply with the requirement specified in 13.2 :

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

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

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

d) Panels and covers which 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.

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

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

13.6 A bolted or screwed connection that incorporates a star washer under the screwhead is appropriate for penetrating nonconductive coatings.

13.7 When the bonding means depends upon screw threads, two or more screws or two full threads of a single screw engaging metal is appropriate.

13.8 Metal-to-metal hinge-bearing members for doors or covers shall be used as a means for bonding the door or cover for grounding only when a multiple bearing-pin type hinge is employed.

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

COMPONENTS

14 General

14.1 Mounting of components

14.1.1 A switch, lampholder, attachment-plug receptacle, plug connector, or similar electrical component, and uninsulated live parts shall be mounted securely and shall not turn.

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 of a plunger or other type that does not tend to rotate when operated. A toggle switch is subject to forces that tend to turn the switch during operation of the switch.*
>
> *b) The means for mounting the switch makes so that the operation of the switch shall loosen 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 the direct contact by persons.*

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

14.1.2 Uninsulated live parts shall be secured to the base or mounting surface so that they shall not turn or shift in position, when it is possible that such motion results in a reduction of spacings. Friction between surfaces shall not be used as a means to prevent shifting or turning of live parts, a lock washer applied as intended is appropriate.

14.1.3 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 shall not turn or shift in position when such motion results in reduction of spacings below the minimum values required. This is to be accomplished by two screws or rivets, by square shoulders or mortices, by a dowel pin, lug, or offset, by a connecting strap or clip fitted into an adjacent part, or by any method determined to be equivalent.

14.2 Operating components

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

14.2.2 Adjusting screws and similar adjustable parts shall not loosen under the conditions of actual use. The use of a lock washer, applied as intended, to reduce the risk of loosening is appropriate.

14.3 Current-carrying parts

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

14.3.2 Parts such as bearings and hinges shall not be used to carry current between fixed and moving parts.

15 Bushings

15.1 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, that shall be substantial, secured in place, and have a smooth, rounded surface to provide support for the wire.

15.2 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 identified as the equivalent of a bushing.

15.3 Ceramic materials and some molded compositions are not prohibited for insulating bushings, separate bushings of wood and of hot-molded shellac are prohibited.

15.4 Fiber shall be employed only where:

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

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

c) It does not deteriorate in normal ambient humidity conditions.

15.5 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, projections, and other anomalies which cut into the bushing and wire insulation.

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

16 Electrical Insulating Material

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

16.2 Polymeric materials are to be used for the sole support of uninsulated live parts only when determined to be equivalent to the materials indicated in 16.1.

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

16.4 The thickness of a flat sheet of insulating material, such as impregnated asbestos-cement composition or phenolic composition employed for panel mounting of parts, shall not be less than the applicable value indicated in Table 16.1.

16.5 A terminal block mounted on a metal surface which is 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 to reduce the risk of the parts and the ends of replaceable terminal screws from reducing spacings below the minimum values required.

Exception: Such insulation is not required when the parts are staked, upset, sealed, or equivalently kept from loosening.

Table 16.1
Thickness of flat sheets of insulating material

Maximum dimensions				Minimum thickness,[a]	
Length or width,		Area,			
inches	(mm)	$inches^2$	(cm^2)	inch	(mm)
6	152	36	232.4	1/16	0.16
12	305	144	928.8	1/8	0.32
24	610	360	2322	3/8	9.5
48	1219	1152	7432	1/2	12.7
48	1219	1728	11148	5/8	15.9
Over 48	Over 1219	Over 1728	Over 11148	3/4	19.1

[a] Material less than the minimum thickness shown shall be used for a panel only when the panel is supported or reinforced to provide equivalent rigidity.

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

17 Lampholders and Lamps

17.1 Lampholders and lamps shall be rated for the circuit in which they are employed.

17.2 A lampholder employing a metal shell, such as a screw shell, used in a high-voltage circuit shall be wired so that the metal shell is connected to an identified (grounded circuit) conductor. When more than one lampholder of this type is provided, the metal shells of all such lampholders shall be connected to the same conductor.

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

17.4 When more than one lamp is provided on the detector, a ″power-on″ lamp shall be white or green, an alarm indicating lamp shall be red, and a trouble lamp shall be amber or yellow. Other colors for the ″power-on″ lamp shall be used only when the lamp is marked to identify the function.

17.5 When two or more color indications are used to visually annunciate detector status, one color must be designated for normal indication and mode of operation. If the color for normal operation is other than white or green, the lamp shall be marked to identify the function. An alarm indication must be red. Use of alternative colors or indication flash rates for non-alarm conditions shall not be prohibited.

17.6 A lamp or equivalent means shall be provided on a spot-type detector head or base to identify it as the unit from which the alarm was initiated.

Exception: The alarm-indicating-means is not required on a detector whose use is restricted to a specific control unit that identifies the individual detector in alarm.

18 Photocell Illuminating Lamps

18.1 A limited life component such as an incandescent lamp, or a light emitting diode (LED) that is used as a light source of a smoke detector photocell light assembly, shall comply with the requirements specified in the Electrical Supervision Test, Section 30.

18.2 To be determined reliable, an LED shall have a predicted failure rate of less than 0.25 percent per 1000 hours (2.5 failures per million hours), and shall comply with the requirements specified in 30.3.3 and 30.3.4. In addition, the operating conditions of the LED in the detector circuit, as well as the LED and detector manufacturer's Quality Assurance (QA) Programs, are to be evaluated as to the level of reliability they provide.

18.3 A reliable LED that complies with the requirement specified in 18.3 shall additionally comply with the requirements specified in the Reduction in Light Output Test, Section 36, and the electrical supervision requirements described in 30.3.1 – 30.3.5.

19 Motors

19.1 A motor shall be protected against overheating under normal and abnormal operating conditions.

19.2 A fan motor shall be protected by thermal or overcurrent protective devices or shall be of the impedance-protected type. See the Locked Rotor Test, Section 58. A thermal or overcurrent protective device shall not open the circuit during the Temperature Test, Section 44.

19.3 A motor having openings in the enclosure or frame shall be arranged so that particles dropping out of the motor shall not fall onto flammable material within or under the detector.

20 Protective Devices

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

21 Printed Wiring Boards

21.1 Printed wiring boards shall comply with the Standard for Printed-Wiring Boards, UL 796. The components of a printed wiring board shall be attached securely and the spacings between circuits shall comply with the spacing requirements for rigidly clamped assemblies (see Table 27.1). The board shall be mounted so that deflection of the board during servicing shall not result in damage to the board or in a reduction of electrical spacings below those required in this standard.

22 Switches

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

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

Exception: A non-self-restoring switch shall be employed only when a related audible trouble signal is to be obtained from the control unit to which the detector is connected, with the switch in the "off-normal" position.

23 Transformers and Coils

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

Exception: An autotransformer shall be used only when the terminal or lead connected to the autotransformer winding that is common to both input and output circuits is identified and the output circuits are located only within the enclosure containing the autotransformer. See 11.6.1 and 11.6.2.

23.2 The insulation of coil windings of relays, transformers, and other insulation, shall resist the absorption of moisture.

23.3 Film-coated or equivalently insulated wire does not require additional treatment to stop moisture absorption.

24 Dropping Resistors

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

25 Heat Detector

25.1 The temperature rating of a heat detector provided on a combination smoke and heat detector shall not be greater than 60°C (140°F), unless the smoke detector has been investigated and found appropriate for installation at a higher temperature.

26 Batteries

26.1 General

26.1.1 When a battery or set of batteries is employed as the main source of power for a smoke detector, it shall comply with the requirements of the Battery Tests, Section 68.

26.1.2 Batteries included as part of a detector shall be located and mounted to reduce the likelihood of terminals of cells coming in contact with uninsulated live parts, terminals or adjacent cells, or metal parts of the enclosure as a result of shifting.

26.1.3 A battery compartment intended for use with rechargeable batteries that emit gases during charging shall be provided with vent holes and a coating that is resistant to the corrosive action of the electrolyte.

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

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

26.2 Battery connections

26.2.1 A lead or terminal assembly connection to a battery shall be provided with strain relief and shall be identified with the proper polarity (plus or minus signs) unless the intended connection is determined by the terminal configuration. It is not prohibited for polarity to be indicated on the unit adjacent to the battery terminals or leads.

26.2.2 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 that 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 that is resistant to the corrosive action of the electrolyte.

26.2.3 Each lead of a clip-lead assembly employed as a part of a battery operated detector shall not be smaller than No. 26 AWG (0.21 mm^2) stranded wire, and the insulation shall not be less than 1/64 inch (0.4 mm) thick.

SPACINGS

27 General

27.1 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 27.1.

27.2 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 27.1.

27.3 The ″Through Air″ and ″Over Surface″ spacings of Table 27.1 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 spacing 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-ampere ratings of all components in the enclosure.

27.4 The spacing requirements specified in Table 27.1 do not apply to the inherent spacings inside motors, except at wiring terminals, nor to inherent spacings for a component provided as part of the detector. Such spacings are judged on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete device, including clearances to dead metal or enclosures, shall be as indicated in Table 27.1.

27.5 The ″To Walls of Enclosure″ spacings of Table 27.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

27.6 Film-coated or equivalently insulated wire is identified as an uninsulated live part. Enamel is capable of being used as turn-to-turn insulation in coils.

Table 27.1
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 (0.71 mm) thick. When a liner or barrier is used which is less than 0.028 inch, and not less than 0.013 inch (0.33 mm) thick, it shall be used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it is not affected adversely by arcing. When insulating material having a thickness of less than that specified is used, it shall be found to be appropriate for the particular application.

[b] Measurements are to be made with solid wire of an ampacity that is intended 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 and printed wiring boards.

[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 69.

PERFORMANCE

28 General

28.1 Test units and data

28.1.1 Detectors that are fully representative of production units are to be used for the tests specified in Sections 29 – 69, unless otherwise specified. The sensitivity setting or range of sensitivities provided on the units for test define the production sensitivity.

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

28.2 Test voltages

28.2.1 Unless otherwise specified, the test voltage for each test shall be as specified in Table 28.1 and at rated frequency.

Table 28.1
Test voltages

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

[a] The voltage rating shall be applied at the voltage waveform(s) specified in the markings. See 74.1 (c).
[b] Detectors rated at frequencies other than 60 hertz are to be tested at their rated nameplate voltage and frequency.

28.3 Test samples and data

28.3.1 The following samples and data are required. The data required in (g) and (h) does not have to be in final printed form.

a) At least 28 assembled spot type detectors, 12 preset (as close as intended production calibration permits) to the nominal maximum production sensitivity (most sensitive setting), and 16 preset (as close as intended 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 preset to the minimum sensitivity shall be calibrated so that the sensitivity of any individual unit does not vary more than 25 percent from any other unit in each setting, and shall establish the maximum and minimum sensitivities to be employed in production. Combination smoke detectors are to be provided with means for monitoring each principle of operation during the Sensitivity Test, Section 31.

b) One additional unassembled spot type detector.

c) Six photocell and light assemblies of a projected beam type detector.

d) Three control units, or three power supplies, or both, when the detectors are intended to be employed only with a specific unit or power supply.

e) Three additional samples of detectors that operate on the photoelectric principle, provided with means to reduce the light output as described in 36.2.

f) The monitoring instrument, or reference to a readily available instrument, intended to monitor the sensitivity of the detector.

g) Installation wiring diagram and operating instructions. At least two detectors shall be shown connected in the installation wiring diagram. See 5.1 and 5.2, and Installation Instructions–Wiring Diagram, Section 76.

h) Copy of the Technical Bulletin. See Technical Bulletin, Section 77.

28.4 Component reliability data

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

28.4.2 The data required by 28.4.1 shall include the following or equivalent information:

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

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

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

d) A description of component screening and burn-in test data for solid-state devices or integrated circuits that operate at greater than the limits described in note b of Table 44.1.

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

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

g) For a detector employing a reliable LED as the photocell illuminating light source the data specified in the Overload Tests, Section 54.

28.5 Remote accessories

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

28.6 Detector guards

28.6.1 Mechanical detector guards for use in providing physical protection to an installed smoke detector are to be subjected to the following tests (in conjunction with the smoke detector) as applicable:

a) Normal Operation Test (Section 29);

b) Sensitivity Test (Section 31);

c) Velocity-Sensitivity Test (Section 33);

d) Reduction in Light Output Test (Section 36);

e) Fire Tests (Section 39);

f) Smoldering Smoke Test (Section 40); and

g) Audibility Test (Section 67).

29 Normal Operation Test

29.1 General

29.1.1 A detector shall operate for all conditions of its intended performance, at all sensitivity settings, when used in conjunction with any related power supply or control unit with which it is intended to be employed, and with indicating devices used to form the system combination covered both by the installation wiring diagram and by any supplementary information provided.

29.1.2 The test voltage is to be in accordance with 28.2.1 and the detector is to be in the standby condition and prepared for its intended signaling operation when it is connected to related devices and circuits.

29.1.3 The introduction of smoke into the detector chamber, such as from a smoldering cotton lamp wick, shall result in the operation of the detector in its intended manner, and the means incorporated to identify the initiation of an alarm shall remain activated after the smoke has dissipated from within the detector.

29.1.4 When a heat detector is provided integral with a smoke detector, actuation of the heat detector shall result in the same type of alarm signal as when actuated by smoke.

29.1.5 Neither principle of operation of a combination smoke detector shall be rendered inoperative by any of the Performance Tests (Sections 29 – 69) of this standard. A circuit analysis is to be made, supplemented by electrical measurement when required, to determine that both principles of operation contribute to detector operation.

29.1.6 When an audible alarm signaling appliance is provided integral with a smoke detector, the alarm shall be energized by any one of the following conditions:

a) Operation of the test means,

b) Introduction of an abnormal amount of smoke, or

c) Reception of an alarm signal from the connected control unit.

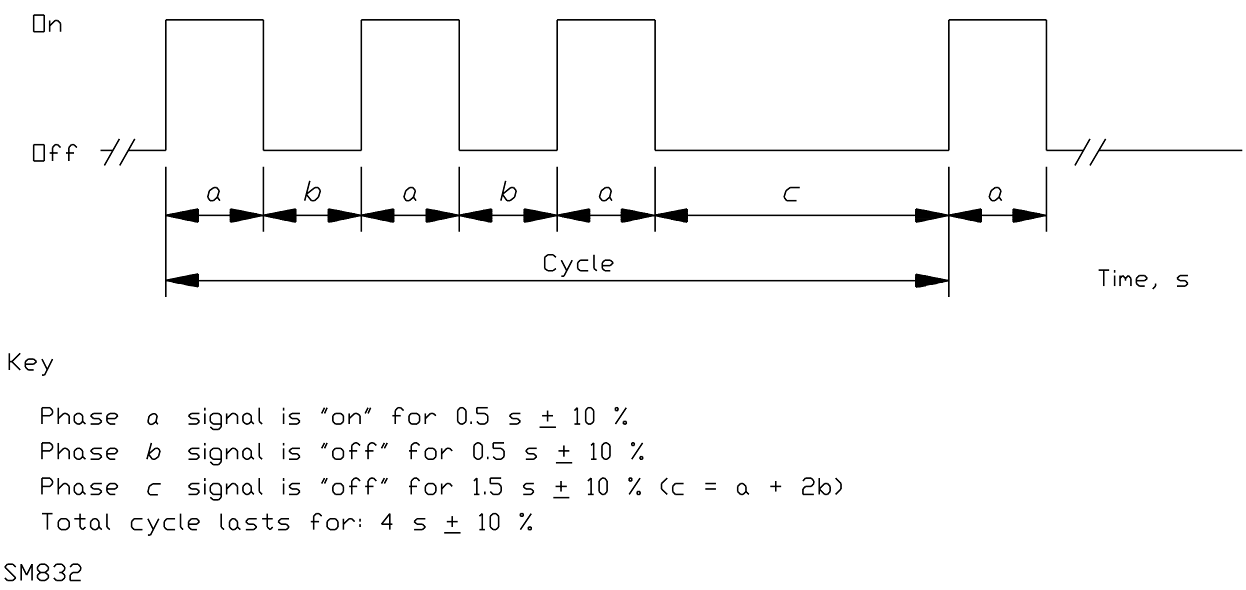
29.2 Standardized alarm signal

29.2.1 A detector that produces an audible signal which is intended to initiate immediate evacuation from the protected area, shall produce the signal in the form of the ″three pulse″ temporal pattern shown in Figure 29.1. 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. Where the intended action is not immediate evacuation, the audible signal shall produce an alert signal distinctive from the ″three pulse″ temporal system.

29.3 Sensitivity shift criteria

29.3.1 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 31.1.1.

Figure 29.1
Standardized alarm signal temporal pattern



30 Electrical Supervision Test

30.1 General

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

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

b) Failure of a limited-life component. See 3.7,

c) De-energization of the detector power supply circuit, and

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

30.1.2 The requirements in 30.1.1 do not apply to the following:

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

b) Circuits for trouble-indicating devices.

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

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

e) The leads of a trickle-charged battery.

f) A circuit for a supplementary signal annunciator, signal-sounding appliance, motor controller, or similar appliance, only when a break, short circuit, or ground fault in no way affects the operation of the detector other than to result in the omission of the supplementary feature.

30.1.3 A motor included in a detector, such as a blower motor that is required to operate continuously during operation, shall be monitored to indicate motor stalling or burnout. Motor stalling or burnout shall not result in a risk of fire.

30.1.4 Interruption and restoration of any source of electrical power connected to a detector shall not result in an alarm signal.

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

30.1.6 When one leg of the power supply system to a detector is intended to be connected to a grounded circuit, a ground fault in the other leg shall result in an audible trouble signal at either:

a) The detector,

b) The control unit, or

c) The power supply to which the detector is connected.

Such faults shall not result in an alarm signal.

30.1.7 To determine that a detector complies with the requirements for electrical supervision, the detector is to be tested with the representative system combination in the standby condition, and the type of fault to be detected is then to be introduced. Each fault is to be applied separately, the results noted and the fault removed. The system combination is then to be restored to the standby condition prior to establishing the next fault.

30.2 Component failure

30.2.1 Failure of a limited life electronic component, such as opening or shorting of electrolytic capacitors, shall be indicated by a trouble signal or a reliable component shall be used. Failure of the component shall not result in a risk of fire or electric shock.

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

30.2.3 The heaters of all electronic tubes or other functional heating elements employed in a detector shall be electrically monitored to indicate an open circuit fault by a trouble signal when the fault prevents operation of the detector or results in loss of sensitivity.

30.2.4 In determining that a detector complies with the requirement with respect to failure of a limited life component, the fault condition, open or short, is to be applied, in turn, with the detector connected to a source of supply in accordance with the requirements in 28.2.1. See also the Abnormal Operation Test, Section 57.

30.3 Photocell illuminating lamps

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

30.3.2 In detectors employing a limited life LED light source, the source shall be monitored for an open, short, or, except as exempted in 30.3.3, 50 percent or greater light degradation, by means of a trouble signal. Failure of the light source shall not result in an alarm signal. See 3.2.

30.3.3 A 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 maximum failure rate prediction described in 18.3.

30.3.4 When the light output of an LED source lamp is reduced to the 50 percent level or the average level achieved by the LED during its previous evaluation program, the detector shall comply with the requirements of the Fire Tests, Section 39, and the Smoldering Smoke Test, Section 40.

30.3.5 In detectors employing a reliable LED light source, the source does not have to be monitored. It is not prohibited for failure of the reliable LED to result in an alarm signal at the end of the failure rate prediction described in 3.8.

30.4 Battery powered units

30.4.1 A detector that 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 a trouble signal is obtained, followed by 7 days of trouble signal indication.

30.4.2 To determine compliance with 30.4.1, three samples are to be equipped with batteries that 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, to deplete a 1000 milliampere-hour rated battery, allow a 10 milliampere (1 percent load) or less drain, continuously, until the battery voltage reaches the predetermined test level.

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

30.4.4 To determine compliance with 30.4.3, two samples of a detector that locks in on an alarm mode are to be equipped with batteries that have been depleted and stabilized at a level 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 a trouble mode when the battery trouble voltage is reached. The trouble signal shall persist for seven consecutive days. When the battery voltage recovers to a point where the trouble signal is no longer emitted, the units are to be placed into alarm again until the trouble signal is reinstituted.

30.4.5 A decrease in the battery capacity of a detector that 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 a trouble signal. The trouble signal shall be produced at least once each minute for seven consecutive days.

30.5 Chamber monitoring (Required only when the detector employs a chamber monitoring feature)

30.5.1 The clean-air condition of a smoke detector chamber shall be monitored for contamination. A trouble signal shall be indicated at the detector before the clean-air reference value changes by more than 50 percent of the shift required to place the detector into alarm.

30.5.2 Two detectors, one set at maximum and one set at minimum sensitivity, are to be used for the test. Each detector is to have the clean-air reference value in the smoke detector chamber gradually adjusted over a 48-hour period in increments not exceeding 1/14 of the value required to reach 50 percent of the shift that places the detector into alarm. The reference value is to be adjusted not more than once each hour.

31 Sensitivity Test

31.1 General

31.1.1 A spot type smoke detector when calibrated to each end of its production window shall operate within the limits specified in (a) when subjected to a smoldering smoke or aerosol buildup condition using the test equipment described in 31.2.1 – 31.4.3, and when subjected to a range of air velocities. The smoke generating method used for this test (i.e., smoldering cotton lamp wick or aerosol generator) shall be the same as the method selected by the manufacturer for compliance with the required production tests (refer to Section 72) and shall be so documented in product reports and procedures created to document compliance to this standard. When the detector employs a variable field adjustable sensitivity setting, test measurements are to be made at maximum and minimum settings. The sensitivity measurement is to be made with the detector located in the air stream in the least and most favorable horizontal positions for smoke entry as determined in the Directionality Test, Section 32. When a detector employs alarm verification [see 74.1 (s)], the sensitivity measurements are to be made with and without the alarm verification bypass applied. When a detector evaluated for a special application employs sensitivities outside of the range specified in (a), it shall have been evaluated using the sensitivities use in the conditions covered by the detector’s Technical Bulletin (see Technical Bulletin, Section 77).

a) Visible Smoke Obscuration Limits (Gray Smoke):

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

(b) Measuring Ionization Chamber (MIC) Measurement:

93 pA (minimum) – 37.5 pA (maximum)

31.1.2 A projected beam-type smoke detector employing a light beam projected across a protected space to a separate light-receiving unit shall not operate with less than 0.2 percent per foot (0.65 percent per meter) [0.00087 O.D. per foot (0.0029 O.D. per meter)] obscuration of its light beam and shall operate when the light it transmits through clear air is obscured by smoke by an amount:

a) Equal to or less than 2 percent per foot (0.3 m) of length of its light beam for lengths of 22 feet (6.7 m) or less,

b) Not more than 36 percent total obscuration of its light beam for lengths of 22 to 44 feet (6.7 to 13.4 m), and

c) Equal to or less than 1 percent per foot (0.3 m) of its light beam for lengths of more than 44 feet (13.4 m).

31.1.3 The sensitivity tests are to be conducted as follows:

a) Spot Type Detector – By means of the test chamber. See 31.4.3 and

b) Projected Beam Type Detector – By means of transparencies calibrated in the test chamber.

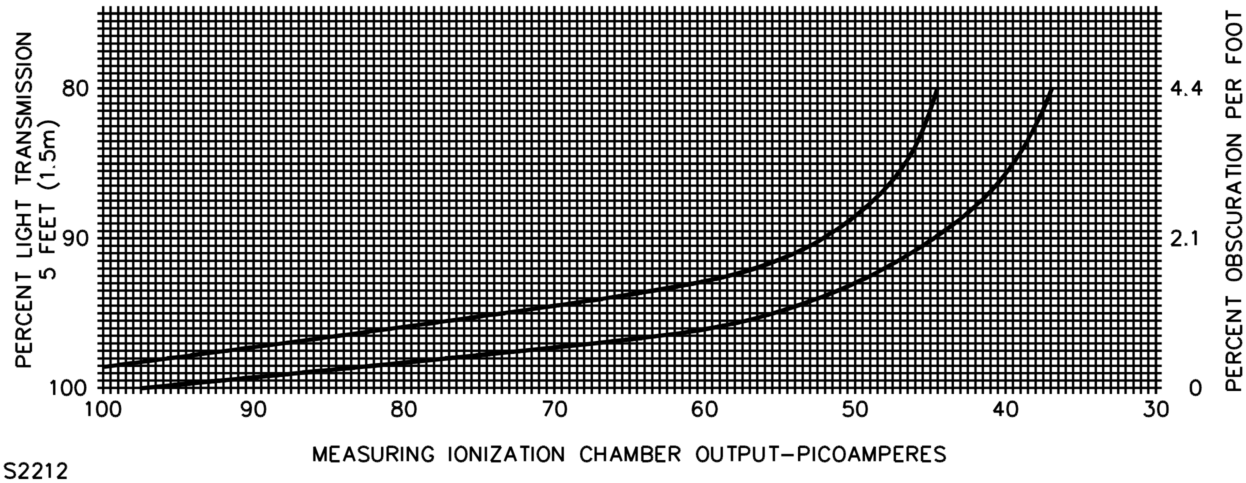
31.2 Combustibles

31.2.1 A cotton lamp wick, nominally 1/8 inch (3.2 mm) in diameter, a minimum of 5 inches (127 mm) long and secured by a thin wire inserted through one end, is to be employed as the source of smoke. Prior to use, the wick is to be conditioned at least 72 hours at 45°C (113°F) and 10 percent or less relative humidity. It is then to be stored in a desiccator at room temperature and 10 percent or less relative humidity. The wick end is to be cut square and smoldering initiated by momentarily placing the wick end over a horizontally mounted resistive heater element energized to a dull red color. Upon ignition, it is possible for momentary flaming to occur for 1 second, after which the flame is to be extinguished. The wick is then permitted to smolder a minimum of 30 seconds before being placed in the chamber. The smoldering rate of the wick is to be such that the relationship between the MIC output and the percent light transmission remains within the curves illustrated in Figure 31.1. The visible smoke buildup rate is to be maintained within the limits illustrated in Figure 31.2. For black smoke, a small kerosene lamp with a 1/4 inch (6.4 mm) wide wick [the flame is to be shielded with the cylinder described in 31.4.3 (n)] is to be placed outside the test compartment and the smoke permitted to enter through an inverted funnel-pipe arrangement.

31.3 Aerosol generation equipment (alternate method)

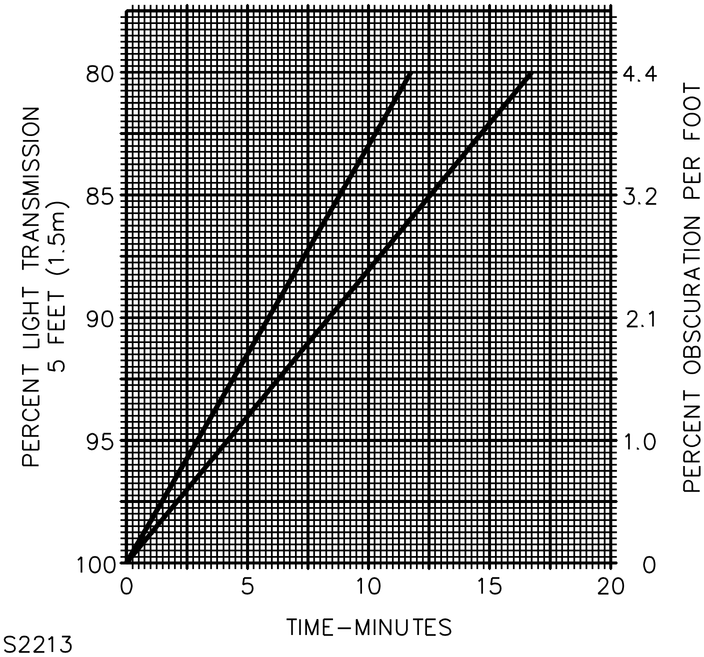
31.3.1 The equipment used shall generate the buildup rates specified in Figures 31.1 and 31.2.

Figure 31.1
Sensitivity test limits
Gray smoke – cotton wick/aerosol – 32 fpm
Room ambient temperature, 85 percent relative humidity



S2212

Figure 31.2
Smoke build-up rate – sensitivity test
Gray smoke – cotton wick/aerosol – 32 fpm
Room ambient temperature, 85 percent relative humidity



31.4 Test equipment

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

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

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

in which:

O_u is percent obscuration per foot (or per meter),

T_s is smoke/aerosol density meter reading with smoke,

T_c is smoke/aerosol density meter reading with clear air, and

d is distance in feet (or meters).

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

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

in which:

O_d is percent obscuration at distance d,

T_s is smoke/aerosol density meter reading with smoke, and

T_c is smoke/aerosol density meter reading with clear air.

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

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

in which:

T_d *is percent transmission at distance d,*

T_s *is smoke/aerosol density meter reading with smoke, and*

T_c *is smoke/aerosol density meter reading with clear air.*

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

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

in which:

O_d *is percent obscuration at distance d,*

O_u *is percent obscuration per foot (or per meter), and*

d is distance in feet (or meters).

e) At any distance, the total optical density shall be:

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

in which:

OD_t is optical density,

T_c is smoke/aerosol density meter reading with clear air, and

T_s is smoke/aerosol density meter reading with smoke.

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

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

in which:

OD is optical density per foot (or per meter),

T_c is smoke/aerosol density meter reading with clear air,

T_s is smoke/aerosol density meter reading with smoke, and

d is distance in feet (meters).

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

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

[b] One MIC suitable for this purpose is Electronikcentralen, Horsholm Denmark, Type EC 23095 measuring ionization chamber.

31.4.3 A typical test chamber consists of the following items. When other chamber configurations are used they shall provide a homogeneous smoke/aerosol mix and a laminar air flow across the detector, adjustable from 30 to 150 feet per minute (fpm) (0.16 to 0.76 m/s).

a) Outer Cabinet – Constructed of 3/4-inch (19.1-mm) exterior grade plywood, and having overall inside dimensions of 65-3/4 inches (1.67 m) length by 18-1/4 inches (464 mm) depth by 18-1/8 inches (460 mm) width. Has a centrally located gasketed hinged top door 33-7/8 inches (860 mm) wide in the top with a 14-1/2 by 24-inch (368 by 610-mm) clear plastic window. A 1/4-

inch (6.4-mm) diameter hole is located in the window center for air flow measurement. Box is provided with a 7-inch (178-mm) diameter exhaust port in the right end, centered 4-1/2 inches (114 mm) above the bottom and employed with a sliding or hinged wooden cover.

b) Inner Compartment – Constructed of 3/4-inch (19.1-mm) plywood, having inside dimensions of 41-3/4 inches (1.06 m) length by 11-1/2 inches (292 mm) height covering the entire width of the inside of the outer cabinet. The left end has a 4-inch (102-mm) diameter hole for the 30 – 35 fpm circulating fan centered 4-1/2 inches (114 mm) from the side and 3-7/8 inches (98 mm) from the bottom rear corner, a 5-3/4-inch (146-mm) diameter hole for the 150 fpm circulating fan centered 3-7/8 inches (96.1 mm) above the bottom, and a 4-inch (102-mm) diameter hole for the light beam centered 3 inches (76.2 mm) in either direction from the top back corner. The right end is the same as the left end except that it has one additional 4-inch (102-mm) diameter hole centered 3 inches (76.2 mm) in either direction from the top front corner. Nominal 5/8-inch (15.9-mm) molding strips are used to secure the end pieces and the top. All interior surfaces are painted with a flat black paint.

c) Circulating Fan (150 fpm)[c] – 250 cubic feet per minute (cfm) (0.12 m^3 /s); rated 115 volts, 60 hertz, 5-3/4-inch (146-mm) diameter. The fan, located on either side of the opening, is connected to a motor controller (autotransformer), see (o), for variable speed adjustment.

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

d) Circulating Fan (30 – 35 fpm)[e] – 110 cfm (0.05 m^3 /s), rated 8 – 28 volts DC (24 volts DC nominal), 6 watts (at 24 volts DC), 4.69 inches (119 mm) square. The fan is connected to a regulated DC power supply.

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

f) Photocell[f] – Selenium barrier layer type, 1.5-inch (38-mm) diameter for active area. Photovoltaic cell active material is sealed against environment and mounted on a 3/4-inch (19.1 mm) plywood bracket 5 inches (127 mm) behind a panel that has a 2-1/2-inch (63.1-mm) diameter hole to limit the detection of forward-scattered light. Photocell has a 25 percent maximum deviation from true linearity at 200 foot-candles (2152 lm/m^2) with a 200 ohm load resistance, and has a sensitivity of 4.4 ±0.3 microamperes per foot-candle (0.416 ±0.046 microamperes per lm/m^2) flowing through a 200 ohm load (meter resistance or other). The photocell (in use) is loaded with a nominal 100 ohm, 1 percent load, trimmed with a 10,000 ohm, ten turn potentiometer placed across the loaded photocell in a configuration which has negligible affect on the total photocell load regardless of the potentiometer setting, as shown in Figure 31.3 and is nominally illuminated at 22 foot-candles (236.7 lm/m^2). Spectral response peak is between 530 and 580 nanometers with 30 percent sensitivity response at 350 and 660 nanometers.

g) Airstream Deflector – Constructed of sheet aluminum, 18 inches (457 mm) wide by 15-1/2 inches (394 mm) long, secured at each end by screws to two 3/4-inch (19.1-mm) thick plywood sections; each section is to be 8-5/8 inches (219 mm) high, 9-1/4 inches (235-mm) long (adjacent to top of test box) with a 10-inch (254-mm) radius curved section to which the deflecting plate is to be attached. The plate is to extend 1 inch (25.4 mm) beyond the upper edge and 5/8 inch (15.9 mm) beyond the lower edge. Each plywood cutout is to be secured to the side wall of the test compartment.

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

i) Screen – Constructed of screening material of 0.01-inch (0.3-mm) aluminum wire, having nominal 1/16 inch (1.6 mm) square openings, 18-1/8 inches (460.0 mm) long by 7 inches (178 mm) wide. To be wedged adjacent to airstream straightener.

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

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

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

m) Lamp – Low-voltage automotive spotlight, Type 4515 or equivalent, rated at 6 volts DC, and mounted on 3/4-inch (19.1-mm) plywood bracket 4 inches (102 mm) from the side wall in line with the photocell. The distance from the lamp (lens face) to photocell is to be exactly 5 feet (1.52 m). The lamp is to be operated from a voltage regulated supply at 2.40 volts. Exact specifications: the lamp voltage is to be adjusted to a level that yields a lamp color temperature of 2373 ±50 Kelvin. At that level, the photocell current is to be 100 ±25 microamperes into 100 ohms. The lamp is not to result in random meter fluctuations.

n) Combustible Holder and Screen (32 fpm velocity) – Steel cylinder open on both ends, having 3-inch (76.2-mm) diameter by 6-inch (152.4-mm) height with 1/8-inch (3.2-mm) diameter holes on 9/32-inch (7.1-mm) centers. Smaller 1/32-inch (0.8-mm) diameter holes spaced 3/32-inch (2.4-mm) on centers are arranged in 9/32-inch (7.1-mm) squares around each larger hole. Wick is held vertically by a wire in the center of and is supported by the screen. Combustible is cotton lamp wick with the smoldering end pointing downward so as to extend 5 inches (127 mm) into screen.

o) Combustible Holder and Screen (300 fpm velocity) – Same overall dimensions as holder for 32 fpm velocity except 5-3/4 inches high, fabricated from solid sheet metal with a 1/2 by 1-7/8 inch (13 by 48 mm) rectangular opening at top for insertion of wick and a 3/16 inch (5 mm) diameter hole on side 1 inch (25 mm) from bottom. See Figure 31.3.

p) Meter Assembly – Digital microampere assembly consisting of a voltmeter having a minimum impedance of 10 megohms (clear air condition is indicated as 10 millivolts), and a trim potentiometer for adjustment of the meter. Connected directly to photocell. An analog direct current microammeter, having a maximum impedance of 100 ohms and a linearity of 1 percent or better over a range of 50 – 100 microamperes, is also appropriate for use.

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

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

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

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

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

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

[c] A fan intended for this purpose is Model 7600, by Pamoter, (Papst-Motoren GMBH & Co., KG) rated 115 volts, 60 hertz; or equivalent.

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

[e] Rotron, Model MD24B2, or equivalent.

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

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

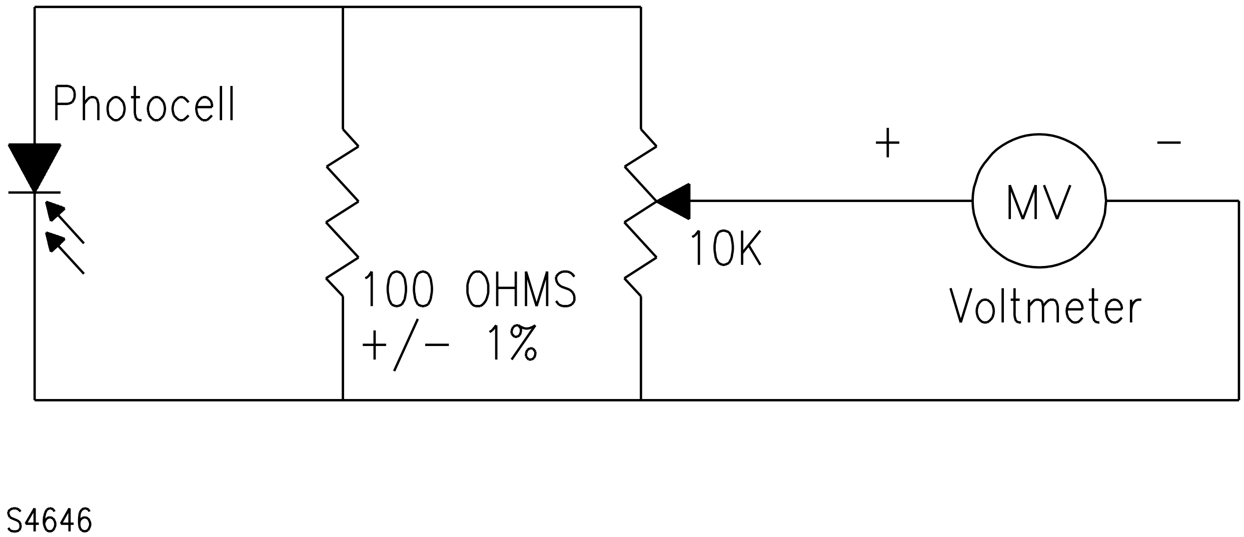
[h] An instrument intended for this application is manufactured by Electronikcentralen, Horsholm, Denmark, MIC Type EC 23095, and Measuring Ionization Chamber (MIC) Type EC 23095 and control equipment.

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

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

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

Figure 31.3
Potentiometer placement



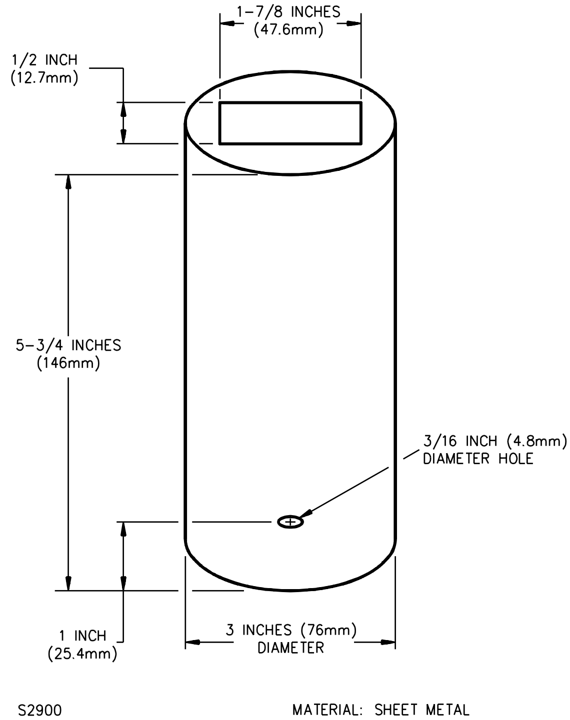
31.5 Test method

31.5.1 The test is to be conducted in an ambient temperature of 23 ±2°C (73 ±3.6°F) at a relative humidity of 50 ±20 percent and a barometric pressure of 760 ±30 mm (93.3 kPa) of mercury.

31.5.2 A minimum of 12 samples of the detector, previously energized from a source of supply in accordance with 28.2.1 for at least 16 hours or for a time interval as specified by the manufacturer, are to be subjected to this test. The detector under test is to be tested in the least and most favorable horizontal positions of smoke entry. See the Directionality Test, Section 32.

31.5.3 The air velocity in the test compartment is to be maintained at 32 ±2 fpm (0.16 ±001 m/s), as measured 1 inch (25.4 mm) in front of the middle section of the detector with a hot wire anemometer, or equivalent air velocity measuring instrument. The velocity measurement is to be made with the detector removed.

Figure 31.4
Wick holder (300 fpm)



31.5.4 The smoke/aerosol is to be admitted into the test chamber and operation is to be continued until the detector is actuated in a continuous (steady or pulsing) alarm condition. For detectors whose alarm is non-pulsing and emits alarm pulses with the initial entry of smoke, a continuous alarm condition is one that is continuous (non-pulsing) for not less than 5 seconds. The MIC/light relationship and the visible smoke buildup rate is to remain within the limits represented by the curves illustrated in Figures 31.1 and 31.2. When the trial-to-trial variation in percent light transmission alarm is ±0.2 or less, only three trials are required to be conducted on each sample. When the variation is greater than ±0.2, five trials are to be performed. The test chamber is to be exhausted between each trial until the MIC and light beam indicate a clear condition. The airflow is to be allowed to stabilize for at least 30 seconds before each test trial.

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

a) Visible Obscuration (percent light transmission),

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

c) Time of test trial.

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

31.6 Uniformity of operation

31.6.1 The measurement of the sensitivity indicating means, which is employed to provide an indication of the sensitivity level, shall be within 25 percent of the manufacturer's assigned values. See 6.2.2.

31.6.2 The measured average sensitivity of the detectors shall be within 25 percent of the marked sensitivity rating or range of the detector.

31.7 Sensitivity test feature

31.7.1 When this test feature is the method used by the manufacturer to comply with the requirements in 6.2.1 – 6.2.3, the test feature is to have the capability of verifying that the sensitivity of the detector is within 25 percent of the marked range.

31.7.2 When a sensitivity test feature is provided as an operational test to simulate either mechanically or electrically a specified level of smoke in the sensing chamber, the maximum permissible measured level shall not exceed 6 percent per foot [0.027 OD/foot (0.088 OD/m)] obscuration using gray smoke.

31.7.3 Four samples, two at maximum and two at minimum sensitivity, are to be subjected to this test. Each sample is to be connected to a rated supply voltage. The sensitivity is to be determined by conducting a curve plot of smoke obscuration versus an instrument (meter) reading, or equivalent.

31.8 Alarm verification

31.8.1 This test is to be conducted only on detectors that employ an alarm verification circuit that is bypassed in order to comply with the Fire Tests, Section 39, and the Smoldering Smoke Test, Section 40. To determine the delay time of an alarm verification circuit, sensitivity measurements are to be made on each of 10 samples; 5 preset to the maximum anticipated production sensitivity and 5 preset to the minimum anticipated production sensitivity. With the alarm verification bypassed, each detector is to be subjected to an increase in smoke until the alarm circuit is energized at which point the bypass is immediately removed and the detector reset to normal standby and the test continued until the detector realarms. The sensitivity measurement is to be recorded at each alarm point and the time differential noted between the two alarm points. The measured sensitivity with the bypass applied shall be within the limits specified in 31.1.1. The measured time differential is to be between 10 and 30 seconds. When the alarm verification delay time cannot be obtained using the method described, an equivalent procedure is to be employed.

32 Directionality Test

32.1 The sensitivity of the detector shall comply with the requirements of 31.1.1 using gray smoke/aerosol in any orientation with the air flow in the chamber. The detector is to be tested at a 30 – 35 fpm (0.15 – 0.18 m/s) air velocity in its least favorable position for smoke entry and at each 90 degree angle from this position. The positions are to include all four compass points with the detector in a horizontal position with the oncoming air directed to each of four sides and with the detector positioned on edge with the detector front facing the oncoming air. The locations of the least and most favorable smoke entry positions are to be marked on all detectors to be used in subsequent tests. See 31.1.1; the Fire Tests, Section 39; and the Smoldering Smoke Test, Section 40.

32.2 Two samples, one set at the maximum production sensitivity, and one set at the minimum sensitivity, are to be employed for this test. A sample to be positioned on edge is to be mounted on a wooden board so that the edge of the sample rests on the mounting platform. The mounting board is to:

a) Extend a maximum of 2 inches (50.8 mm) beyond the vertical sides of the sample and

b) Have no extension beyond the top edge.

32.3 When the height of a detector is too great to be accommodated in the platform test area, it is to be located adjacent to the left edge of the mounting platform with the top edge touching the roof of the test compartment and corresponding adjustments made in the location of the velocity measurement. See 31.4.3.

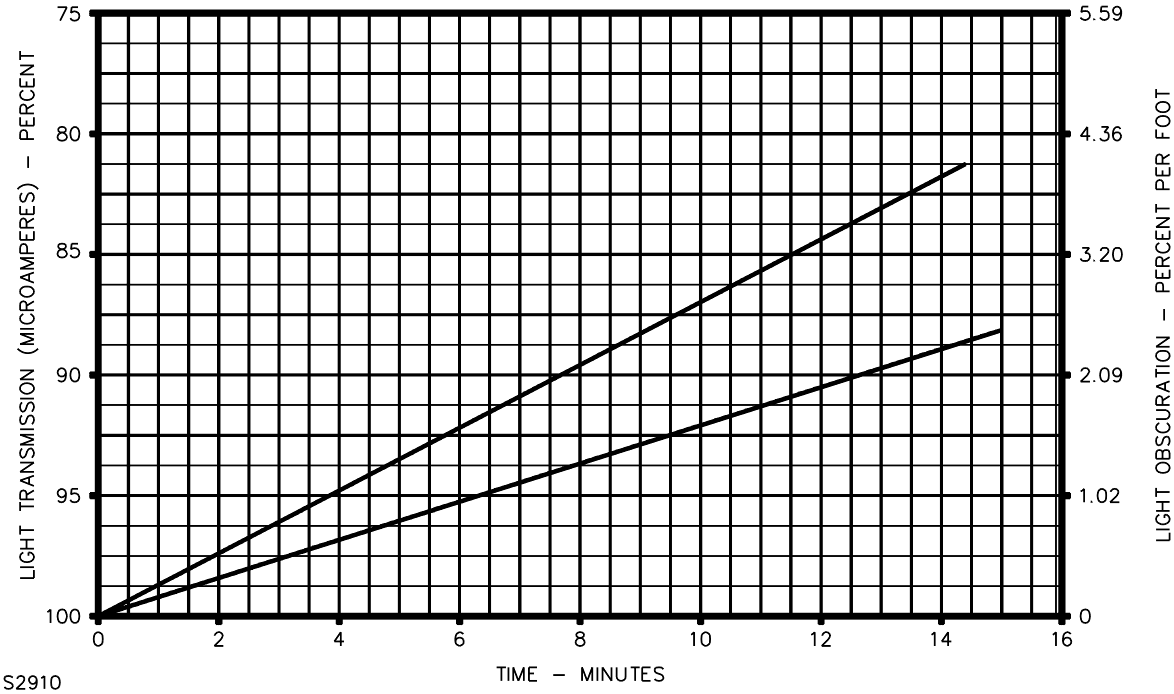
33 Velocity-Sensitivity Test

33.1 The sensitivity of a detector shall not vary more than 1 percent per foot obscuration outside of the production window limits, using gray smoke/aerosol, when tested in accordance with the sensitivity test at air velocities of 32 and 300 fpm (0.16 and 1.52 m/s) ±10 percent. In no case shall the sensitivity exceed the limits specified in 31.1.1 for gray smoke.

33.2 Two detectors, one at maximum and one at minimum sensitivity, are to be subjected, in turn, to the sensitivity test; first at a velocity of 32 fpm (0.16 m/s), and then at a velocity of 300 fpm (1.52 m/s). At 300 fpm the smoldering rate of the wick/aerosol buildup is to be such that the relationship between the MIC output and percent light transmission remains within the limits represented by the curve illustrated in Figure 31.1. The visible smoke buildup rate is to be maintained within the limits illustrated in Figure 33.1.

33.3 For this test, the detectors are to be oriented in the least favorable and most favorable positions for smoke entry.

Figure 33.1
Smoke buildup rate – velocity-sensitivity test
Gray smoke – cotton wick/aerosol – 300fpm



34 Smoke Entry (Stack Effect) Test

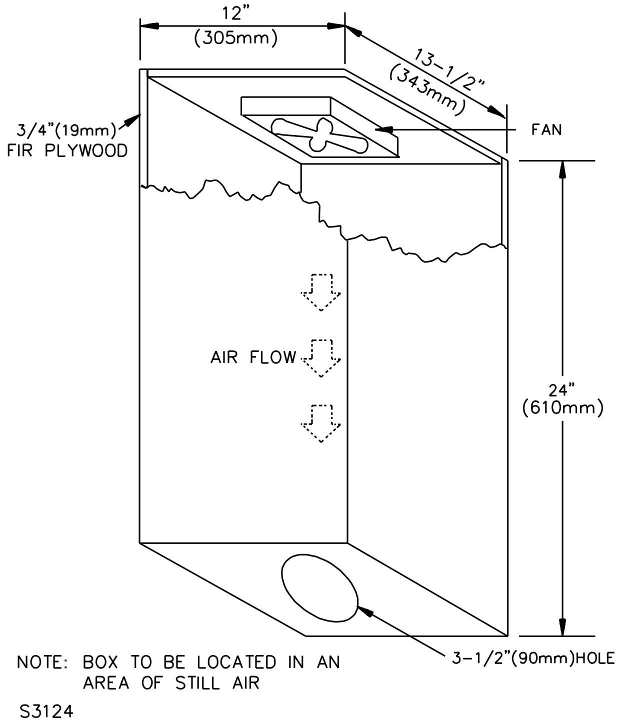
34.1 The sensitivity of a detector shall not vary by more than specified in 29.3.1 when subjected to the test conditions described in 34.2 – 34.4, which simulate air passing through an electrical conduit system that is connected to a smoke detector.

34.2 The test box shown in Figure 34.1 is to be employed. Fan operation is to be adjusted so that the free flow air velocity at the center of the hole in the base is 300 feet per minute (91.4 mpm) and with the hole covered, the fan shall produce a back pressure measuring between 0.012 – 0.015 inches (0.304 – 0.381 mm) of water. The fan is then to be turned off. A smoke detector is to be installed in accordance with the manufacturer's installation instructions, facing downward and covering the hole in the base of the test box, to simulate installation in a ceiling.

34.3 The entire test box/smoke detector assembly is to be placed (detector side down) in an opening provided in a modified top door of the test chamber described in 31.4.3. The detector shall then be tested for sensitivity while in this position. Two samples are to be tested, one at maximum and one at minimum sensitivity.

34.4 The procedure described in 34.2 and 34.3 is to be repeated on both detectors, except the fan is to be turned on.

Figure 34.1
Test apparatus Smoke entry (stack effect) test



35 Lamp Interchangeability Test (Photoelectric)

35.1 The sensitivity of a photoelectric smoke detector (both spot and beam type) shall vary not more than specified in 29.3.1 from its initial measurement and shall comply with the requirements of the Sensitivity Test, Section 31, when tested with the intended replacement lamps.

35.2 Three samples, set at the minimum sensitivity setting, are to be subjected to the Sensitivity Test, Section 31. The detectors are then to be de-energized, the photocell illuminating lamps replaced, reenergized, and subjected again to the Sensitivity Test, Section 31.

36 Reduction in Light Output Test

36.1 The sensitivity of a detector employing an LED as the functional light source shall not be reduced to less than the minimum levels when the light output from the LED is reduced to 50 percent of the intended output or to the light level anticipated at the end of the failure rate prediction described in 3.8 and 18.3.

36.2 Five samples, calibrated to the minimum sensitivity, are to be subjected to the Sensitivity Test, Section 31, while connected to a source of rated voltage and frequency. Following this, the light output from the LED is to be reduced to 50 percent of the intended output or to the light level anticipated at the end of the failure rate prediction described in 3.8 when less than 50 percent light reduction, by reducing the supply voltage to the detector, or an equivalent method. (The level of reduction of light is to be determined initially by means of a light meter intended for this use, review of curve sheets, or the equivalent.) The samples shall then be subjected to the Fire Tests, Section 39, and the Smoldering Smoke Test, Section 40.

37 Stability Test

37.1 There shall be no false alarms of a detector set at the maximum sensitivity setting when two representative samples are subjected to the test specified in (a) – (f). Different detectors are to be employed for each test. A test is not required to be conducted when the principle of operation is such that conducting the test has no possible effect. A detector for which sensitivity is affected by air velocity is to be tested in the position in which a false alarm is most likely to occur.

a) Operation (with a laminar flow) for 90 days in a relatively clean atmosphere in an air stream having a velocity of 300 ±25 fpm (1.5 ±0.13 m/s) in an ambient room temperature of 23 ±2°C (73.4 ±3°F), 30 to 50 percent relative humidity.

b) Three plunges from an ambient humidity of 20 ±5 percent relative humidity to an ambient of 90 ±5 percent relative humidity at 23 ±2°C (73.4 ±3°F).

c) Ten cycles of temperature variations between minus 17.8°C (0°F) and plus 66°C (150°F), except that the range shall be between 0°C (32°F) and 49°C (120°F) when the detector is marked for household use only. See 74.1 (p).

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

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

f) Twenty cycles subjected to high light intensity from a distance of 1 foot (0.3 m), 10 cycles using a 150 watt incandescent lamp, 10 cycles using a 4-light fluorescent fixture with 40 watt daylight lamps at a rate of 4 cycles per minute. Each cycle is to consist of 10 seconds of exposure and 5 seconds not exposed. The peak luminous intensity of the incandescent lamp test shall be 175 candela. The peak luminous intensity of the fluorescent fixture test shall be 424 candela.

37.2 Two detectors, set at the maximum production sensitivity setting, are to be mounted in a position of intended use, energized from a source of supply in accordance with 28.2.1 and subjected to each of the test conditions in 37.1.

37.3 For 37.1 (b), the detector is to be plunged from one humidity level to the other in not more than 3 seconds per plunge and maintained at each humidity level for not less than 1/2 hour between plunges.

37.4 For 37.1 (c), the time of cycling from one extreme to the other is to be a maximum of 1 hour and a minimum of 5 minutes and not less than 15 minutes at each temperature level. For 37.1 (d), the time of change from one pressure to the other is to be 30 seconds. For 37.1 (e) and (f), the detector is to be positioned in a plane to permit the maximum entry of light into the chamber. Each cycle is to start at one test condition, changing to the other extreme, and returning to the original test condition.

37.5 The test samples subjected to 37.1 (a) – (f) are to be tested for sensitivity (see the Sensitivity Test, Section 31) using gray smoke/aerosol following the completion of each test. The response of any detector, when tested in accordance with the Sensitivity Test, Section 31, shall vary not more than specified in 29.3.1.

38 Test for Effect of Air Velocity

38.1 Except as indicated otherwise, neither of two detectors, calibrated to the maximum sensitivity setting, shall false alarm when subjected, in turn, to each of the test conditions specified in (a) – (c):

a) Ten cycles of change in air velocity from 0 – 300 fpm ±25 fpm (0 – 91 mpm ±7.5 mpm). For each cycle, the maximum air velocity is to be applied for at least 15 minutes and shut off for at least 15 minutes.

b) Ten cycles of constant air velocity at 985 ±98 fpm (300 ±30 mpm). For each cycle, the air velocity is to be applied for at least 15 minutes and shut off for at least 15 minutes.

c) Ten 2-second air gusts up to a maximum of 1970 fpm (600 mpm) immediately following the test in (b).

Exception: It is not prohibited for a false alarm to occur under the test conditions specified in (b) or (c) when the detector is marked in accordance with 74.2.

38.2 For the test condition specified in 38.1 (a), the detector is to be tested in the smoke box having the 300 fpm capacity. For the test conditions specified 38.1 (b) and (c), the detector is to be placed in the duct smoke detector test assembly described in the Standard for Smoke Detectors for Duct Application, UL 268A, or an equivalent test apparatus. The detector is to be energized from a rated source of supply voltage, and subjected to an aerosol-free air flow with the most favorable horizontal position for smoke entry facing the oncoming air flow. For the test conditions in 38.1 (a) and (b), the velocity is to be increased from 0 – 300 fpm ±25 fpm (0 – 91 mpm ±7.5 mpm) and from 0 – 985 fpm ±98 fpm (0 – 300 mpm ±30 mpm) in not more than 8 seconds for each stage. For the test condition in 38.1 (c), the increase in velocity from 985 to 1970 feet (300 to 600 meters) per minute is to be attained in not more than 3 seconds.

39 Fire Tests

39.1 General

39.1.1 Each detector subjected to tests specified in 39.2.1 – 39.4.1 shall operate for continuous (steady or pulsing) alarm when installed as intended in service and exposed to the four types of controlled test fires (see 39.1.2 – 39.4.1). For a detector that has a nonpulsing alarm that emits alarm pulses with the initial entry of smoke, a continuous alarm is one that is continuous (nonpulsing) for not less than 5 seconds. The response time shall not be more than 4 minutes for Test A, B and C. All combustibles are to be ignited with the device as described. The bottom of the container for all combustibles is to be about 3 feet (0.9 m) above the floor. Both the paper and wood brand are to be preconditioned in a relative humidity of 50 ±5 percent at a temperature of 23 ±2°C (73 ±3.6°F) for at least 48 hours prior to the test.

39.1.2 With reference to the requirements of 39.1.1, and in lieu of employing detectors with a precalibrated alarm setting, it is not prohibited to employ detectors that are equipped with means to provide an analog output (electrical measurement) of the detector sensitivity during the course of the test trials. The detectors are then subjected to the Sensitivity Test, Section 31, in the smoke box with the analog output recorded to translate the electrical reading into an obscuration measurement. It is possible to obtain the minimum production sensitivity setting using this type of arrangement without conducting repeat tests after recalibration. This method is also usable for the Smoldering Smoke Test, Section 40.

39.1.3 To bypass the alarm verification feature (circuit) of a detector during the fire tests the unit shall be marked in accordance with 74.1 (s).

39.2 Paper fire – Test A

39.2.1 The following materials and procedures are to be used for the paper fire test. Dimensions and locations of test apparatus are intended for reference only. These are variable as long as the correct build up rates are achieved.

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

b) Receptacle – To be formed of 1/32 inch (0.8 mm) thick sheet metal, 4 inches (102 mm) diameter and 12 inches (0.3 m) high and seamed together, with no air gap at the seam, with a 6 inch (152 mm) square support flange at the bottom.

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

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

1) Flame breakthrough is to occur at between 1 and 3 minutes.

2) The first principle peak is to occur at between 1 and 3 minutes.

3) Smoke is to peak at between 27 and 37 percent per foot obscuration [0.137 and 0.2 OD/foot (0.45 and 0.66 OD/m)] at the ceiling detector location, and between 21.5 and 37 percent per foot [0.0105 and 0.2 OD/foot (0.345 and 0.66 OD/m)] at each sidewall location.

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

5) The secondary peak is not to exceed 13 percent per foot obscuration [0.061 OD/foot (0.198 OD/m] at any detector location.

6) Length of test is to be 4 minutes.

39.3 Wood fire – Test B

39.3.1 The following materials and procedures are to be used for the wood fire test. Dimensions and locations of test apparatus are intended for reference only. These are variable as long as the correct build up rates are achieved.

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

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

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

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

1) Smoke buildup is to begin at between 80 and 120 seconds at the ceiling detector location, and between 60 and 120 seconds at each sidewall detector location.

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

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

4) Flame breakthrough is to occur at between 150 and 190 seconds.

5) Length of test is to be 4 minutes.

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

39.4 Flammable liquid fire – Test C

39.4.1 The following materials and procedures are to be used for the flammable liquid fire test. Dimensions and locations of test apparatus are intended for reference only. These are variable as long as the correct build up rates are achieved.

a) Combustible – Consists of a mixture of 25 percent toluene and 75 percent heptane (of sufficient quantity to generate curves within the limits specified by Figure 39.1) which is to be burned in a metal receptacle.

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

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

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

1) Maximum obscuration is not to exceed 13 percent per foot [0.061 OD/foot (0.199 OD/m)] at the ceiling detector location, or 21.5 percent per foot [0.105 OD/foot (0.345 OD/m)] at either sidewall detector location.

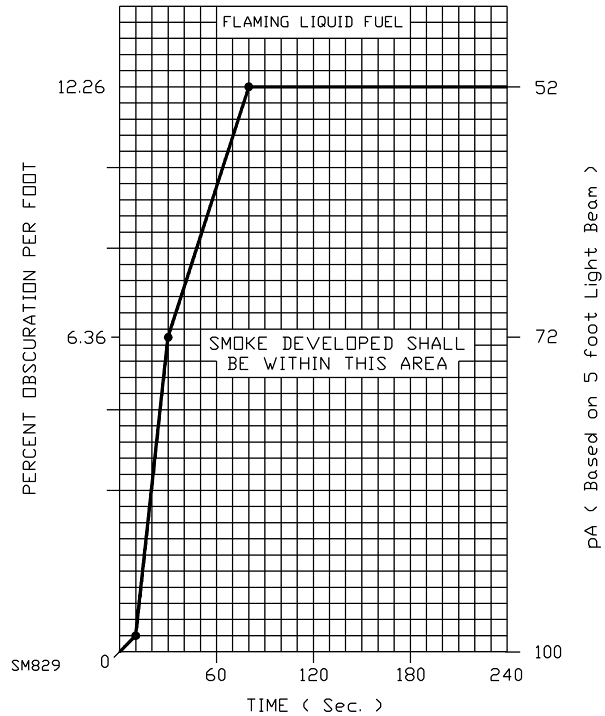
2) Length of test is to be 4 minutes.

39.5 Igniter assembly

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

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

Figure 39.1
Heptane fire profile



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

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

39.6 Test method

39.6.1 The fire tests are to be conducted in a 36 by 22 by 10 foot high (10.9 by 6.7 by 3.1 m) room having a smooth ceiling with no physical obstructions. Air movement in the test room is to be minimal. The distance from the base of the combustible to the ceiling shall be 7 feet (2.1 m). The room is to be provided with a means for the removal of smoke. Heating, humidity, and air conditioning are to be provided for maintaining the room ambient, when required. Specified dimensions are for reference only and are variable as long as the correct smoke build up rates are achieved. See Figure 39.2.

39.6.2 The tests are to be conducted in an ambient temperature between 20.0 and 25.5°C (68 and 78°F) and a relative humidity of 50 ±10 percent. The detector samples, each adjusted to the minimum production sensitivity, are to be energized from a source of supply in accordance with the requirements specified in 28.2.1.

39.6.3 A detector intended for flush mounting is to be mounted flush with the mounting base. The wall mounted detectors are to be placed in the least favorable position of smoke entry with respect to the oncoming smoke flow unless the manufacturer's installation instructions indicate a specific mounting arrangement, or the mounting position is obvious. The ceiling mounted detectors are to be mounted such that the least favorable position of one sample faces the oncoming smoke flow, with the remaining samples rotated 120 and 240 degrees respectively.

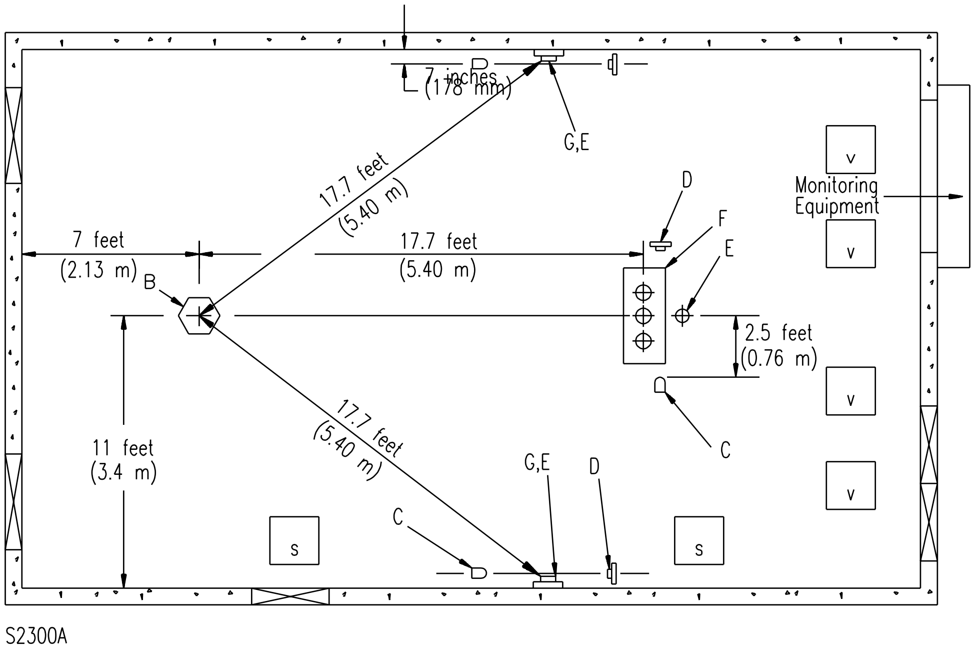
39.6.4 When intended for ceiling mounting only, three detectors are to be tested on a ceiling panel; see Figure 39.3. When intended for wall mounting only, two detectors are to be tested, one on each side wall; see Figure 39.4. For detectors intended for both wall and ceiling mounting, five detectors are to be tested: three on the ceiling and one on each side wall; see Figure 39.5.

39.6.5 All detector samples shall respond to the test fire of each combustible. The test time is to start at ignition. The smoke obscuration level at each detector location is to be monitored by a photocell-light-beam assembly, mounted directly on the ceiling and on each side wall, and spaced 5 feet (1.5 m) apart. See 31.4.3 (f) and (m) for a description of this assembly. Combination smoke detectors are to be provided with means for monitoring each principle of operation during testing. Each principle shall contribute in response, either wholly or partially, to at least one of the test fires, or the Smoldering Smoke Test, Section 40.

39.6.6 To determine the acceptability of each test fire, the smoke profile curves as described in each fire test shall be obtained for the appliance combustible. See Figures 39.6 – 39.13.

39.6.7 Measuring ionization chambers (MIC), are to be used to measure the relative buildup of particles of combustion during each trial at each detector location for the wood and paper fires. The MIC utilizes the ionization principle with air drawn through the chamber at a rate of 25 ±5 liters per minute by a regulated vacuum pump. A monitoring head is to be located at each detector location as shown in Figure 39.2.

Figure 39.2
Fire test room



A. Fire Test Room Dimensions

1. Length – 36 feet (11m)

2. Width – 22 feet (6.7 m)

3. Ceiling – height 10 feet (3.0 m) suspended type. Consists of 2 by 4 feet (0.6 by 1.2 m) by 5/8 inch (15.9 mm) thick noncombustible fissured mineral fiber layer in panels.

B. Test Fire

1. 3 feet (0.91 m) above floor for the Fire Tests

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

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

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

E. Measuring Ionization Chamber (MIC) – see 40.9.

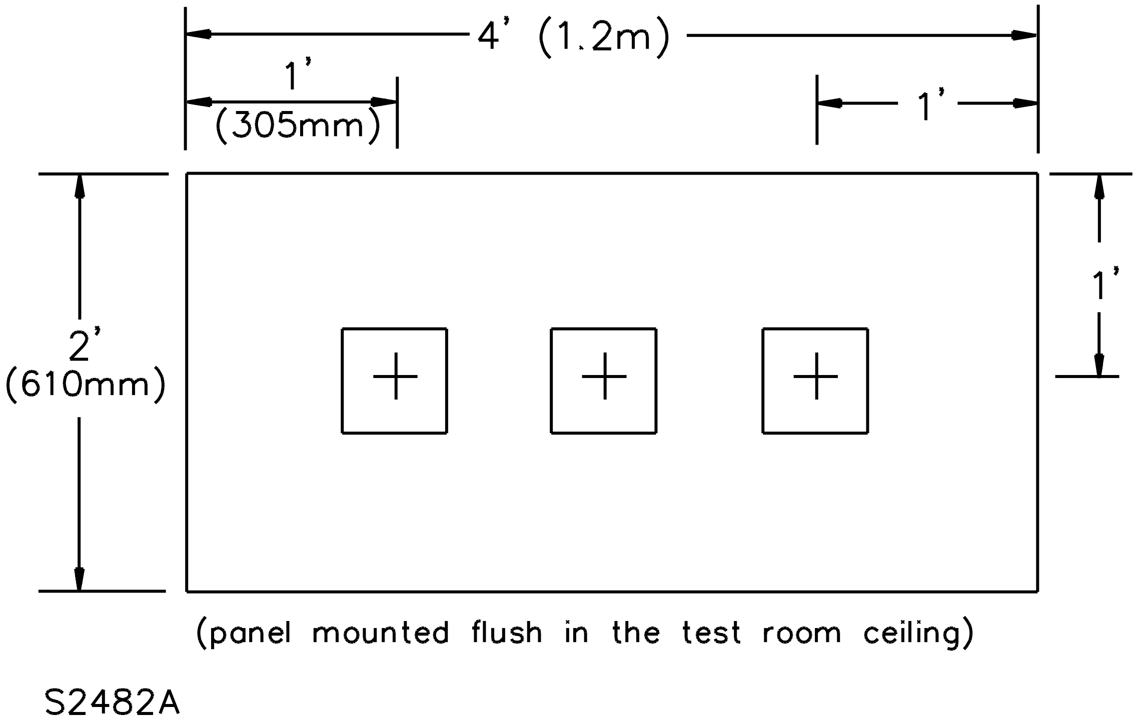
F. Test Panel, Ceiling Mounted Detectors – see Figures 39.3 and 39.5.

G. Test Panel, Sidewall Mounted Detectors – see Figures 39.4 and 39.5.

S. Air Supply

V. Exhaust Vents

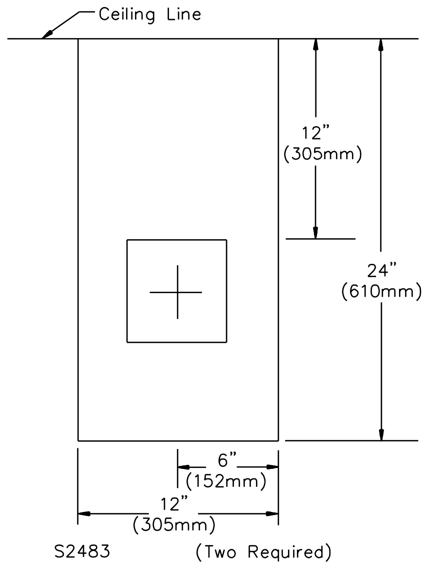
Figure 39.3
Ceiling panel size and sample location for ceiling mounting of detectors



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

39.6.9 To determine the acceptability of the test trial for each combustible and each detector location, the relationship between the MIC output (ordinate) and the percent light obscuration (abscissa) is to plotted. The data generated is to remain within the limits represented by the curves illustrated in Figures 39.8 – 39.11.

Figure 39.4
Test panel and detector location for side wall mounted detectors



NOTE – Distance less than 12 inches (305 mm), and not less than 4 inches (102 mm) is appropriate only when so specified in the installation instructions.

Figure 39.5
Panel mounting for fire tests

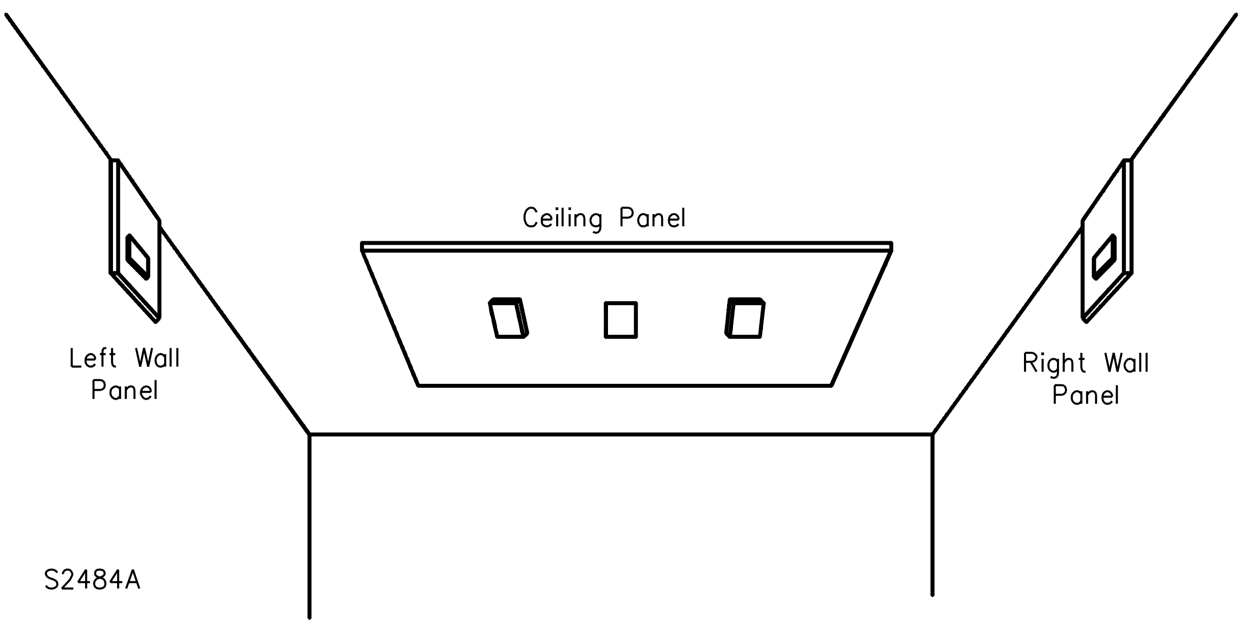
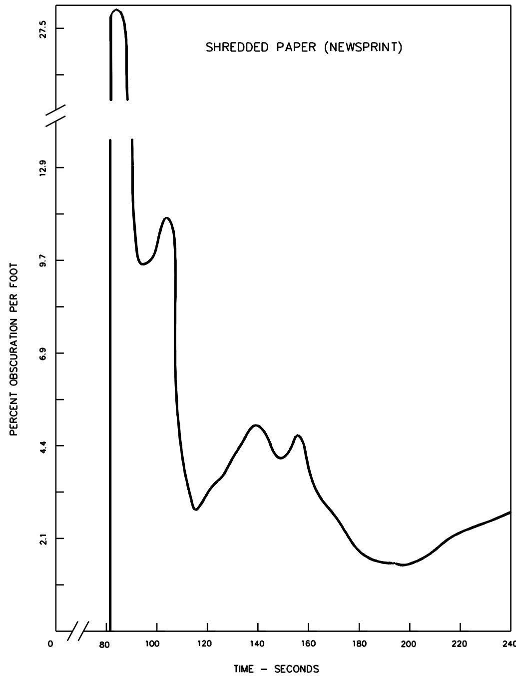
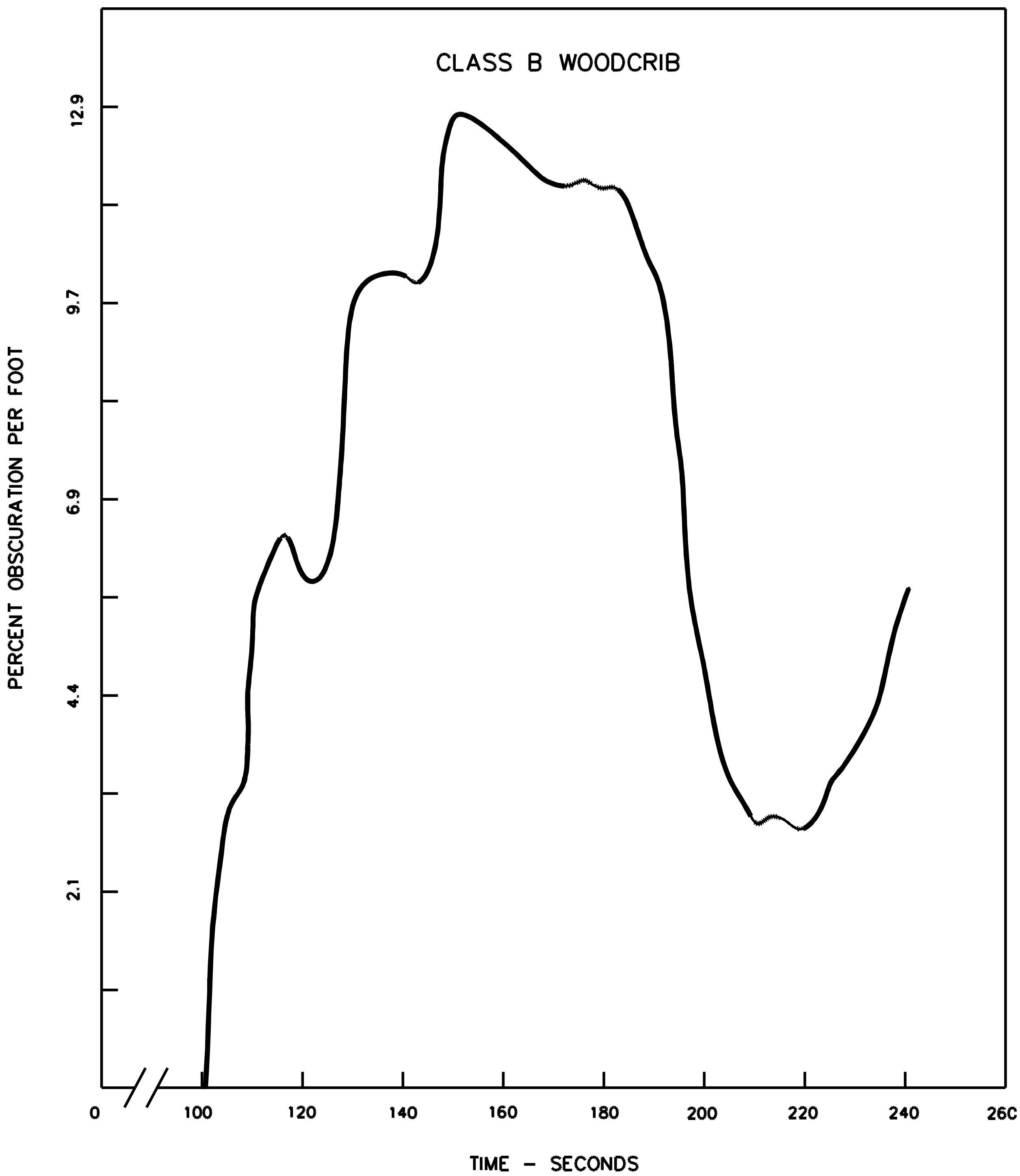


Figure 39.6
Shredded paper (newsprint) profile



S2485A

Figure 39.7
Woodcrib profile



S2485B

Figure 39.8
Paper fire – ceiling location

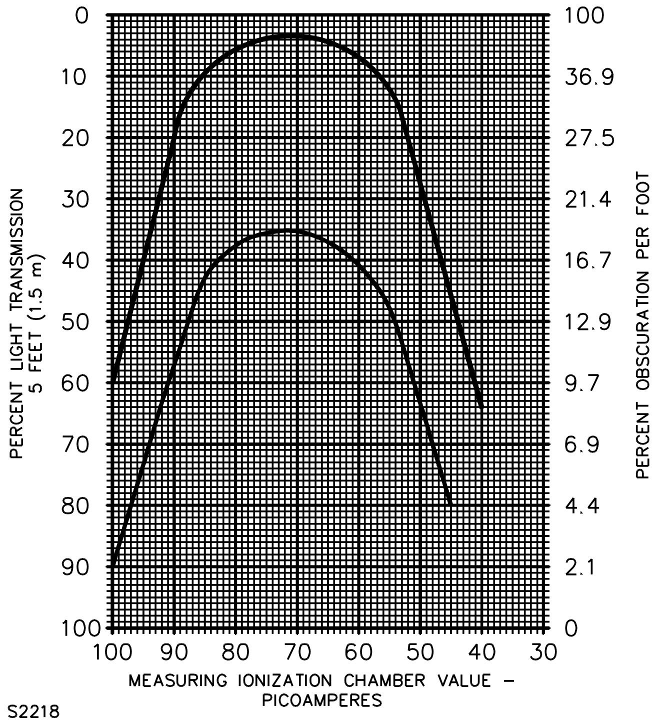


Figure 39.9
Paper fire – wall location

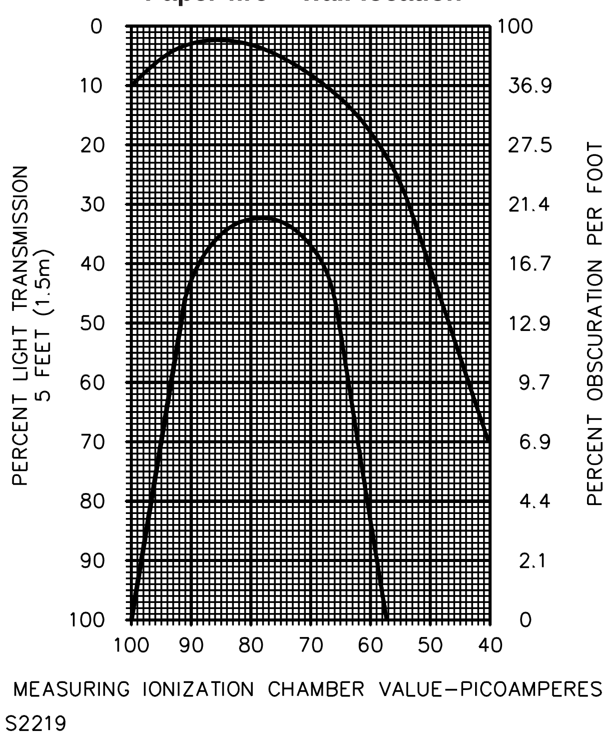
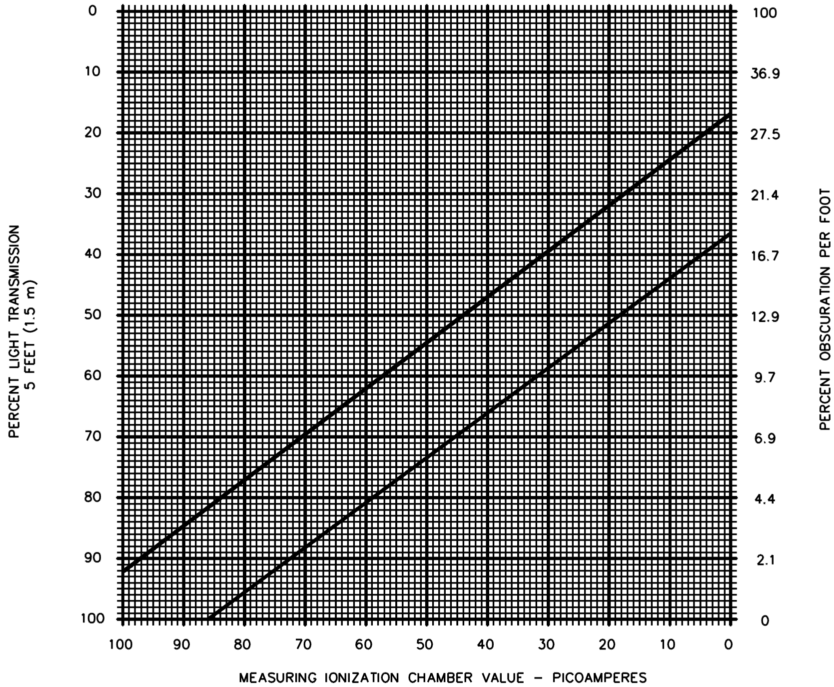
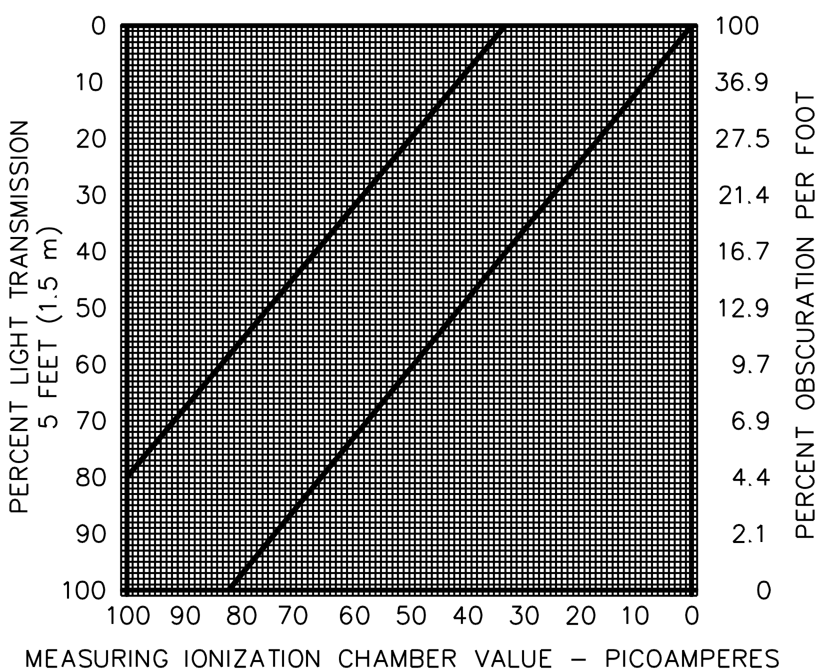


Figure 39.10
Wood fire – ceiling location



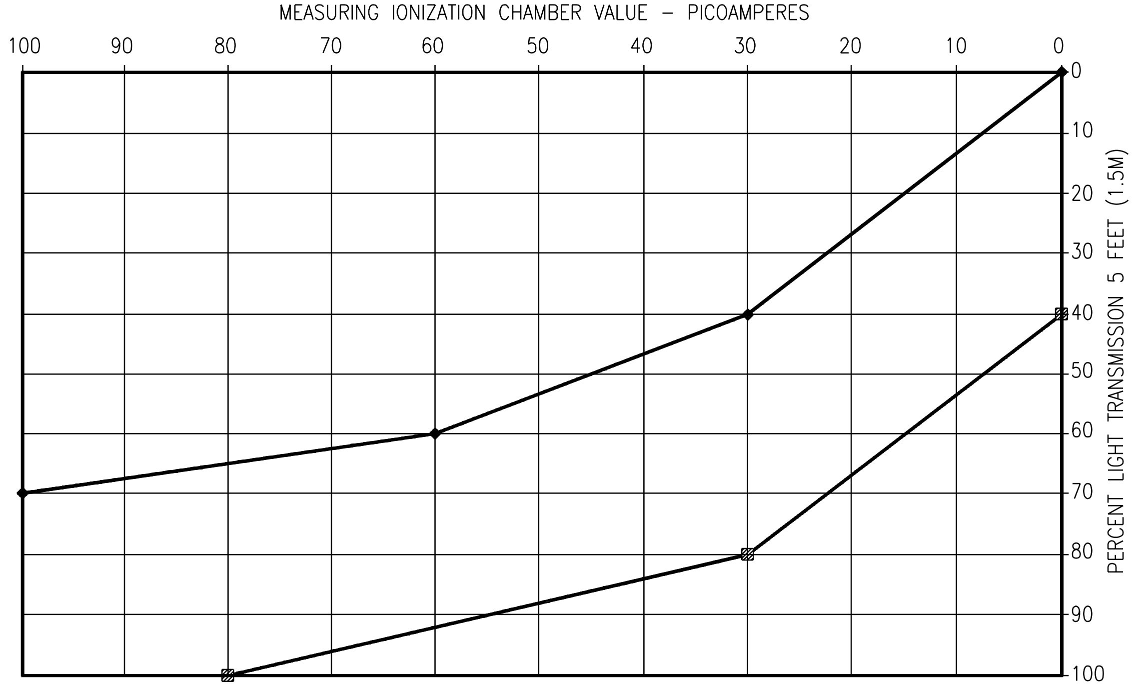
S2220

Figure 39.11
Wood fire – wall location



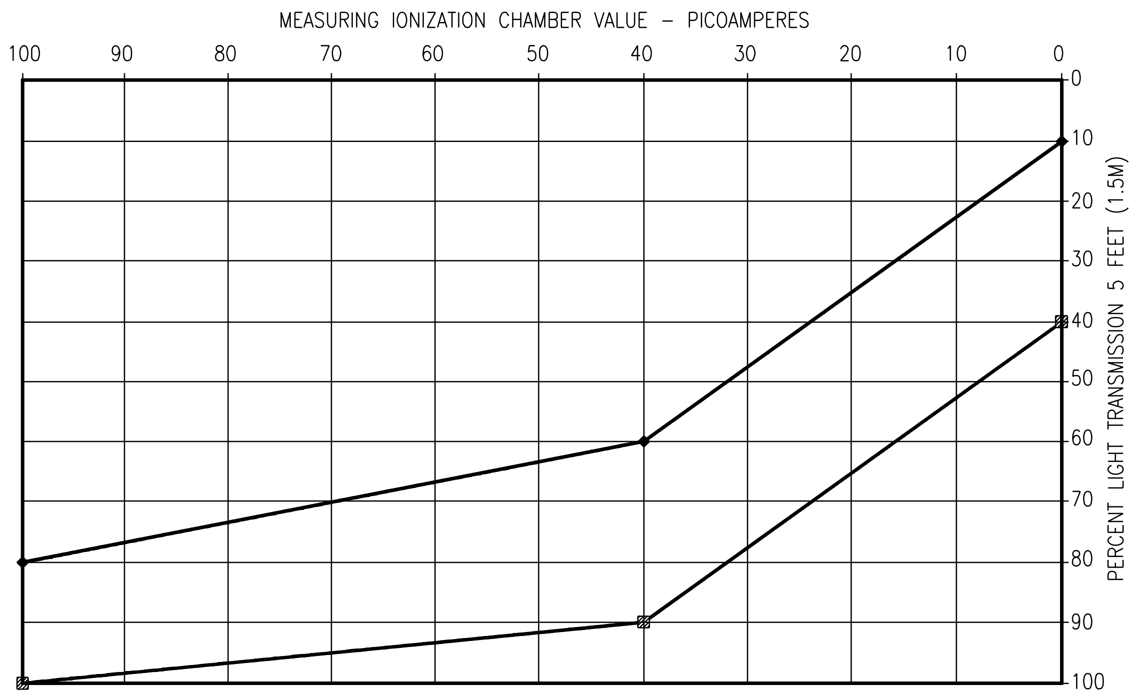
S2221

Figure 39.12
Flammable liquid fire, ceiling location



S4477

Figure 39.13
Flammable liquid fire, wall location



S4478

40 Smoldering Smoke Test

40.1 Each detector shall operate for continuous (steady or pulsing) alarm when installed as intended in service, and exposed to the controlled smoldering smoke condition specified in 40.2 – 40.11. For a detector whose alarm is identified as nonpulsing, and that emits alarm pulses with the initial entry of smoke, a continuous alarm condition is one which is continuous (nonpulsing) for not less than 5 seconds.

40.2 The alarm verification feature (circuit) of a detector shall be bypassed during the smoldering smoke test only when the unit is marked in accordance with 74.1 (s).

40.3 Unless specifically indicated otherwise in the detector installation instructions, the detectors are to be installed in the least favorable position for smoke entry with respect to the smoldering smoke source as determined by the Directionality Test, Section 32. Detectors adjusted to the minimum production sensitivity are to be employed for this test.

40.4 The combustible for this test is to be to ten Ponderosa pine sticks (nonresinous, free from knots or pitches) placed in a spoke pattern on the hotplate so that sticks are 36 degrees (0.63 rad) apart. The end of each stick is to be flush with the edge of the hotplate. Each stick is to be 3 by 1 by 3/4 inches (76.2 by 25.4 by 19.1 mm) with the 3/4 by 3 inch (19.1 by 76.2 mm) face in contact with the hotplate. All surfaces of each stick are to be relatively smooth and free from burrs or holes. The grain of the wood is to be parallel to the stick length. Each stick is to be conditioned for not less than 48 hours at 52°C (125°F) in an air-circulating oven. The stick weight is to be 16 ±2 grams (0.56 ±0.07 oz) following the oven conditioning.

Exception: The above stick dimensions and the number and placement of sticks are variable as long as the correct smoke build up rates are achieved.

40.5 The heat source is to be a 240 volt, 1550 watt hotplate[m] having a steel plate 8-1/2 inches (216 mm) in diameter and 1/4 inch (6.4 mm) thick, the top most portion of which is to be 8 inches (200 mm) above the floor. The temperature of the hotplate is to be monitored by an iron-constantan No. 30 AWG (0.05 mm^2) (Type J) thermocouple attached to the edge of the steel plate by placing its junction in a hole 0.015 inch (0.38 mm) in diameter and 1/4 inch (6.4 mm) deep and peening over the opening to secure it. The thermocouple is to be connected to a proportioning temperature controller that is able to be precisely set for the specified hotplate temperature. The controller sensitivity is to be adjusted so that all conditions for this test are met. Once set for a specific temperature, the hotplate is to be maintained at that temperature, (as monitored by a temperature measuring meter). Prior to the start of the test, the hotplate temperature is to be 23 ±2°C (73 ±4°F). The initial proportioning controller temperature setting is to be 205°C (401°F). The hotplate and controller are then to be energized and the test time started (T = 0). The proportioning controller setting is to be increased to obtain the temperature sequence specified in Table 40.1 and Figure 40.1 (the hotplate temperature normally lags the controller setting by 2 minutes during the incremental increases).

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

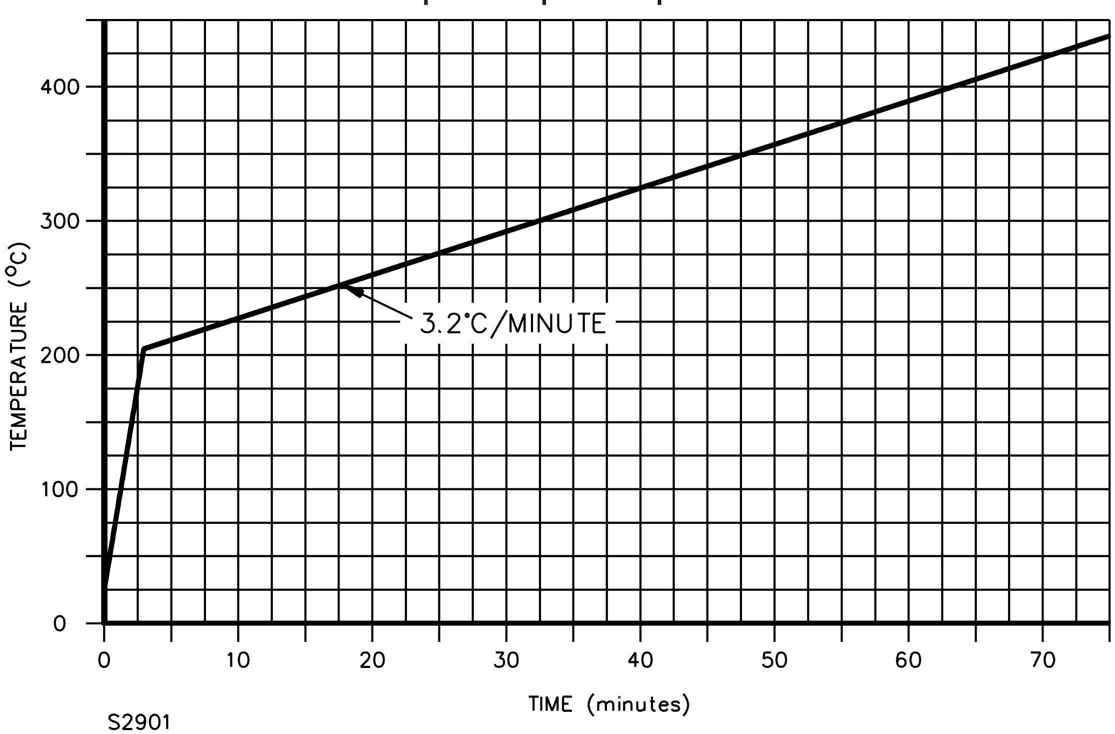
Table 40.1
Hotplate temperature

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

40.6 The Smoldering Smoke Test is to be conducted on the same samples and in the same room and ambient conditions and under the same mounting conditions as employed for the Fire Tests; see 39.6.1 – 39.6.3. The detector samples are to be energized from a source of supply in accordance with 28.2.1.

40.7 All detectors shall respond to the test trial before the obscuration level exceeds 10.0 percent per foot (29.26 percent per meter) [0.0458 OD/foot (0.15 OD/m)] at the detector location as measured by the photocell-lamp assembly described in 31.4.1 31.3.3 (f) and (m). Flaming of the wood prior to the obscuration level occurring invalidates the test unless the detectors respond prior to the flaming occurring.

Figure 40.1
Hotplate temperature profile



40.8 For this test, the visible smoke buildup rate is to be maintained within the limits illustrated in Figure 40.2. At no time during the test trial is the buildup rate to exceed 5 percent obscuration per minute as measured over the length of the 5-foot (1.5-m) light beam.

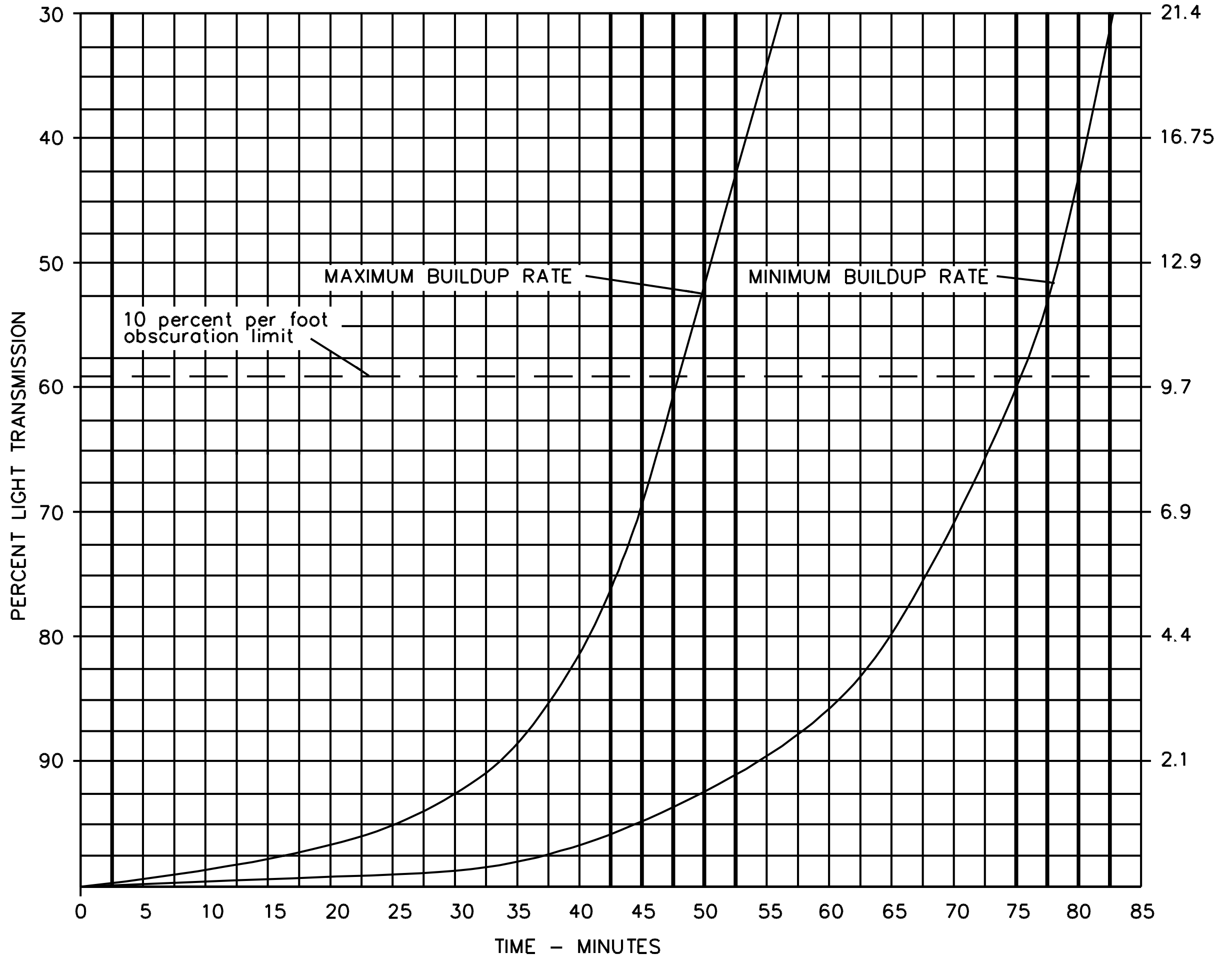
40.9 A measuring ionization chamber (MIC)[n] is to be used to measure the relative buildup of particles of combustion during the test. The MIC utilizes the ionization principle with air drawn through the chamber at a rate of 30 ±3 liters per minute by a regulated vacuum pump. The monitoring head is to be located as illustrated in Figure 39.3.

[n] Cerberus Ltd., Mannedorf, Switzerland, or Electronikcentralen, Horsholm, Denmark, Measuring Ionization Chamber (MIC), Type EC23045-1.

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

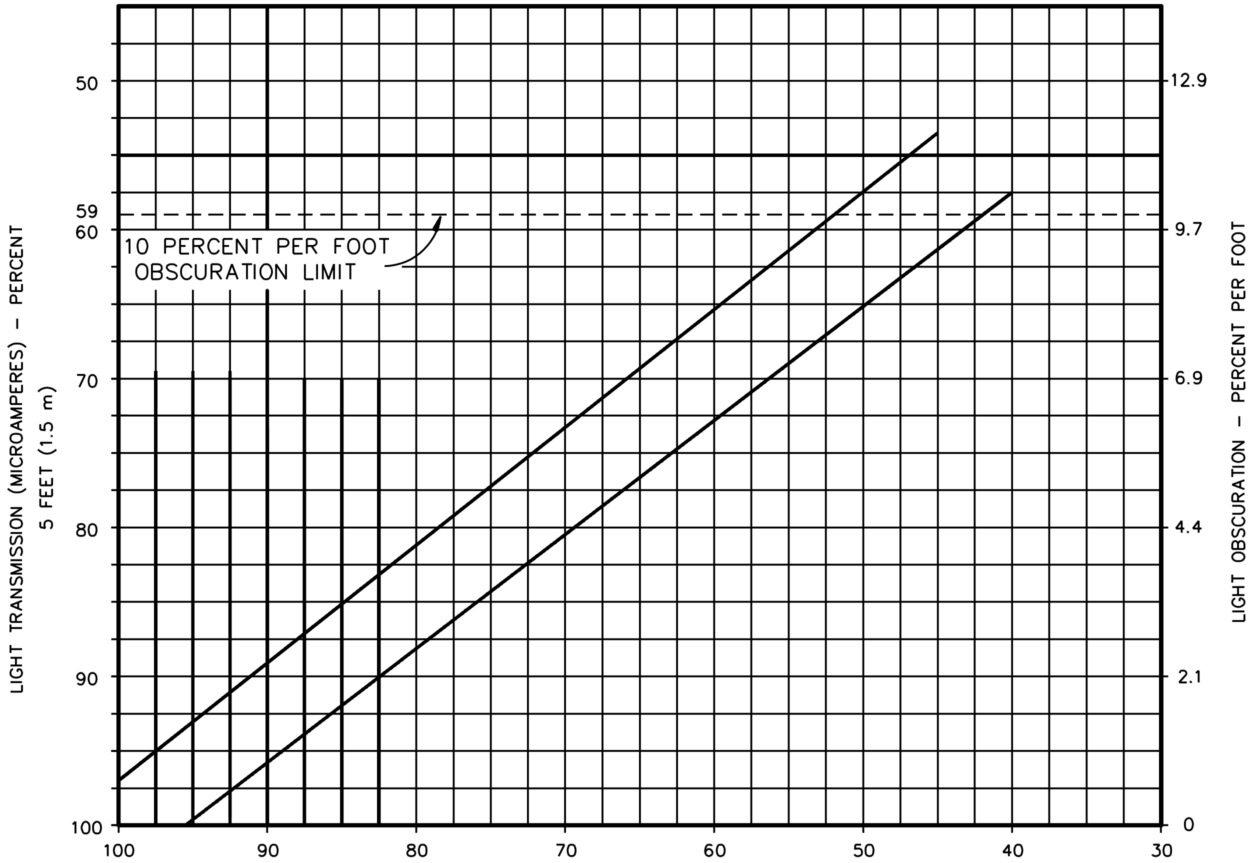
40.11 To determine the acceptability of the test trial, the relationship between the MIC output (ordinate) and the percent light transmission (abscissa) is to be plotted at 1 minute intervals during the test. The points generated are to remain within the curves illustrated in Figure 40.3.

Figure 40.2
Smoldering test profile



S2488A

Figure 40.3
Smoldering smoke test Measuring ionization chamber/light beam lights



S2909A

NOTE – Limits are based on a Measuring Ionization Chamber resistance of 20×10^{10} ohms measured at 21°C, 77 percent RH, and 760 mm Hg.

41 Smoldering Smoke Test (Maximum Obscuration Without Alarm)

41.1 Each of four detectors, calibrated to the maximum sensitivity anticipated in production, shall not alarm prior to an obscuration level of 0.5 percent per foot (1.65 percent/m), or less, measured in the detector area when subjected to the Smoldering Smoke Test, Section 40.

41.2 All conditions for this test are to be as described for the Smoldering Smoke Test, Section 40, except that the four samples subjected to this test are to be adjusted to the maximum production sensitivity and the samples are to be oriented in the most favorable position facing the fire as determined in the Directionality Test, Section 32.

42 Circuit Measurement Test

42.1 General

42.1.1 The input and output current of each circuit of a detector shall not exceed the marked rating of the detector by more than 10 percent when operated under conditions of intended use and with the detector connected to a source of supply as specified in 28.2.1. Measurements shall also be made of components such as capacitors to determine that they are being employed within the manufacturer's ratings.

42.1.2 For two-wire detectors, surge current, start-up time, normal supervisory current, and alarm current are to be measured at the:

a) Detector's rated input voltage values and

b) Nominal voltage value.

The measured current values shall be within the rated values.

42.1.3 For a two-wire detector rated as having pulsing normal standby current, the detector shall be subjected to the Dynamic Load Immunity Test specified in the Standard for Control Units for Fire Protective Signaling Systems, UL 864.

42.2 Battery trouble voltage determination

42.2.1 An increase in the internal resistance, or a decrease in terminal voltage, of a battery employed as the primary source of power to a detector shall not impair operation for an alarm signal before a trouble signal is obtained. In addition, any combination of voltage and resistance at which a trouble signal is obtained shall be greater than the battery voltage and resistance combination measured over a 1 year period in the room ambient condition of the Battery Tests, Section 68.

42.2.2 The trouble level of a battery operated smoke detector shall be determined (using the test circuit in Figure 42.1 and the voltage-resistance curves of Figure 42.2) for each of the following voltages:

a) Rated battery voltage,

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

c) Voltages between rated and trouble level voltage.

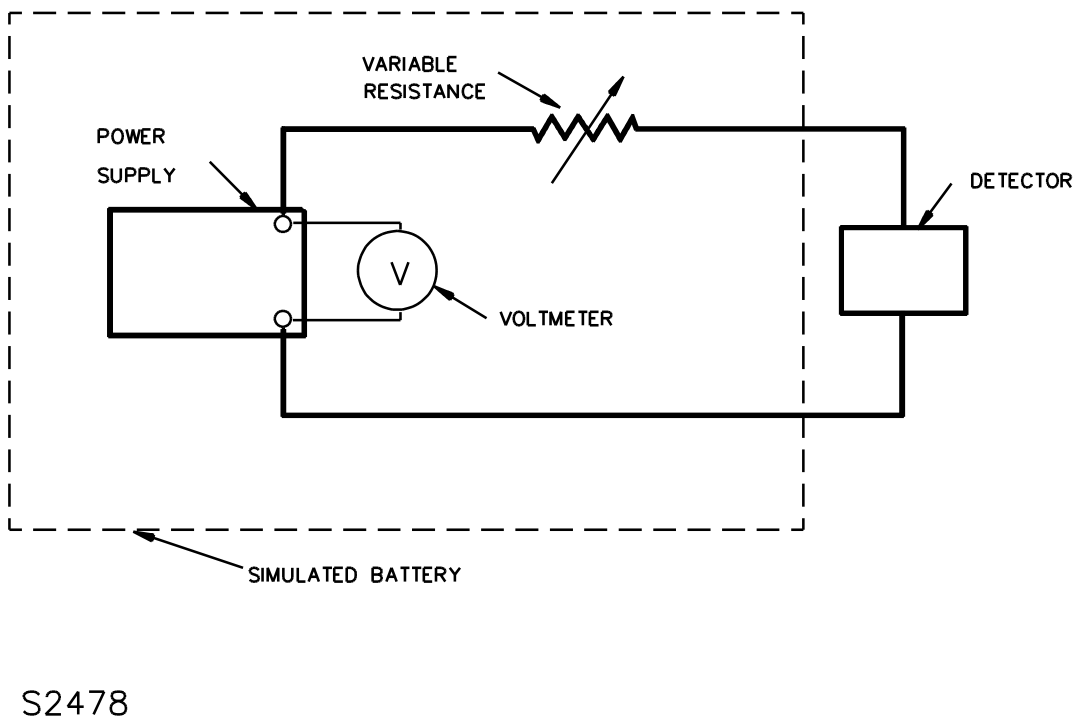
42.2.3 To determine compliance with 42.2.1 each of three detectors is to be connected in series with a variable regulated direct current power supply and a variable resistor as illustrated in Figure 42.1. The trouble level is to be determined by the following steps:

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 detector is to be tested for alarm operation at each resistance level and at the trouble level.

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

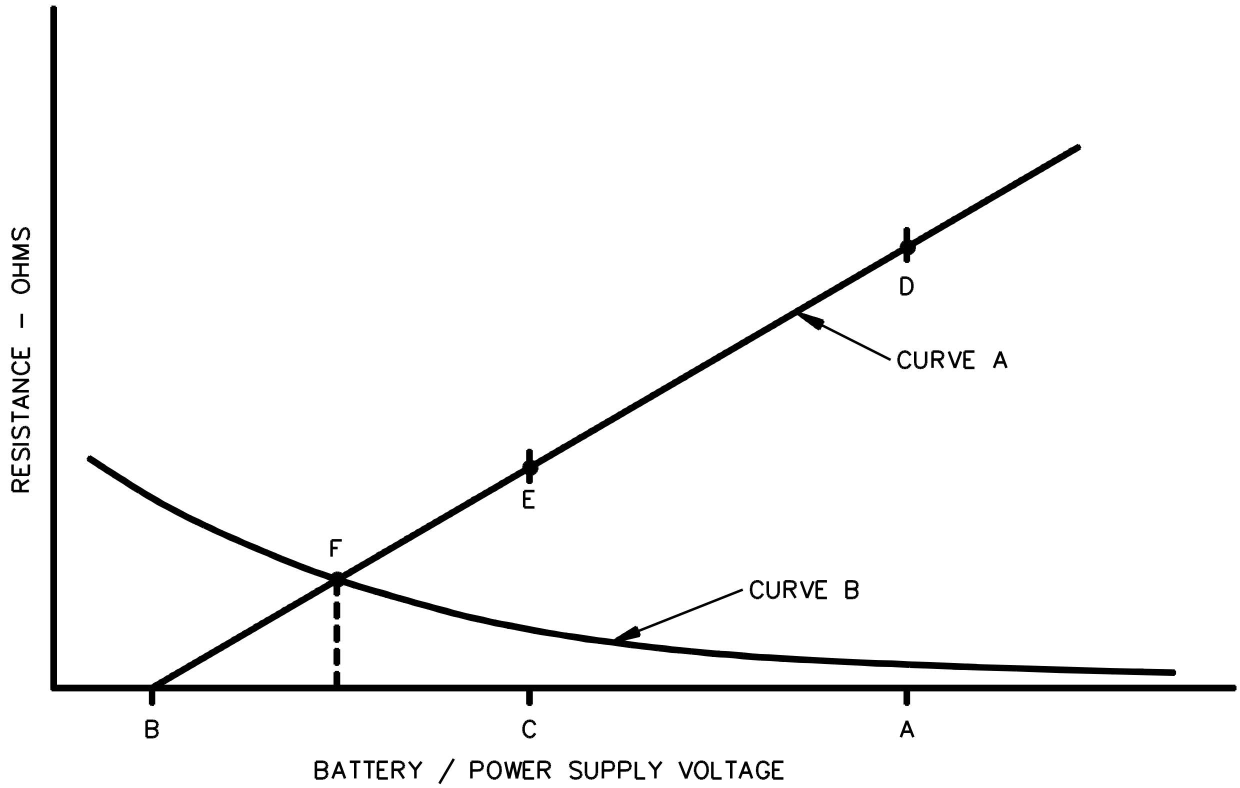
c) Voltage Values Between Rated and Trouble Level Voltages – The voltage of the power supply is to be set at prespecified voltages between the rated battery voltage and the trouble level voltage. The series resistor is then to be increased in increments of 0.1 – 10 ohms, at a rate of not more than one increment per minute, until a trouble signal is obtained. The detector 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.

Figure 42.1
Test circuit



42.2.4 To determine that a battery is capable of supplying alarm and trouble signal power to the detector for at least 1 year under the room ambient condition described in the Battery Tests, Section 68, Curve A of Figure 42.2 is to be plotted from the data obtained in the measurements described in 42.2.3 and compared to Curve B of Figure 42.2, 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.

Figure 42.2
Trouble level determination



S2479

A – Rated battery voltage.

B – Trouble level voltage (assuming minimal resistance).

C – Voltage value between rated and trouble level.

D – Trouble level resistance at rated battery voltage.

E – Trouble level resistance at voltage value C.

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

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

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

43 Overvoltage and Undervoltage Tests

43.1 Overvoltage test

43.1.1 A detector shall:

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

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

Sensitivity measurements at the increased voltage shall vary not more than specified in 29.3.1.

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

43.2 Undervoltage test

43.2.1 A detector shall operate for its intended signaling performance while energized from a source of supply of 85 percent of the test voltage specified by 28.2.1 and while at both maximum and minimum sensitivity settings. Sensitivity measurements at the reduced voltage shall vary not more than specified in 29.3.1.

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

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

43.2.4 A two-wire detector intended for connection to a two-wire initiating device circuit is to be tested at 100 percent of its rated voltage range. Sensitivity measurements at the rated limits shall not vary more than specified in 29.3.1.

44 Temperature Test

44.1 The materials or components employed in a detector shall not be subjected to a temperature rise greater than the values indicated in Table 44.1 under any condition of intended operation. When the temperature rise of a component in Table 44.1 in the standby condition is exceeded, in no case shall it be greater than for the temperature permitted under an alarm condition, when malfunction of that component results in a trouble signal.

44.2 Except as noted in 44.3, all values for temperature rises apply to equipment intended for use in prevailing ambient temperatures that usually are not higher than 25°C (77°F).

44.3 When equipment is intended specifically for use in a prevailing ambient temperature constantly more than 25°C (77°F), the test of the equipment is to be made at the higher ambient temperature, and allowable temperature rises specified in Table 44.1 are to be reduced by the amount of the difference between that higher ambient temperature and 25°C (77°F).

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

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

44.6 Temperatures are to be measured by means of thermocouples consisting of wires not larger than No. 24 AWG (0.21 mm^2). Measuring the temperature of a coil is to be accomplished by either the thermocouple or resistance method. The thermocouple method, however, is not to be employed for a temperature measurement at any point where supplementary thermal insulation is employed.

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

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

Table 44.1
Maximum temperature rises

Materials and components	Normal standby, °C	Normal standby, (°F)	(Signaling) alarm condition, °C	(Signaling) alarm condition, (°F)
A. COMPONENTS				
1. Capacitors: [a,b]				
a. Electrolytic types	25	45	40	72
b. Other types	25	45	65	117
2. Rectifiers – At any point				
a. Germanium	25	45	50	90
b. Selenium	25	45	50	90
c. Silicon				
(i) Maximum 60 percent of rated voltage	50	90	75	135
(ii) 61 percent or more of rated voltage	25	45	75	135
3. Relay, solenoid, transformer, and other coils with:				
a. Class 105 insulation system:				
Thermocouple method	25	45	65	117
Resistance method	35	63	75	135
b. Class 130 insulation system:				
Thermocouple method	45	81	85	153
Resistance method	55	99	95	171
c. Class 155 insulation system:				
(i) Class 2 transformers:				
Thermocouple method	95	171	95	171
Resistance method	115	207	115	207
(ii) Power transformers:				
Thermocouple method	110	198	110	198
Resistance method	115	207	115	207
d. Class 180 insulation system:				
(i) Class 2 transformers:				
Thermocouple method	115	207	115	207
Resistance method	135	243	135	243
(ii) Power transformers:				
Thermocouple method	125	225	125	225
Resistance method	135	243	135	243
4. Resistors:[c]				
a. Carbon	25	45	50	90
b. Wire wound	50	90	125	225
c. Other	25	45	50	90
5. Solid state devices	See footnote d			
6. Other components and materials:				
a. Fiber used as electrical insulation or cord bushings	25	45	65	117
b. Varnished cloth insulation	25	45	60	108
c. Thermoplastic materials	Rise based on temperature limit of the material			
d. Phenolic composition used as electrical insulation or as parts whose malfunction or deterioration results in a risk of electric shock, explosion, fire, or injury to persons[e]				
e. Wood or other combustibles	25	45	125	225
f. Sealing compound	25	45	65	117

Table 44.1 Continued on Next Page

Table 44.1 Continued

Materials and components	Normal standby,		(Signaling) alarm condition,	
	°C	(°F)	°C	(°F)
g. Fuses	25	45	65	117
B. CONDUCTORS				
1. Appliance wiring material[f]	25°C (45°F) less than the temperature limit of the wire			
2. Flexible cord (for example, SJO, SJT)	35	63	35	63
3. Conductors of field-wired circuits to be permanently connected to the product	35	63	35	63
C. GENERAL				
1. All surfaces of the product and surfaces adjacent to or upon which the product is be mounted	65	117	65	17
2. Surfaces normally contacted by the user in operating the unit (such as control knobs, push buttons, and levers):				
a. Metal	35	63	35	63
b. Nonmetallic	60	108	60	108
3. Surfaces subjected to casual contact by the user (such as the enclosure or grille):				
a. Metal	45	81	45	81
b. Nonmetallic	65	117	65	117

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

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

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

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

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

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

3) Each assembled production unit is subjected to a burn-in test, under the condition which results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F) followed by a Normal Operation Test, Section 29.

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

[f] For standard insulated conductors other than those mentioned, reference shall be made to the National Electrical Code, ANSI/NFPA 70, the maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.

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

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

in which:

T is the temperature to be determined in degrees C,

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

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

t is the known temperature in degrees C.

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

44.11 The detector is to be connected to a source of supply as specified in 28.2.1 and operated under the conditions specified in (a) – (c):

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

b) ALARM – (1 hour), and

c) ALARM – (7 hours abnormal test).

44.12 For test condition 44.11 (c), when the temperature limits are exceeded, there shall be no manifestation of a fire or impending malfunction, and the detector shall operate as intended following the test.

44.13 The detector is to be subjected to the Dielectric Voltage-Withstand Test, Section 59, following test 44.11 (b) or (c).

45 Vibration Test

45.1 A detector shall withstand vibration without breakage or damage to parts. Following the vibration the detector shall operate for its intended signaling operation.

45.2 To determine compliance with 45.1, sensitivity measurements using gray smoke, conducted following vibration as specified in 45.3, in accordance with the Sensitivity Test, Section 31, shall vary not more than specified in 29.3.1.

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

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

46 Replacement Test, Head and Covers

46.1 A detector employing a cover that is intended to be attached or closed by a snap type action or a removable head shall withstand 50 cycles of removal and replacement or opening and closure, where applicable, and shall comply with the requirements of the Jarring Test, Section 47.

46.2 A detector is to be installed as intended in service and the cover or head removed and replaced, or opened and closed, as specified by the manufacturer. The unit is then to be subjected to the Jarring Test, Section 47.

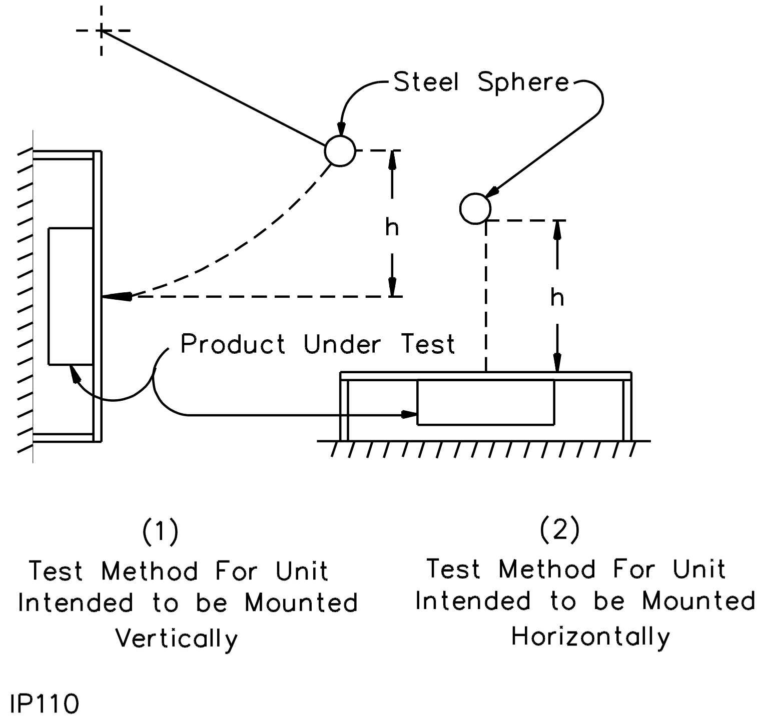
47 Jarring Test

47.1 A detector shall withstand jarring resulting from impact and vibration such as that experienced in service, without causing an alarm or trouble signal, without dislodgment of any parts, and without impairing its subsequent operation. Dislodgment of parts shall occur only when the dislodged part(s) does not affect the operation of the unit, or there are no high-voltage parts exposed.

47.2 The detector (and associated equipment, when provided), is to be mounted, in turn, as intended for use, see Figure 47.1, to the center of a 6 by 4 foot (1.8 by 1.2 m) nominal 3/4-inch (19.1-mm) thick plywood board that is to be secured in place at four corners. A 3 foot-pound (4.08 J) impact is to be applied to the center of the reverse side of this board by means of a 1.18-pound (0.54-kg), 2-inch (50.8-mm) diameter steel sphere swung through a pendulum arc from a height (h) of 2.54 feet (775 mm) or dropped from a height (h) of 2.54 feet (775 mm), based upon the mounting of the equipment.

47.3 The test is to be conducted with the detector in the standby condition and connected to a rated source of supply in accordance with 28.2.1. Following the jarring the detector shall be tested for sensitivity using gray smoke. Sensitivity measurements shall vary not more than specified in 29.3.1.

Figure 47.1
Jarring test



48 Variable Ambient Temperature Tests

48.1 Operation in high and low ambients

48.1.1 A detector shall operate for its intended signaling performance when tested in an ambient temperature of 0 and 49°C (32 and 120°F) and a relative humidity of 30 to 50 percent.

48.1.2 Two detectors, one at maximum and one at minimum sensitivity, are to be maintained at each ambient temperature for a minimum of 3 hours. The detectors are to be tested for sensitivity while connected to a source of supply in accordance with 28.2.1.

48.1.3 Sensitivity measurements shall be recorded before and during exposure to each ambient temperature in accordance with the Sensitivity Test, Section 31, except that the relationship between the MIC output and the percent light transmission remains within the limits represented by the curves illustrated in Figures 48.1 and 48.3 for the 0°C (32°F) and 49°C (120°F) ambient, respectively. The visible smoke buildup rates are to be maintained within the limits illustrated in Figures 48.2 and 48.4 for the 0°C and 49°C ambient, respectively.

Figure 48.1
Sensitivity test limits
0°C ambient – gray smoke – cotton wick – 30 fpm

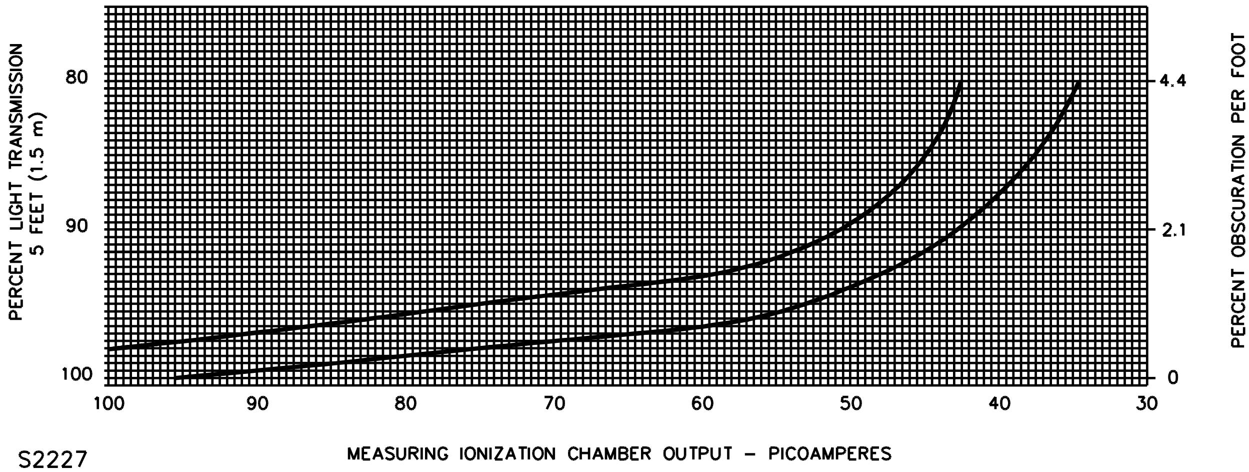


Figure 48.2
Smoke build-up rate – sensitivity test
0°C ambient – gray smoke – 32 fpm

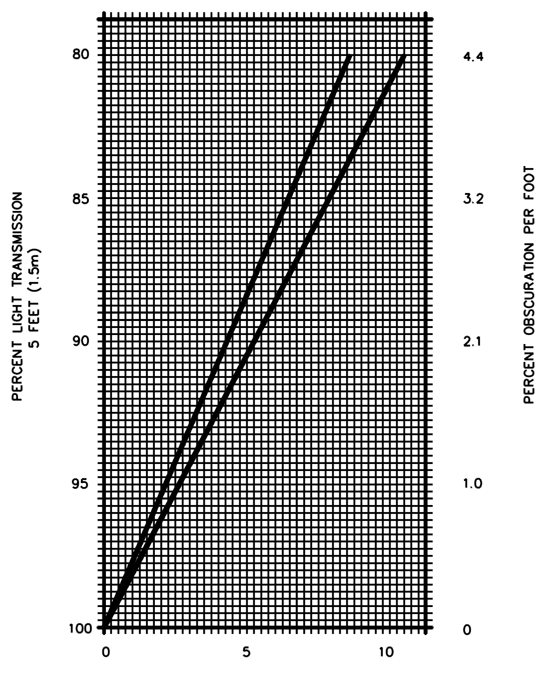
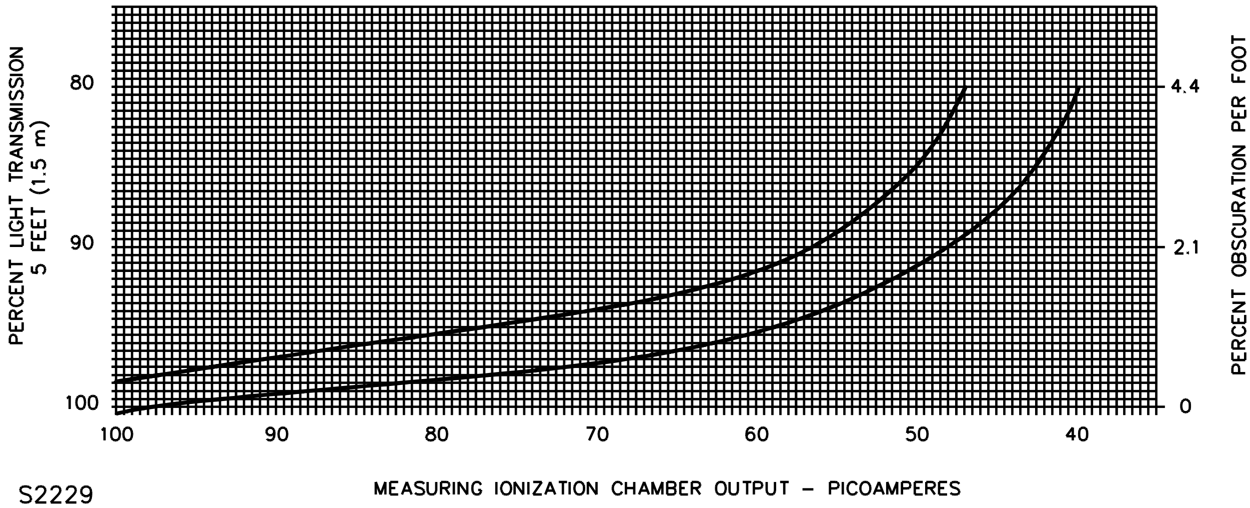
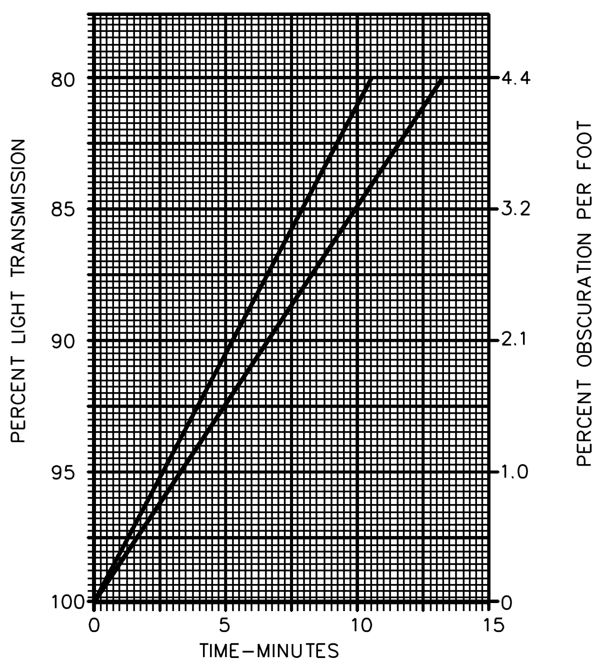


Figure 48.3
Sensitivity test limits
49°C ambient – gray smoke – 30 fpm



S2229

Figure 48.4
Smoke build-up rate – sensitivity test
49°C ambient – gray smoke – cotton wick – 32 fpm



S2230

48.1.4 Each detector shall operate as intended in each ambient. The sensitivity readings using gray smoke measured at each ambient temperature shall vary not more than specified in 29.3.1.

48.2 Effect of shipping and storage

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

48.2.2 Two detectors, one at maximum and one at minimum sensitivity, packaged as intended for shipping, are to be subjected, in turn, to a temperature of 70°C (158°F) for a period of 24 hours, allowed to cool to room temperature for at least 1 hour, exposed to a temperature of minus 30°C (minus 22°F) for at least 3 hours, and then permitted to warm up to room temperature for a minimum of 3 hours. The detectors are then to be tested for sensitivity using gray smoke while connected to a source of rated supply voltage in accordance with 28.2.1.

48.2.3 Sensitivity measurements are to be recorded, before and after exposure to both ambient conditions, in accordance with the Sensitivity Test, Section 31.

48.2.4 The sensitivity readings using gray smoke measured after exposure shall comply with the requirements of the Sensitivity Test, Section 31, and shall vary not more than specified in 29.3.1.

49 Humidity Test

49.1 Two detectors, one at maximum and one at minimum sensitivity, shall operate for their intended signaling performance when exposed for 168 hours to air having a relative humidity of 93 ±2 percent and a temperature of 40 ±2°C (104 ±4°F) while energized from a source of supply in accordance with 28.2.1. There shall not be false alarms during the exposure.

49.2 Sensitivity measurements are to be recorded before and during exposure to the humidity condition in accordance with the Sensitivity Test, Section 31, except that the smoldering rate of the wick is to be such that the relationship between the MIC output and the percent light transmission remains within the limits illustrated in Figure 31.1. The visible smoke buildup rate is to be maintained within the limits illustrated in Figure 31.2.

49.3 The sensitivity values using gray smoke during exposure to the humid atmosphere shall vary not more than specified in 29.3.1.

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

50 Corrosion Tests

50.1 A detector shall operate as intended after being subjected to the corrosive atmosphere tests described in 50.2 – 50.4. The samples are to be placed in the test chambers that are located in a room having a temperature of 23 ±2°C (73 ±4°F) and 20 – 50 percent relative humidity. The samples are to be mounted in their intended position of use on a platform 1 inch (25.4 mm) above the bottom. The relative humidity inside the chamber during the test is to be 95 percent.

50.2 Two samples, one at the maximum and one at the minimum sensitivity setting, are to be exposed to a moist hydrogen sulfide-air mixture in a closed glass chamber for 10 days. The amount of hydrogen sulfide is to be the equivalent of 0.1 percent of the volume of the chamber. A small amount of water (10 ml of water per 0.003 m^3) of chamber volume) is to be maintained in the bottom of the chamber for humidity.

50.3 Two samples, one at maximum and one at minimum sensitivity setting, are to be exposed to a moist carbon dioxide-sulphur dioxide-air mixture in a closed glass chamber for 10 days. The amount of carbon dioxide is to be the equivalent of 1.0 percent, and the amount of sulphur dioxide is to be the equivalent of 0.5 percent of the volume of the chamber. A small amount of water (10 ml of water per 0.003 m^3 of chamber volume) is to be maintained in the bottom of the chamber for humidity.

50.4 The detectors are to be tested for sensitivity using gray smoke prior to exposure to the corrosive atmospheres. Following the corrosion exposures described in 50.2 and 50.3, the detectors are to be dried in a circulating air oven at a temperature of 40°C (104°F) for at least 24 hours after which the detectors are to be again tested for sensitivity. Sensitivity measurements following the exposure to the corrosive atmospheres shall not false alarm, and the sensitivity shall vary not more than 1 percent per foot obscuration (0.014 optical density per meter) in the direction of low sensitivity. In any case, the sensitivity shall not exceed the limits specified in the Sensitivity Test, Section 31.

51 Transient Tests

51.1 General

51.1.1 Two detectors, one at maximum and one at minimum sensitivity:

a) Shall operate for their intended signaling performance,

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

c) Shall not have their sensitivity affected adversely after being subjected to 500 internally induced transients, extraneous transients, 500 (high-voltage) supply line transients, and 60 supply line (low-voltage) circuit transients, while energized from a source of supply as specified in 28.2.1 and connected to the devices intended to be used with the detector.

51.2 Internally induced transients

51.2.1 The detector is to be energized in the standby condition from a source of supply as specified in 28.2.1. The supply is to be interrupted a total of 500 cycles. Each interruption is to be for 1 second at a rate of not more than 6 interruptions per minute. Following the test the detector is to be operated for its intended signaling performance.

51.3 Extraneous transients

51.3.1 A detector shall not false alarm or its intended operation be impaired when subjected to extraneous transients generated by the devices and appliances described in 51.3.2. In addition, the detector shall respond to smoke or other aerosol during application of the transient condition.

51.3.2 To determine compliance with 51.3.1, two smoke detectors are to be energized from a source of rated voltage and frequency and subjected to transients generated from the following devices located 1 foot (305 mm) from the detector, interconnecting wires, or both. The time of application for condition (a) shall be at least 2 minutes. Conditions (c), (d), and (e) are to be applied for 10 cycles, each application of 2 seconds duration, except the last application shall be of a 2-minute duration. Near the end of the last cycle, an abnormal amount of smoke or other aerosol is to be introduced into the detector chamber to determine whether the unit is operational for smoke with the transient applied.

a) Sequential arc (Jacob's ladder) generated between two 15 inch (381 mm) long, No. 14 AWG (2.1 mm^2) solid copper conductors attached rigidly in a vertical position to the output terminals of an oil burner ignition transformer or gas tube transformer rated 120 volts, 60 hertz primary; 10,000 volts, 60 hertz, 23 milliamperes secondary. The two wires are to be formed in a taper, starting with an 1/8 inch (3.2 mm) separation at the bottom (adjacent to terminals) and extending to 1-1/4 inches (31.8 mm) at the top.

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

1) 27 megahertz,

2) 150 megahertz,

3) 450 megahertz,

4) 866 megahertz, and

5) 910 megahertz.

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

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

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

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

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

51.4 Supply line (high-voltage) transients

51.4.1 A high-voltage AC-operated detector is to be subjected to supply line transients induced directly onto the power supply circuit.

51.4.2 For this test, the detector is to be connected to a transient generator, consisting of a 2 kVA isolating power transformer and control equipment capable of producing the transients described in 51.4.3. See Figure 51.1. The output impedance of the transient generator is to be 50 ohms.

51.4.3 The transients produced are to be oscillatory and are to have an initial peak voltage of 6000 volts. The rise time is to be less than 1/2 microsecond. Successive peaks of the transient are to decay to a value of no more than 60 percent of the value of the preceding peak. Each transient is to have a total duration of 20 microseconds and is to be applied once every 10 seconds.

51.4.4 The unit is to be subjected to 500 oscillatory transient pulses included at a rate of six transients per minute. Each transient pulse is to be induced 90 degrees into the positive half of the 60 hertz cycle.

51.4.5 Following the test the unit is to be tested for sensitivity. Sensitivity measurements, using gray smoke, shall vary not more than specified in 29.3.1.

51.5 Supply line (low-voltage circuit) transients

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

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

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

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

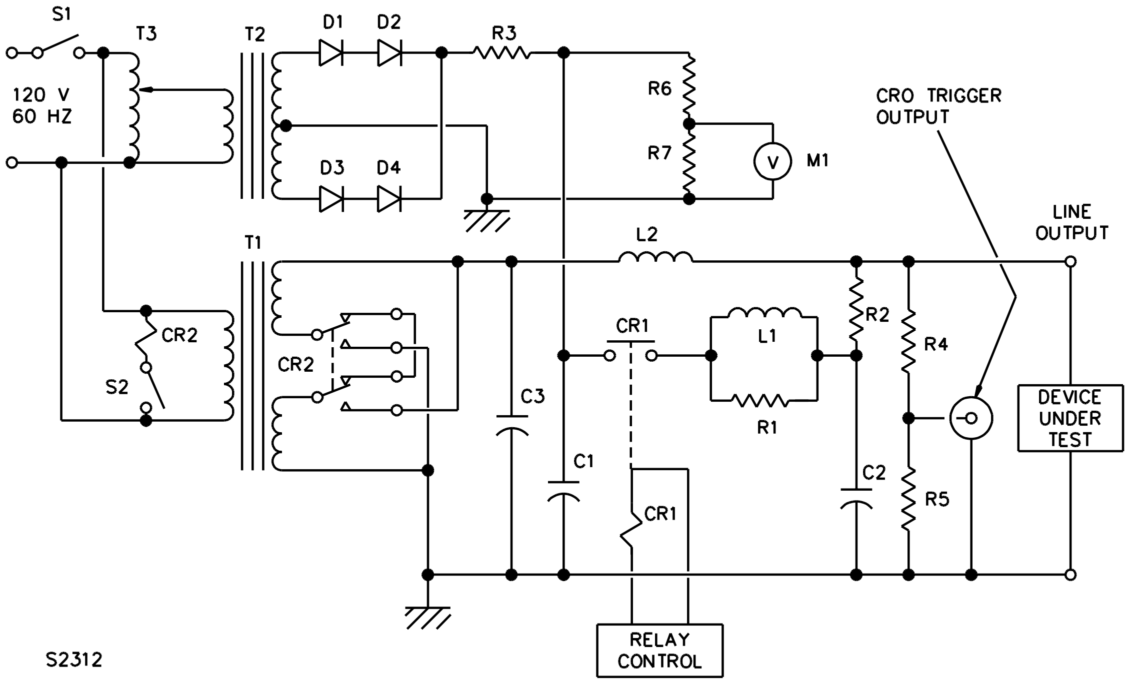
51.5.3 The detector is to be subjected to 60 transient pulses induced at the rate of six pulses per minute as follows:

a) Twenty pulses (two at each transient voltage level specified in 51.5.2) between each circuit lead or terminal and earth ground, consisting of ten pulses of one polarity, and ten of the opposite polarity (total of 40 pulses) and

b) Twenty pulses (two at each transient voltage level specified in 51.5.2) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten of the opposite polarity.

51.5.4 At the conclusion of the test, the detector shall comply with the requirements of the Normal Operation Test, Section 29, and the Sensitivity Test, Section 31.

Figure 51.1
Surge generator circuit



C1	– Capacitor, 0.025 µF, 10 kV
C2	– Capacitor, 0.006 µF, 10 kV
C3	– Capacitor, 10 µF, 400 V
CR1	– Relay, coil 24 VDC. Contacts, 3-pole, single throw, each contact rated 25 A, 600 VAC maximum, all three poles wired in series.
CR2	– Relay, coil 120 VAC. Contacts DPDT. Provides either 120 V or 240 V test circuit.
D1 – D4	– Diodes, 25 kV PIV each
L1	– Inductor 15 µH [33 turns, No. 22 AWG wire, wound on 0.835 inch (21.2 mm) diameter PVC tubing]
L2	– Inductor, 70 µH [45 turns, No. 14 AWG wire, wound on 2.375 inch (60.33 mm) diameter PVC tubing]
M1	– Meter, 0 – 20 VDC
R1	– Resistor, 22 Ohms, 1 W, composition
R2	– Resistor, 12 Ohms, 1 W, composition
R3	– Resistor, 1.3 megohms, (12 in series, 110K ohms each, 1/2 W)
R4	– Resistor, 47K ohms (10 in series, 4.7K ohms each, 1/2 W)
R5	– Resistor, 470 ohms, 1/2 W
R6	– Resistor, 200 megohms, 2 W, 10 kV
R7	– Resistor, 0.2 megohms (2 in series, 100K ohms each, 2 W, carbon)
S1	– Switch, SPST
S2	– Switch, SPST, key-operated, 120 VAC, 1 A
T1	– Transformer, 2 kVA, 120 V primary, 1:1 (120 V or 240 V output)
T2	– Transformer, 90 VA, 120/15,000 V
T3	– Variable autotransformer, 2.5 A

52 Static Discharge Test

52.1 The intended performance of a detector shall not be impaired or a false alarm obtained, when the detector is subjected to static electric discharges. Operation of the trouble circuit during this test is not to be identified as a malfunction, when the subsequent intended operation is not affected. The test is to be conducted in an ambient temperature of 23 ±3°C (73.4 ±5°F) at a relative humidity of 10±5 percent and a barometric pressure of not less than 700 mm of mercury (193.5 kPa).

52.2 Each of two detectors, one at maximum and one at minimum sensitivity, is to be mounted on the underside of a 3/4-inch (18.1-mm) thick plywood panel in its intended mounting position and connected to a source of supply in accordance with 28.2.1. When a detector is intended to be installed on a metal backbox, the box is to be connected to earth ground. A 250 picofarad low leakage capacitor, rated 10,000 volts DC, is to be connected to two high-voltage insulated leads, 3 feet (0.9 m) long, stripped 1 inch (25.4 mm) at each end. A 1500 ohm resistor is to be inserted in series with one lead. The end of each lead is to be attached to a 1/2-inch (12.7-mm) diameter metal test probe with a spherical end mounted on an insulating rod. The capacitor is to be charged by touching the ends of the test leads to a source of 10,000 volts DC for at least 2 seconds for each discharge. One probe is to be first touched to the detector and the other probe then touched to earth ground. An electrostatic voltmeter is to be employed to measure the voltage and is to be removed prior to conducting the discharge.

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

52.4 Following the discharges, the detector is to be tested for sensitivity using gray smoke. Sensitivity measurements shall be within the limits specified in 29.3.1.

53 Dust Test

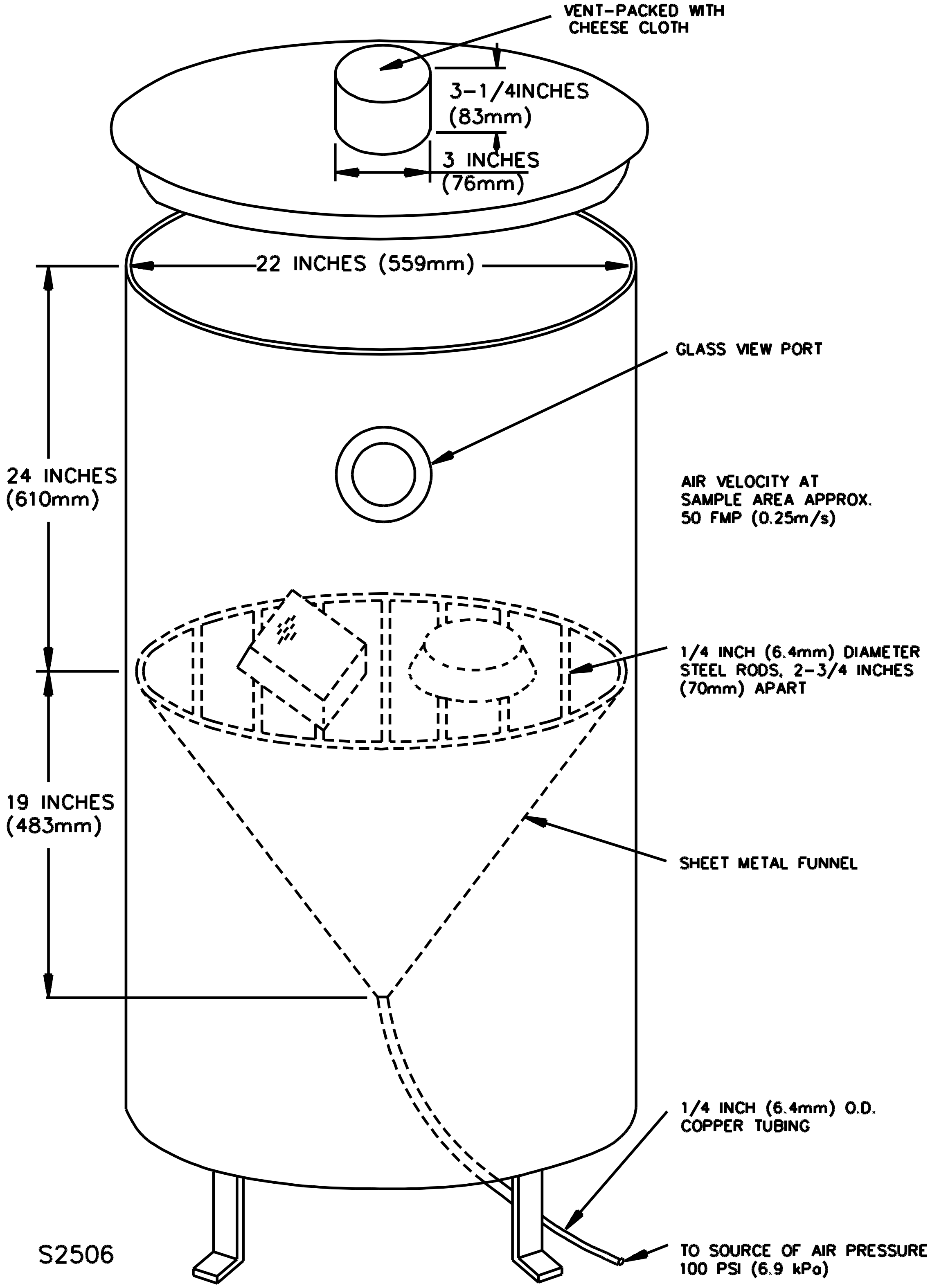
53.1 The sensitivity of a detector shall not be reduced excessively by an accumulation of dust. Energization of the alarm or trouble circuit is not prohibited.

53.2 To determine compliance with 53.1, two samples, one at maximum and one at minimum sensitivity, are to be placed, de-energized, on metal supports in an air tight chamber having an internal volume of at least 3 cubic feet (0.09 m^3). See Figure 53.1.

53.3 2 ounces (0.06 kg) of cement dust, maintained in an ambient room temperature of 23 ±2°C (73.4 ±3°F) at 20 – 50 percent relative humidity and capable of passing through a 200 mesh screen, are to be circulated for 15 minutes by means of compressed air or a blower so as to completely envelop the sample in the chamber. The air flow is to be maintained at an air velocity of at least 50 fpm (0.25 m/s).

53.4 Following the exposure to dust the detector is to be removed carefully, mounted in its intended position, energized from a source of supply in accordance with 28.2.1, and tested for sensitivity, using gray smoke, unless a trouble signal or false alarm is obtained. Sensitivity measurements following this test shall not vary by more than specified in 29.3.1.

Figure 53.1
Dust test chamber



54 Overload Tests

54.1 Detector

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

54.1.2 Rated test loads are to be connected to the output circuits of the detector energized from the detector power supply. The test loads are to be those devices, such as remote indicators, relays, and the like, or their equivalent, intended for connection. When the equivalent load consists of an inductive load, a power factor of 60 percent is to be employed. The rated loads are to be established initially with the detector connected to a source of supply as specified in 28.2.1, following which the voltage is to be increased to 115 percent of rating.

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

54.2 Separately energized circuits

54.2.1 Separately energized circuits of a detector, such as dry contacts, shall operate as intended after being subjected for 50 cycles of signal operation at a rate of not more than 6 cpm while connected to a source of supply in accordance with the requirements specified in 28.2.1, with 150 percent rated loads at 60 percent power factor applied to output circuits that do not receive energy from the detector. There shall be no electrical or mechanical malfunction of the switching circuit.

54.2.2 The test loads are to be adjusted to carry 150 percent of rated current while connected to a separate source of supply as specified in 28.2.1.

55 Endurance Test

55.1 Detector

55.1.1 Following the Overload Test – Detector (see 54.1.1 – 54.1.3), the same detector shall operate for its intended signaling operation after being subjected to 6000 cycles of 5-second alarm signal operation at a rate of not more than 10 cpm with the detector connected to a source of supply as specified in 28.2.1 and with related devices or equivalent loads connected to the output circuits. There shall not be electrical or mechanical malfunction or evidence of malfunction of the detector components.

55.1.2 Sensitivity measurements using gray smoke are to be recorded before and after this test, as specified in the Sensitivity Test, Section 31. The sensitivity values shall vary not more than specified in 29.3.1.

55.2 Separately energized circuits

55.2.1 Following the Overload Test – Separately Energized Circuits (see 54.2.1 and 54.2.2), the same separately energized circuits of the detector shall operate as intended when operated for 6000 cycles at a rate of not more than 10 cpm at a duty time cycle of 50 percent off and 50 percent on. When an electrical load is involved, the contacts of the device are to make and break the normal current at the voltage specified by 28.2.1. The load is to represent that which the device is intended to control. The Endurance Tests of the separately energized circuits shall be conducted either separately or in conjunction with the Endurance Test of the detector. There shall not be electrical or mechanical malfunction of the detector nor malfunction or welding of any relay contacts.

Exception: This test is not necessarily required when the contact rating of the switching circuits is at least twice that of the load controlled.

55.3 Audible signaling appliance

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

56 Fire Test (Heat Detector)

56.1 A heat detector provided as part of a smoke detector assembly shall comply with the applicable performance requirements specified in the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521. It shall be sensitive enough to qualify for at least a 50 foot (15.2 m) spacing when subjected to the Fire Test described in UL 521.

56.2 Two samples of the smoke detector incorporating the heat detector shall be subjected to this test.

57 Abnormal Operation Test

57.1 A detector shall operate continuously under abnormal (fault) conditions without resulting in a risk of fire.

57.2 The detector is to be operated under the most severe abnormal circuit fault conditions encountered in service while connected to a source of supply as specified in 28.2.1. There shall not be emission of flame or molten metal, or any other manifestation of a fire.

57.3 During this test, the fault condition is to be maintained continuously until constant temperatures are attained, or burnout occurs, when the fault condition does not result in the operation of an overload protective device. The shorting of an electrolytic capacitor(s) and operation in the alarm condition for more than 1 hour represents typical abnormal conditions. See 30.2.1 – 30.2.4, and 54.1.1.

58 Locked Rotor Test

58.1 General

58.1.1 A motor provided with thermal protection complying with the Standard for Overheating Protection for Motors, UL 2111, and an impedance-protected motor complying with the requirements for such motors comply with these requirements without the necessity of further tests.

58.2 Thermal or overcurrent protection

58.2.1 When the rotor of the motor is locked, the maximum temperature on a Class A insulated motor winding shall be 200°C (392°F) during the first hour of operation and 175°C (347°F) thereafter. After the first hour of operation, the average temperature, found by taking the arithmetic mean of the maximum temperatures and the arithmetic mean of the minimum temperatures, shall not exceed 150°C (302°F).

58.2.2 Temperatures are to be measured by thermocouples on the surface of coils of the motor. The test of a manually reset device is to be continued for four operations of the protective device, with the device being reset as quickly as possible after it has opened. For an automatically reset device, the locked-rotor test is to be continued for 72 hours unless the detector includes other controls (such as a timer) that limits the duration of the operation to a shorter interval. During the test, the motor is to be connected to a source of supply as specified in 28.2.1.

58.2.3 An automatic-reset thermal protector of a motor shall perform as intended when operated for 15 days (unless the detector includes other controls, such as a timer, which positively and reliably limits the operation to a shorter interval, or unless the device permanently opens the circuit prior to the expiration of that period), with the rotor of the motor locked, and with the motor connected to a supply circuit having a voltage of 100 – 110 percent of the rated voltage of the motor. There shall not be permanent damage to the motor (including excessive deterioration of the insulation), and, in a situation where the device permanently opens the circuit, it shall do so without grounding to the motor frame, damaging the motor, or resulting in a risk of fire. A manual-reset thermal protector of a motor shall interrupt for 50 operations, without damage to itself, the locked-rotor current of the motor.

58.2.4 There shall not be any ignition of cotton surrounding the enclosure of a thermal protector of a motor when three samples of the device are subjected to limited short-circuit currents. For a motor rated at 1/2 horsepower (373 W output) or less, and 250 volts or less, the current is to be 200 amperes. For a motor having other ratings, and not more than 1 horsepower (746 W output), it is to be 1000 amperes. The power factor of the test circuit is to be 0.9 – 1.0, and the circuit capacity is to be measured without the device in the circuit. A nonrenewable cartridge fuse is to be connected in series with the device under test. The fuse rating is to be not less than four times the rated current of the detector except that the fuse rating is not to be less than 20 amperes for a detector rated 150 volts or more, and not more than 600 volts. The test on one sample is to be made by closing the device on the short circuit.

58.3 Impedance protection

58.3.1 When operated under locked-rotor conditions for 15 days:

a) A motor shall not attain a temperature of more than 150°C (302°F) during the first 72 hours of operation;

b) The motor winding shall not burn out or become grounded to the frame, nor shall there be any evidence of excessive deterioration of insulation; and

c) The supply-circuit fuses shall not open.

Exception: The test does not have to be continued longer than required for the windings of the motor (of either the open or totally enclosed type) to reach constant temperature, when this constant temperature is not more than 100°C (212°F).

58.3.2 During the test, a motor having a nominal rating of 115 volts is to be connected to a circuit having a voltage of 120 volts, and a motor having a nominal rating of 230 volts is to be connected to a circuit having a voltage of 240 volts. A motor having any other voltage rating is to be connected to a circuit having a voltage of 100 – 105 percent of the voltage rating of the motor.

58.3.3 To determine that a motor complies with the requirements of 58.3.1, temperature readings are to be taken as follows:

a) For a totally enclosed motor – a motor whose outer metal enclosure is complete – the temperature is to be measured by means of a thermocouple on the enclosure.

b) For any other motor, the temperature is to be measured by means of a thermocouple on the integrally applied insulation of the winding under the coil wrap, when present.

c) When the coil is encapsulated, the winding temperature is to be determined by the resistance method.

58.3.4 The rotor of the motor is to be locked in a stationary position. The motor is to be mounted on wood or other thermal insulating material determined to be equivalent. Blades or other motor attachments are to be removed from the motor. Integral mounting brackets are to be left in place. The frame of the motor is to be connected to ground by means of a solid conductor (that is, with no fuse in the grounding conductor). A 30-ampere time-delay fuse is to be connected in each ungrounded conductor of the supply cord.

58.3.5 At the conclusion of the first 72 hours of the Locked Rotor Test, the motor shall withstand the Dielectric Voltage-Withstand Test, Section 59.

58.3.6 At the conclusion of the 15-day test, a potential of twice the marked rated voltage of the motor is to be applied between the windings and the frame to determine whether or not the winding has become grounded.

59 Dielectric Voltage-Withstand Test

59.1 A detector shall withstand for 1 minute, without breakdown, the application of a sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential, between high-voltage live parts and exposed dead metal parts, and between live parts of high- and low-voltage circuits. The test potential is to be:

a) For a detector rated 30 volts AC rms (42.4 volts DC or AC peak) or less – 500 volts (707 volts, when a DC potential is used).

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

c) For a detector rated more than 250 volts AC rms – 1000 volts plus twice the rated voltage (1414 times plus 2.828 times the rated AC rms voltage, when a DC potential is used).

59.2 Any reference or component grounds are to be disconnected prior to the test applications.

59.3 When the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is sufficient to prevent maintaining the specified AC test potential, it is appropriate to test the capacitors and capacitor-type filters using a DC potential in accordance with 59.1.

59.4 The test potential is to be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. Starting at zero, the applied potential is to be increased at a rate of 200 volts per minute until the required test value is reached and is to be held at that value for 1 minute.

59.5 When there is the possibility of short circuit or damage to a printed-wiring assembly or other electronic-circuit component by application of the test potential, the component is to be removed, disconnected, or otherwise rendered inoperative before the test. It is not prohibited to test a representative subassembly instead of an entire unit.

60 Polarity Reversal Test

60.1 A smoke detector shall operate in its intended manner after being connected in each polarity for at least 24 hours or until a trouble or alarm signal is obtained. For a battery-operated detector intended to be connected by a polarized clip assembly, the reverse polarity is to be applied for a minimum of 1 second. A trouble or alarm signal is to be permitted under any incorrect polarity applied. Samples are to be connected as specified in the Normal Operation Test, Section 29.

60.2 Two samples are to be subjected to this test. Sensitivity measurements using gray smoke prior to and following the test are to be made as specified in the Sensitivity Test, Section 31. Measurements following the polarity reversal shall not vary more than specified in 29.3.1.

61 Tests on Polymeric Materials

61.1 General

61.1.2 Polymeric materials intended for the sole support of current-carrying parts or as an enclosure of a detector shall be subjected to the tests specified in 61.2.1 – 61.4.6. When possible, a complete detector is to be used.

61.2 Temperature test

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

61.2.2 Three representative samples are to be mounted on supports as intended in service and placed in the oven. Following the aging period indicated in 61.2.1, the samples are to be viewed (while in the oven) for distortion, removed, permitted to cool to room temperature, and then reexamined for compliance with the requirements of 61.2.1. Falling off the detector cover is shall occur only when high-voltage parts are not exposed, operation for smoke is not affected, and the cover is able to be placed as intended. Sensitivity measurements, using gray smoke, conducted in the event of questionable distortion, shall not vary more than specified in 29.3.1.

61.3 Flame test (3/4 inch)

61.3.1 When equipment is tested as described in 61.3.2 – 61.3.6, the material shall not flame for more than 1 minute after two 30-second applications of a test flame, with an interval of 1 minute between applications of the flame. The sample shall not be completely consumed.

Exception: Parts that are molded from materials that are classed as 5VA, 5VB, V-0, V-2, by the vertical burning test described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are not required to be subjected to the flammability test described in 61.3.2 – 61.3.6.

61.3.2 Three samples of the equipment are to be placed in a forced draft circulating air oven maintained at a uniform temperature not less than 10° C (18°F) higher than the maximum temperature of the material measured under normal operating conditions, and not less than 70°C (158°F) in any case. The samples are to remain in the oven for 7 days. After cooling to room temperature for a minimum of 4 hours, the samples are to be tested as described in 61.3.3 – 61.3.6.

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

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

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

61.3.3 Three samples of the part are to be subjected to the flame test described in 61.3.5. In the performance of the test, the equipment is to be supported in its normal operating position in a draft free location. Nonpolymeric portions are not to be removed and insofar as possible, the internal mechanism of the equipment is to be in place. The flame is to be applied to an inside surface of the sample at a location judged ignitable because of its proximity to a source of ignition. Each sample shall be tested with the flame applied to a different location.

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

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

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

61.3.4 With reference to 61.3.3, the sections most ignitable are to be identified as those adjacent to coil windings, splices, open-type switches, or arcing parts.

61.3.5 The flame of a Bunsen or Tirrill burner having a tube with a length of 3.94 ±0.39 inches (100 ±10 mm) and an inside diameter of 0.374 ±0.12 inch (9.5 ±0.3 mm) is to be adjusted to have a 3/4-inch (19-mm) height of yellow flame with no blue cone Two 30-second applications of the tip of the flame are to be made to each section of the equipment chosen as indicated in 61.3.4, with 1 minute intervals between the applications. A supply of technical-grade methane gas is to be used with a regulator and meter for uniform gas flow.

Exception: Natural gas having a heat content of 1000 Btu/ft^3 (37 MJ/m^3) at 23°C has been found to provide similar results and is not prohibited from use.

61.3.6 When one sample from a set of three does not comply with 61.3.1, an additional set of three samples shall be tested. All samples from the second set shall comply with 61.3.1.

61.4 Flame test (5 inch)

61.4.1 When equipment is tested as described in 61.4.2 – 61.4.5, all of the following results shall be obtained:

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

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

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

Exception: Parts that are molded from materials that are classed as 5VA by the five inch burning test described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are not required to be subjected to the flammability tests described in 61.4.2 – 61.4.5.

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

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

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

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

61.4.3 The three samples are to result in the performance described in 61.4.1. When one sample does not comply, the test is to be repeated on a set of three new samples with the flame applied under the same conditions as for the unsuccessful sample. All the new specimens shall comply with 61.4.1.

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

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

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

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

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

62 Strain Relief Test

62.1 Each lead employed for field connections or an internal lead or cord subjected to movement or handling during installation and servicing, including a battery clip lead assembly, shall withstand for 1 minute a force of 10 pounds (44.5 N) without any evidence of damage or of transmitting the stress to internal connections. A connector used in the lead assembly shall withstand a pull of 5 pounds force (22.3 N) without any evidence of damage, transmittal of stress to internal connections, or separation.

62.2 A strain relief test on a cord or leads which depend upon a thermoplastic enclosure or part is to be conducted following exposure to either temperature conditioning test described in 61.2.1. The test is to be performed after the sample has been placed in room temperature for at least 3 hours.

63 Non-compulsory Fire and Smoldering Smoke Tests

63.1 When the sensitivity of detectors subjected to any one of the following tests exceeds the maximum sensitivity change permitted for that particular test then the same samples, adjusted to the minimum sensitivity settings, shall comply with the Fire Tests, Section 39, and the Smoldering Smoke Test, Section 40:

a) Undervoltage Test, 43.2.1 – 43.2.3,

b) Overvoltage Test, 43.1.1 and 43.1.2,

c) Jarring Test, Section 47,

d) Corrosion Tests, Section 50,

e) Vibration Test, Section 45,

f) Dust Test, Section 53.

g) Lamp Interchangeability Test (Photoelectric), Section 35, and

h) Reduction in Light Output Test, Section 36.

63.2 For the tests specified in 63.1 (a) and (b), the supply voltage to the detectors in the Fire Tests, Section 39, and the Smoldering Smoke Test, Section 40, is to be at the voltage indicated for the applicable tests.

64 Accelerated Aging Test (Long-Term Stability Test)

64.1 The tests specified in 64.2 – 64.4 are an alternate test method to the 90-day stability test requirements of 37.1 (a).

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

64.3 When subjected to 10 cycles of change of air velocity, there shall be no false alarms. Sensitivity measurements, using gray smoke, recorded before and after the exposures are to comply with the Sensitivity Test, Section 31, and shall vary not more than specified in 29.3.1.

64.4 Two samples, one at maximum and one at minimum sensitivity, or both at the sensitivity that is most affected by the test temperature, as determined by the Variable Ambient Temperature Tests, Section 48, are to be placed in a circulating air oven and energized for 14 days from a source of rated voltage and frequency. Following removal, the energized samples are to be permitted to cool to room temperature for at least 24 hours and subjected in turn, to 10 cycles of change of air velocity test described in 37.1 (d) and then to the Sensitivity Test, Section 31.

65 Survivability Test

65.1 Two samples of the smoke detector shall be exposed to a temperature of 121°C (250°F) for a period of 4 minutes. The units are to be removed from the test chamber and allowed to return to room temperature. The units are then to be subjected to the Audibility Test, Section 66, (when applicable) and the Sensitivity Test, Section 31.

65.2 Following conditioning, the samples shall be capable of producing an audible output of 85 db(A) at 10 feet (3.05 m), and the sensitivity of each detector shall not vary by more than specified in 29.3.1.

66 Audibility Test

66.1 General

66.1.1 When tested as described in 66.2.1 – 66.2.4, an alarm sounding appliance integral with the detector shall provide, for at least 4 minutes, a sound output equivalent to that of an omnidirectional source with an A-weighted sound pressure level of at least 85 decibels at 10 feet (3.05 m) with two reflecting planes assumed. It is not prohibited for detectors to be tested with the horn duty cycle, 29.2.1, defeated and emitting a continuous tone.

66.2 Sound output measurement

66.2.1 The sound power output of the detector is to be measured in a reverberation room qualified for pure tones specified in the Standard for Precision Methods for the Determination of Sound Power Levels of Discrete-Frequency and Narrow Band Noise Sources in Reverberation Rooms, ANSI S1.32-1980. The sound power in each 1/3 octave band is to be determined using the comparison method. The A-weighting factor is to be added to each 1/3 octave band. The total power is to be determined on the basis of actual power. An equivalent sound pressure level for a radius of 10 feet (3.05 m) is to be calculated by subtracting 14.6 dB from the A-weighted power level. An additional 6 decibels then is to be added to allow for two reflecting planes.

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

66.2.3 For this test, the detector is to be energized from a source of rated voltage and frequency.

66.2.4 At least two samples are to be tested. Units intended for interconnection are to be tested interconnected with a maximum resistance of 50 ohms in each line.

67 Field Service Tests

67.1 Go/no-go field test

67.1.1 Two detectors, one at maximum and one at minimum sensitivity, shall operate at their intended signaling performance, and each detector's sensitivity shall not shift by more than specified in 29.3.1 after being subjected to 50 cycles of the manufacturer's specified go/no-go field test method and conditioned as described in the Dust Test, Section 53. The samples are to energized with rated voltage and subjected to the go/no-go test at a rate of not more than one field test per 30 minutes.

67.2 Maintenance (cleanability)

67.2.1 Two detectors, one at maximum and one at minimum sensitivity, shall operate for their intended signaling performance, and each detector's sensitivity shall not shift by more than specified in 29.3.1 after being subjected to 50 cycles of the manufacturer's specified field cleaning procedure.

68 Battery Tests

68.1 When a battery is employed as the main source of power for a smoke detector, it shall provide power to the unit under intended ambient conditions for at least 1 year in the standby condition (hourly supervisory transmission), including weekly alarm testing, and then operate the detector for a minimum of 4 minutes of alarm followed by 7 days of trouble signal. See 30.4.1.

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

a) A room ambient temperature of 23±2°C (73.4 ±3.6°F), 30 – 50 percent relative humidity, and 760 mm Hg;

b) High temperature of 45°C (113°F);

c) Low temperature of 0°C (32°F), and

d) Temperature of 30 ±2°C (86 ±3°F), and 85 ±5 percent relative humidity.

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

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

68.5 Prior to placing the battery test setups in the various ambient conditions, each battery is to be subjected to 25 cycles of alarm at a rate of one alarm transmission per minute.

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

68.7 At the end of the year all batteries shall have the capacity to operate the alarm signal for a minimum of 4 minutes followed by 7 days of trouble signal. It is possible that to obtain the trouble signal level the test shall have to be continued with the standby current drain for longer than 1 year. The length of time for subjecting the batteries to the conditions specified in 68.2 (b) – (d) to operate the alarm signal shall be less than 1 year, and not less than 6 months, only when the detector is marked to indicate the battery limitations for the ambient condition involved.

69 Conformal Coatings on Printed Wiring Boards

69.1 Low voltage printed wiring boards

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

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

69.1.3 Four specimens are to be conditioned to room ambient by exposure to ambient air at a temperature of 23 ±2°C (73, minus 3, +4°F) and 50 ± 5 percent relative humidity for not less than 24 hours. Following the conditioning, the four samples shall be subjected to the Dielectric Voltage-Withstand Test, Section 59, for the 0 to 30 volt range. There shall not be indication of dielectric breakdown as a result of the test. All specimens shall be smooth, homogeneous, and free of heat deformation such as bubbles and pin holes, as determined by visual examination.

69.1.4 Four samples are to be exposed to ambient air at a temperature chosen from the applicable temperature index line shown in Figure 69.1 corresponding to the ″in service″ operating temperature of the coating. The aging temperature chosen from the index line shall correspond to not less than 1000 hours of exposure. It is appropriate for any value of temperature to be chosen when it corresponds to no fewer than 300 hours of exposure. The samples are then to be subjected to the Dielectric Voltage-Withstand Test, Section 59, for the 0 to 30 volt range. All specimens shall be smooth, homogeneous, and free of defects such as bubbles and pin holes, as determined by visual examination. There shall not be crazing, chipping, or other visual evidence of deterioration or separation of the coating from the board after conditioning. There shall not be indication of a dielectric breakdown.

69.1.5 As an option to the use of conformal coating for circuits at a potential of 30 volts rms (42.4 volts DC or AC peak) or less, and less than 100 volt-amperes, four samples of the printed wiring board shall be subjected to the following tests. The samples shall be conditioned in the environment described in the Humidity Test, Section 49. Following the conditioning, the four samples shall be subjected to the Dielectric Voltage-withstand test, Section 59, for the 0 – 30 volt range. There shall not be indication of dielectric breakdown as a result of the test.

69.2 High voltage printed wiring boards

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

69.2.2 Three samples of the printed wiring board without electrical components installed, and coated with the conformal coating, shall be subjected to this test. Test leads are to be attached to the printed wiring (prior to the application of the coating) so as to allow for convenient application of the specified test potential. Each sample shall be subjected to a 5,000 volts AC Dielectric Voltage-Withstand Test potential for one minute:

a) The test shall be performed between tracks on the printed wiring board;

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

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

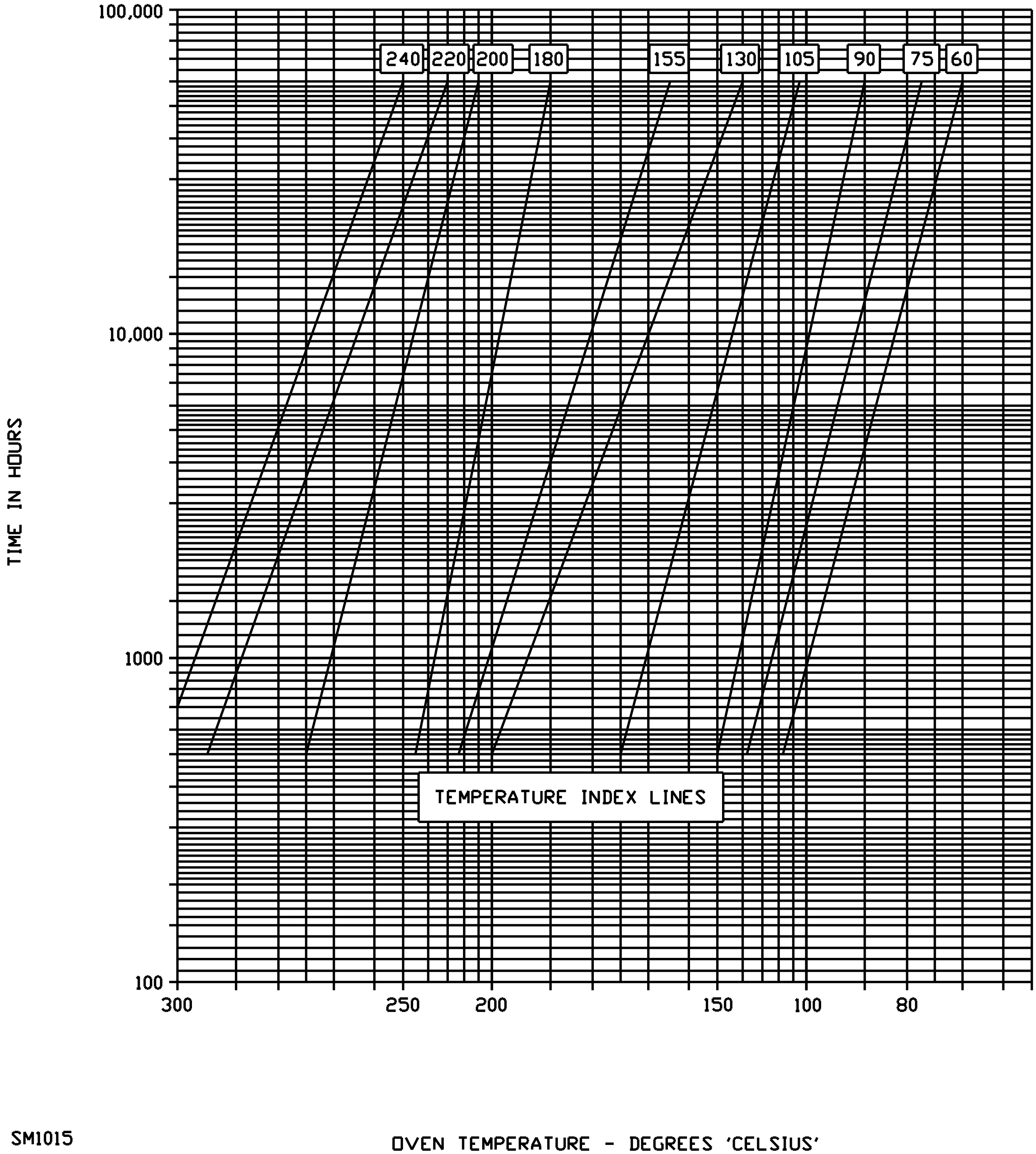
d) A 7 day oven conditioning period at 85 percent relative humidity at 65°C (149°F); and

e) A Dielectric Voltage-Withstand Test potential at 2,500 volts AC repeated 10 times.

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

69.2.3 A sample of the coated printed wiring board, equipped with test leads, without electrical components installed, shall be subjected to this test. The sample shall be subjected to an atmosphere having a relative humidity of 93 ±2 percent at a temperature of 32±2°C (89, minus 3, +4°F) for a period of 24 hours followed by a 500 volts Dielectric Voltage-Withstand Test with the sample maintained in the conditioning atmosphere. There shall be no indication of a dielectric breakdown.

Figure 69.1
Aging time versus aging temperature



MANUFACTURING AND PRODUCTION TESTS

70 General

70.1 The manufacturer shall provide the required production control, inspection, and test procedures. The program shall include at least the tests specified in Sections 71 – 73 conducted on 100 percent of production.

70.2 A record of accepted detectors, and the detector serial number or date code, or equivalent identification is to be maintained.

71 Sensitivity Calibration Tests

71.1 The sensitivity of each detector is to be checked, following the warm-up period specified by the manufacturer and using appropriate instruments, to determine that the sensitivity level is within the marked rating including tolerance, which is within the detector's specified limits. The test equipment is to verify the value or range of sensitivities marked on the detector. The value of instrument reading is to be convertible to percent per foot obscuration.

71.2 For the warm-up period, the detectors are to be energized from a source of supply as specified in 28.2.1. In cases where the detector sensitivity is not within the manufacturer's specifications, the detector is to be corrected and retested. When a retested sample is still outside the specifications, it is to be rejected.

71.3 A warm-up period is not required when the detector components, except for a photocell illuminating lamp, are operated at not more than 25 percent of the component manufacturer's power or temperature rating, whichever is appropriate, in the standby condition or when the individual components are burned-in prior to assembly.

71.4 A warm-up period is required for those detectors or individual components operating at more than 25 percent of rating whose characteristics are variable during initial warm-up, such as solid-state devices, lamp filaments, and resistors, that affect sensitivity.

72 Photocell Illuminating Lamp Test

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

73 Production-Line Dielectric Voltage-Withstand Test

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

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

b) For a detector rated at more than 250 volts – either 1000 volts plus twice the rated voltage (1414 volts plus 2.828 times the rated AC rms voltage, when a DC potential is used) applied for 60 seconds or 1200 volts plus 2.4 times the rated voltage (1697 volts plus 3.394 times the rated AC rms voltage, when a DC potential is used) applied for 1 second.

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

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

73.3 When there is the possibility of short circuit or damage to a printed-wiring assembly or other electronic-circuit component by application of the test potential, the component is to be removed, disconnected, or otherwise rendered inoperative before the test. It is not prohibited to test a representative subassembly instead of an entire unit. It is not prohibited for rectifier diodes in the power supply to be shunted before the test is made to avoid destroying them in the case of a malfunction elsewhere in the secondary circuits.

73.4 A 500 VA or larger transformer, with controlled variable output voltage, is to be used to determine compliance with 73.1. The 500 VA or larger transformer is not required when the high potential testing equipment used is such that it maintains the specified voltage at the detector during the test.

73.5 The test equipment is to include a visible indication of application of the test potential and an audible or visible indication, or both, of breakdown. In the event of breakdown, manual reset of an external switch is required, or an automatic reject of the product under test is to result. When other arrangements are provided they are to be evaluated and accepted when found to achieve the results contemplated.

73.6 When the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is sufficient to prevent maintenance of the specified AC test potential, the detector is to be tested using a DC test potential in accordance with 73.1.

MARKING

74 General

74.1 A detector shall be permanently marked with the following information in a contrasting color, finish, or equivalent. Unless the letter height is specified all markings shall be at least 3/64 inch (1.2 mm) high.

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

b) Model number and date of manufacture, or equivalent; and for two-wire detectors, a compatibility identification marker. Two-wire detectors shall also be marked with the word ″WARNING ″ and the following or equivalent text: ″Connect Detector Only to Control Unit Initiating Device Circuit As Specified In Detector or Control Unit Literature or System May Not Operate. ″

c) Electrical ratings, as follows:

1) Voltage and type of waveform (examples are AC, filtered DC with specified ripple voltage, rectified AC, full wave or half wave).

2) Normal steady state supervisory current, surge current or capacitance, and start-up time. Surge current information is required only for two-wire detector.

3) Alarm current.

4) Maximum permissible current that is intended to be handled by detector.

5) Frequency.

d) Sensitivity setting for a detector having a fixed factory setting. For detectors intended to be adjusted in the field, the range of sensitivity shall be indicated. The marked nominal sensitivity including tolerance shall be indicated in the form of percent per foot obscuration.

e) Intended mounting position of the detector when it is to be mounted in a definite position[p].

f) Identification of lights, switches, meters, and similar components regarding their function unless their function is obvious. Identification of batteries by part number, manufacturer's model number, or equivalent. The identification shall be located adjacent to the component.

g) Maximum rating of a fuse in each fuseholder. Located adjacent to the fuseholder.

h) Reference to an installation wiring diagram, when not attached to the detector, by drawing number and issue number or date. See 76.1.1.

i) A reference to the Technical Bulletin, Section 77.[p]

j) Reference to a specific model number or description of the instrument to be used for checking the sensitivity of the detector.[p]

k) An indication that the device shall not be installed in locations where the normal ambient temperature exceeds 37.8°C (100°F), unless the detector has been determined to be appropriate for installation in a higher ambient temperature.

l) The following or equivalent notice shall be on the outer surface of the enclosure: ″Do Not Paint.″ The letters shall not be less than 1/8 inch (3.2 mm) high and shall be located to be readily visible after the detector is mounted in its intended manner.

m) For a detector that employs a radioactive material the following information shall be indicated directly on the detector exterior (back of detector appropriate):

1) The statement, ″CONTAINS RADIOACTIVE MATERIAL;″

2) Name of Radionuclide and quantity (no abbreviations); and

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

The letter height shall be at least 3/64 inch (1.2 mm) for the marking.

n) A detector intended for permanent connection only to a wiring system other than metal-clad cable or conduit shall be marked to indicate the system or systems for which it is intended. The marking shall be located so that it is visible when power-supply connections to the detector are made.[p]

o) A separable mounting base that is employed with two or more detector heads shall be marked with the name of the manufacturer, model number, and the following or equivalent marking: ″FOR USE WITH MODELS [+]_ DETECTOR HEADS.″

[+] – Insert applicable model numbers

p) A detector intended only for connection to a household system control unit shall be marked with the following (or equivalent) information: ″For Household Use Only.″

q) Sealed units intended to be returned to the manufacturer for servicing shall be marked as follows on the outside of the detector: ″RETURN TO [+]_ FOR SERVICING,″ or equivalent. It is not prohibited for units on which the cover is removable, and that are also intended to be returned to the manufacturer for servicing, to have the marking on the inside of the detector.

[+] – Name and address of manufacturer or supplier

r) Temperature rating of supplementary heat detector, when provided, in degrees Fahrenheit and Celsius.

s) A detector employing alarm verification that is to be bypassed in order to comply with the Fire Tests, Section 39, and the Smoldering Smoke Test, Section 40, shall be marked with the following or equivalent text: ″This Detector Employs A Maximum Alarm Verification Time Delay Of __ Seconds. ″ The applicable time shall be inserted in the blank space.

t) The following or equivalent qualifying statement on a battery-operated detector when battery operation, under other than normal room temperature conditions during the long term battery tests (see the Battery Tests, Section 68), is less than 1 year:

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

Applicable wording is to be used.

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

[p]It is not prohibited for this marking to appear on the installation wiring diagram rather than on the detector as described.

74.2 When a false alarm occurs under the test condition specified in 38.1 (b) or (c), the following marking shall be provided on the detector in 1/8 inch (3.2 mm) high letters:

NOT SUITABLE FOR INSTALLATION IN AREAS WHERE AIR VELOCITIES EXCEED [#]_ FPM ([+]_ METERS PER MINUTE)

[#] – Insert 300 or 1000, whichever is applicable.

[+] – Insert equivalent meter value (91 or 300).

74.3 Information required to appear directly on the detector shall be readily visible after installation. Except for the marking specified in 74.1 (l), the removal or opening of an enclosure cover or the removal of not more than two securing screws of a cover, or an equivalent arrangement to view a marking, complies with the requirement of this paragraph.

74.4 When a manufacturer produces units at more than one factory, each unit shall have a distinctive marking to identify it as the product of a particular factory.

74.5 Additional marking requirements are specified by 9.6.3, 11.7.1, and 11.7.2.

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

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

b) Model number, and

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

Unless the letter height is specified all markings shall be at least 1.2 mm (3/64 inch) high.

75 Packaging Marking

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

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

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

c) The following or equivalent statement:

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

76 Installation Instructions– Wiring Diagram

76.1 All detectors

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

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

a) Monitored connections (identified incoming and outgoing leads) to the initiating device circuit of a control unit and power supply circuit. See Figure 76.1 for examples.

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

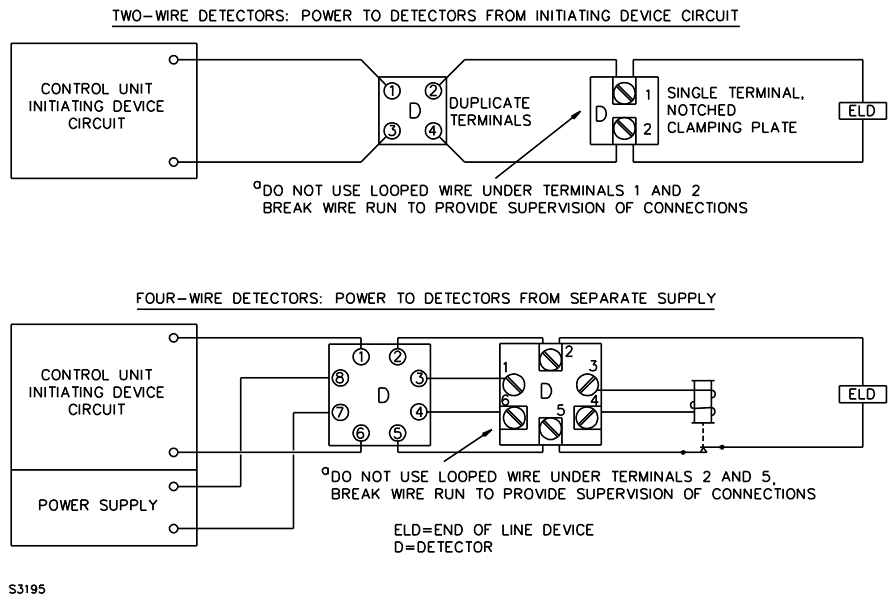
c) When duplicate terminals are not provided to facilitate monitoring of the installation wiring connections, and there is no provision to prevent looping an unbroken wire around or under a terminal, the word ″CAUTION ″ and the following or equivalent text in letters not less than 3/32 inch (2.38 mm)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

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

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

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

Figure 76.1
Sample installation drawing for monitored connection of smoke detectors



[a] See 76.1.2 (c)

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

76.1.7 The instructions shall include the following statement: ″Smoke detectors are not to be used with detector guards unless the combination has been evaluated and found suitable for that purpose.″

76.2 Four-wire detectors

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

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

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

c) Supplementary Circuits – Voltage, current or watts.

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

76.3 Two-wire detectors

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

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

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

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

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

e) Minimum and maximum rated operating voltage.

f) Maximum rated normal standby current.

g) Minimum and maximum rated alarm current and impedance.

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

77 Technical Bulletin

77.1 A Technical Bulletin shall be provided by the manufacturer and is to be available for each installation for use as a reference by the installer. The Bulletin shall include a reference to the National Fire Alarm Code, NFPA 72 when applicable, for the installation of detectors. See 74.1(p). The information in the Bulletin shall include guidelines on detector location, spacings, maintenance, and servicing tests under various environmental conditions and physical configurations. The information shall be in accordance with NFPA 72.

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

77.3 Detailed information shall be provided regarding the use of the sensitivity level or test means provided on the detector. Typical information that shall be provided (when applicable) includes:

a) Nominal reading or setting under clear condition,

b) Nominal reading when close to alarm,

c) Nominal reading at alarm condition, and

d) Guidelines on instrument use of an engineering survey, installation, and maintenance.

77.4 Reference to the Bulletin number and date is required, either on the detector nameplate marking or on the installation drawing. When the installation drawing is included as part of the Technical Bulletin, reference to the Bulletin is to be indicated on the detector.

77.5 The Technical Bulletin, carton, or literature shipped with the detector shall not include manufacturer's claims on the operation of the detector that have not been substantiated by the performance tests included in Sections 29 – 69, or that are not covered in the National Fire Alarm Code or other applicable Standards of the National Fire Protection Association.

77.6 The Technical Bulletin for smoke detectors for special application shall specifically identify the environments within which the detectors are to be installed.

No Text on This Page

SUPPLEMENT SA - RELIABILITY PREDICTION AND CRITERIA FOR ACCEPTANCE

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

SA1 Methods of Determining Failure Rate

SA1.1 PARTS COUNT METHOD – When using this method the failure rate is to be determined as follows:

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

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

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

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

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

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

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

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

[a] When a MIL-Spec component is required in a detector and does not employ a specific marking to that effect, the detector manufacturer shall provide documentation to verify that the component is Mil-Spec graded. It is not prohibited for the documentation to be in the form of a shipping order, invoice, or equivalent, provided by the component supplier.

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

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

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

SA1.3 SCREENING BURN-IN METHOD – This method is required for the evaluation of custom integrated circuit ″chips″ although it is in some instances also applied to other components of a detector, including generic ″chips.″ The evaluation is to consist of a burn-in test program to determine the numerical failure rate coupled with a minimum quality assurance screening program for all production units. See Sections SA2 – SA4.

SA1.4 PUBLISHED RELIABILITY DATA – It is not prohibited that this method be employed for the evaluation of generic integrated circuit ″chips″ as well as any other component of a detector, except for a custom ″chip.″ The evaluation is derived by the use of generic failure rate data from industry and military publications on component reliability based on field accumulated data. Examples of such publications include Micro-Circuit Device Reliability, Linear/Interface Data and Micro-Circuit Device Reliability, and Digital Generic Data. Devices evaluated by this method shall conform to the identification program in SA2.3, and minimum screening program of Table SA3.1.

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

Part type	Failure rate
Transistors	
Silicon NPN	0.18
Silicon PNP	0.29
GePNP	0.41
GeNPN	1.1
FET	0.52
UJT, PUT[a]	1.7
Diodes	
Silicon, general purpose	0.12
Germanium, general purpose	0.26
Zener and avalanche	0.16
Thyristor	0.16
Silicon microwave detector	2.2
Ge microwave detector	5.6
Silicon microwave mixer	3.0
Ge microwave mixer	10.0

Table SA1.3 Continued on Next Page

Table SA1.3 Continued

Part type	Failure rate
Varactor, step	1.5

[a] When the construction of the device is comparable to that of a thyrister, it is not prohibited to assign a lower failure rate (0.16 failures/10^6 hrs).

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

Resistors, fixed			Failure rate
Construction	**Style**	**Mil-R-Spec. (reference only)**	
Composition	RCR	39008	0.002
Composition	RC	11	0.01
Film	RLR	39017	0.015
Film	RL	22684	0.075
Film	RNR	55182	0.017
Film	RN	10509	0.017
Film, power	RD	11804	0.96
Wire wound, accurate	RBR	39005	0.056
Wire wound, accurate	RB	93	0.28
Wire wound, power	RWR	39007	0.033
Wire wound, power	RW	26	0.17
Wire wound, chassis mount	RER	39009	0.062
Wire wound, chassis mount	RE	18546	0.31
Resistors, variable			
Wire wound, trimmer	RTR	39015	0.066
Wire wound, trimmer	RT	27208	0.33
Wire wound, precision	RR	1293419	2.7
Wire wound, semi-precision	RA	39002	2.3
Wire wound, semi-precision	RK	22	2.3
Wire wound, power	RP	22097	2.3
Non-wire wound, trimmer	RJ	94	4.6
Composition (common pot)	RV		
Factory preset and sealed			0.46
Field variable			3.7

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

Dielectric	Style	Mil-C-Spec. (reference only)	Failure rate
Paper/plastic	CHR	39022	0.0006
Paper/plastic	CPV	14157	0.0006
Paper/plastic	CQR	19978	0.0006
Paper/plastic	CQ	19978	0.006
Mica	CMR	39001	0.0032
Mica	CM	5	0.032
Mica	CB	10950	0.58
Glass	CYR	23269	0.011
Ceramic	CKR	39014	0.022
Ceramic	CK	11015	0.22
Tantalum, solid	CSR	39003	0.026
Tantalum, nonsolid	CLR	39006	0.034
Tantalum, nonsolid	CL	3965	0.34
Aluminum, oxide	CU	39018	1.23
Aluminum,			
Dry electrolyte	CE	62	0.41
Ceramic, variable	CV	81	1.1
Piston, variable	PC	14409	0.11

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

Part type	Failure rate
Pulse transformer	0.0027
Audio transformer	0.0066
Power transformer and filters	0.021
RF transformer and coils	0.022
Connectors	0.45
Connections	
Solder, reflow lap to printed circuit boards	0.00012
Solder, wave to printed circuit boards	0.00044
Other hand solder connections (for example, wire to terminal board)	0.0044
Crimp	0.0073
Weld	0.002
Wirewrap	0.0000037
Coaxial connectors	0.63
Toggle switches	0.57
Push button switches	0.38
Sensitive switches	0.90
Rotary switches	1.4
General purpose relays	0.30
High current relay	1.0
Latching relays	0.29
Reed relays	0.26
Meters and bimetal	5.7
Two sided printed wiring boards	0.0024

Table SA1.6 Continued on Next Page

Table SA1.6 Continued

Part type	Failure rate
Multilayer printed wiring boards	0.30
Quartz crystals	0.20
Thermistor	
Bead	0.10
Disc	0.31
Fuses	0.10
Neon lamps	0.20
Photocells	0.02
Light emitting diodes (LED)	
General use (indicator light)	0.20
Light source of photoelectric detectors	2.50[a]

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

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

Quality levelor screen class	Description	Quality factor
A	Mil-M-38510, Class A	0.5
B	Mil-M-38510, Class B	1
B-1	Mil-Std-883A, Method 5004, Class B	2.5
B-2	Supplier equivalent of Mil-Std-883A, Method 5004, Class B	5
C	Mil-M-38510, Class C	8
D	Commercial (or non-mil standard) part with no screening beyond the manufacturer's regular quality assurance practices	75
E	Screening procedure per Table SA3.1	8

Table SA1.8
Quality factor for Table SA1.3

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

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

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

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

Table SA1.10
Component reliability prediction – parts count method sample calculation

Component	Generic failure rate (A)	Qualify factor multiplier (B)	Failure rate[a], failures/10^6 hrs. A times B
Composition resistor	0.01	1	0.01
Composition resistor	0.01	1	0.01
Composition resistor	0.01	1	0.01
Film resistor	0.075	1	0.075
Film resistor	0.075	1	0.075
Wire wound resistor, power	0.17	1	0.17
Capacitor, plastic	0.006	1	0.006
Capacitor, plastic	0.006	1	0.006
Capacitor, tantalum, solid	0.026	1	0.026
Capacitor, dri electrolyte	0.41	1	0.41
Transistor, silicon NPN	0.18	0.3	0.06
Transistor, silicon NPN	0.18	0.3	0.06
Thryster (SCR)	0.16	1	0.16
Diode, silicon	0.12	1	0.12
Diode, silicon	0.12	1	0.12
Relay, reed	0.26	1	0.26
Relay, general purpose	0.30	1	0.30
Connector	0.45	1	0.45
Printed wiring board	0.0024	1	0.0024
Switch, push button	0.38	1	0.38
Potentiometer, factory preset	0.46	1	0.46
LED (indicator lamp)	0.20	1	0.20

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

Figure SA1.1
Tabulation sheet

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

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

S2270

Table SA1.11
Parts stress analysis method references

Type device	Applicable equation	MIL-HDBK- 217 9/20/74 page reference
Monolithic bipolar and MOS digital SSI/MSI		
Devices < 100 gates or 400 transistors	$\pi = \pi_{;L}\ \pi_Q\ (C_1\ \pi_T + C_2\ \pi_E)$	2.1.1-1
Monolithic bipolar and MOS linear devices	$\lambda_p = \pi_L\ \pi_Q\ (C_1\ \pi_{T2} + C_2\ \pi_E)$	2.1.2-1
Monolithic bipolar and MOS digital LSI		
Devices < 100 gates or 400 transistors	$\lambda_p = \pi_L\ \pi_Q\ (C_1\ \pi_T + C_2\ \pi_E)$	2.1.3-1
Monolithic MOS and bipolar memories	$\lambda_p = \pi_L\ \pi_Q\ (C_1\ \pi_T + C_2\ \pi_E)$	2.1.4-1
Hybrid devices	$\lambda_p = \lambda_b\ (\pi_T \times \pi_E \times \pi_Q \times \pi_F)$	2.1.7-1
Transistors, group I general purposes	$\lambda_p = \lambda_b\ (\pi_E \times (_A \times \pi_Q \times \pi_{S2} \times \pi_C)$	2.2.1-1
Transistors, group II field effect transistors	$\lambda_p = \lambda_b\ (\pi_E \times (_A \times \pi_Q \times \pi_C)$	2.2.2-1
Transistors, group III unijunction	$\lambda_p = \lambda_b \times \pi_E \times \pi_Q$	2.2.3-1
Diodes, group IV general purpose	$\lambda_p = \lambda_b\ (\pi_E \times \pi_Q \times (_A \times \pi_{S2} \times \pi_C)$	2.2.4-1
Diodes, group V zeners	$\lambda_p = \lambda_b\ (\pi_E \times (_A \times \pi_Q)$	2.2.5-1
Diodes, group VI thyristers	$\lambda_p = \lambda_b \times \pi_Q \times \pi_E$	2.2.6-1
Diodes, group VII microwave detectors and mixers	$\lambda_p = \lambda_b \times \pi_E \times \pi_Q$	2.2.7-1
Diodes, group VIII varactor step recovery tunnel	$\lambda_p = \lambda_b \times \pi_E \times \pi_Q$	2.2.8-1
RCR and RC insulated fixed composition	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.1-1
RLR, RL, RNR, RN, fixed film insulated	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.2-1
RD/P power film	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.2-5
RBR and RB, fixed wire wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.3-1

Table SA1.11 Continued on Next Page

Table SA1.11 Continued

Type device	Applicable equation	MIL-HDBK- 217 9/20/74 page reference
RWR and RW power type, fixed wire wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.3-3
fixed wire wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q)$	2.5.3-5
RTH bead and disc type thermistors	Read Direct from Table	2.5.4-1
RTR and RT variable lead screw activated, wire wound	$\lambda_p = \lambda_b \times (\pi_E \times \pi_R \times \pi_Q \times \pi_V)$	2.5.5-1
RR precision wire wound potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS} \times \pi_Q (\pi_R \times \pi_V \times \pi_C \times \pi_E)$	2.5.5-3
RA and RK (not ER) semi-precision wire wound potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS} (\pi_R \times \pi_V \times \pi_Q \times \pi_E)$	2.5.5-7
RP high power wound potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS} \times \pi_Q (\pi_R \times \pi_V \times \pi_C \times (_E)$	2.5.5-13
RJ non-wire wound trimmers	$\lambda_p = \lambda_b \times \pi_{TAPS} (\pi_R \times \pi_V \times \pi_Q \times (_E)$	2.5.6-1
RV composition potentiometers	$\lambda_p = \lambda_b \times \pi_{TAPS} (\pi_R \times \pi_V \times \pi_Q \times (_E)$	2.5.6-5
CPV paper and plastic film, est. rel.	$\lambda_p = \lambda_b (\pi_E \times \pi_Q)$	2.6.1-1
CHR metalized paper, est. rel.		
CQ & CQR paper and plastic film, ER & NON-ER		
CM mica molded, CMR mica dipped, est. rel.	$\lambda_p = \lambda_b (\pi_E \times \pi_Q)$	2.6.2-1
CB button mica	$\lambda_p = \lambda_b (\pi_E) (\pi_Q)$	2.6.2-3
CYR glass capacitors, est. rel.	$\lambda_p = \lambda_b (\pi_E \times \pi_{CV} \times \pi_Q)$	2.6.3-1
CK ceramic, general purpose, CKR ceramic, general purpose, est. rel.	$\lambda_p = \lambda_b (\pi_E \times \pi_Q)$	2.6.4-1
CC ceramic, temperature compensating	$\lambda_p = \lambda_b (\pi_E) (\pi_Q)$	2.6.4-5
CSR solid tantalum electrolytic, est. rel.	$\lambda_p = \lambda_b (\pi_E \times \pi_{SR} \times \pi_Q)$	2.6.5-1
CLR nonsolid tantalum, est. rel., CL nonsolid tantalum, NON est. rel.	$\lambda_p = \lambda_b (\pi_E \times \pi_Q)$	2.6.5-3
CU aluminum, oxide electrolytic	$\lambda_p = \lambda_b (\pi_E) \times \pi_Q$	2.6.6-1
CE aluminum, dry electrolyte	$\lambda_p = \lambda_b (\pi_E) \times \pi_Q$	2.6.6-3
CV variable, ceramic capacitors	$\lambda_p = \lambda_b (\pi_E) \times \pi_Q$	2.6.7-1
PC variable, piston type tubular trimmer	$\lambda_p = \lambda_b (\pi_E) \times \pi_Q$	2.6.8-1
Transformers	$\lambda_p = \lambda_b (\pi_E \times \pi_F)$	2.7-1
Motors high speed	$\lambda_p = (\lambda_E + \lambda_W) (_E$	2.8.1-1
Blowers	$\lambda_p = \lambda_E + \lambda_W$	2.8.2-1
Relays	$\lambda_p = \lambda_b (\pi_E \times \pi_C \times \pi_{CYC} \times \pi_F)$	2.9-1
Switches, snap-action toggle or pushbutton	$\lambda_p = \lambda_b (\pi_E \times \pi_C \times \pi_{CYC})$	2.10-1
Basic sensitive switches	$\lambda_p = \lambda_b (\pi_E \times \pi_{CYC})$	2.10-2
Rotary, ceramic or glass wafer silver alloy contacts	$\lambda_p = \lambda_b (\pi_E \times \pi_{CYC})$	2.10-3
Connectors	$\lambda_p = \lambda_b (\pi_E \times \lambda_p) + N\pi_{CYC}$	2-11-1

Note – π_Q multiplier same as for JAN Class C when Table SA3.1 screening is conducted.

CRITERIA FOR ACCEPTANCE OF MICROELECTRONIC DEVICES

SA2 General

SA2.1 The evaluation and criteria for acceptance of microelectronic devices consists of a two part procedure:

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

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

SA2.2 Although this program is oriented primarily to custom integrated circuits (″chips″), it is also applied for other microelectronic devices.

SA2.3 Components that comply with the requirements of this program shall be distinctively marked for identification purposes. The detector manufacturer shall maintain on file, accessible to an inspector, copies of the purchase and shipping orders for all detectors and ″chips″ so that a tally of detectors shipped is able to be compared to the quantity of screened devices procured from the component vendor.

SA3 Part I – Quality Assurance Screening Program

SA3.1 A minimum screening program (see Table SA3.1) is to be established by the component manufacturer (vendor).

SA3.2 The test methods and conditions referenced in Table SA3.1 are based on the most current revisions to MIL-STD-883B dated July 31, 1977.

SA4 Part II – Determination of Failure Rate Number Supplemented by Burn-In Test

SA4.1 General

SA4.1.1 The objective of this part is to determine a numerical failure rate for the device. The method employs Arrehenius calculations and activation energy tables to correlate elevated temperature operation to a failure rate at 38°C (100°F) (maximum installation ambient temperature of the detector).

Table SA3.1
Minimum screening programs

Hermetic packages	
1. Internal visual (Method 2010.1 condition B modified)____________________	100 percent[a]
2. Bond strength (Method 2011)____________________	Sample basis[a]
3. Stabilization bake (Method 1008C, 150°C, 24 hours)____________________	100 percent[b]
4. Temperature cycling (Method 1010C, minus 55°C to 150°C, 10 cycles____________________	100 percent[e]
5. Seal (fine leak, Method 1014B, 5×10^{-8} cc/Sec)____________________	100 percent[c]
6. Seal (gross leak – Method 1014B fluorocarbon)____________________	100 percent
7. Functional electrical, 25°C____________________	100 percent
8. External visual, Method 2009____________________	100 percent
9. Quality conformance____________________	AQL 1.5% per MIL-STD 105 Level II
A. Functional electrical, 25°C	
B. Temperature cycling (Method 1010C, minus 55°C to 125°C, 10 cycles)	
C. Seal (Fine leak, Method 1014B 5×10^{-8} cc/Sec)[d]	
D. External visual, Method 2009	
Plastic packages	
1. Internal visual (Method 2010.1 condition B modified)____________________	100 percent[a]
2. Bond strength (Method 2011)____________________	Sample basis[a]
3. Temperature cycling (Method 1010C, minus 55°C to 125°C, 10 cycles____________________	100 percent[e,f]
4. Functional electrical test, 25°C____________________	100 percent
5. External visual, Method 2009____________________	100 percent
6. Quality conformance____________________	AQL 1.5% per MIL-STD 105 Level II
A. Functional electrical test, 25°C	
B. Temperature cycling (Method 1010C, minus 55°C to 125°C, 10 cycles)	
C. External visual, Method 2009	

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

[b] The stabilization bake shall not be required only when the production process includes equivalent conditioning.

[c] Shall be reduced to 1.5 percent AQL only when the vendor's first lot of 25,000 units shows statistical justification.

[d] Shall not be required only when justified by the reject rate in item 5.

[e] It is appropriate to substitute either condition B or C of thermal shock Method 1011.1.

[f] Shall not be required only when the sample lot used in the burn-in test is subjected to 100 cycles of the temperature cycling and no devices fail as a result of the temperature cycling. The manufacturer shall then perform an annual audit of the device package type. It is appropriate for this audit to be in the form of choosing samples from the same package type and subjecting them to the Temperature Cycling or Thermal Shock (Method 1010C or 1011.1, Conditions B or C, MIL-STD-883D. Records shall be maintained for inspection.(MIL-STD-883D). Records shall be maintained for inspection.

SA4.2 Determination sequence

SA4.2.1 The following step-by-step procedure is to be employed in determining the failure rate number:

a) Estimate numerical failure rate.

b) Choose test temperature for acceptance test.

c) Using chosen test temperature, refer to curves in Figure SA4.1 to determine related test time for initial conditional acceptance and final acceptance.

d) Using the equation in SA4.5 and the initial conditioning test time determined in (c), calculate the failure rate of the device for conditional acceptance.

e) Sample lot size to be used in temperature test is determined from Table SA4.1. This table lists initial sample lot sizes based on expected failure rates in percent per 1000 hours at a 60 percent confidence level and number of devices that fail during the test, the latter listed as accept numbers. When a different temperature is employed, it is appropriate for lot sizes to be derived from a table of Summation of Terms of Poisson's Exponential Binomial Limit[b] at a 60 percent confidence level.

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

[b]Reliability Handbook by W. Grant Ireson.

SA4.3 Test calculations and procedures

SA4.3.1 Figure SA4.1 illustrates basic curves which represent burn-in test conditions for a device of 1000 hours for initial conditional acceptance and is continued to 3000 hours for final acceptance when tested at an elevated temperature of 125°C (257°F).

SA4.3.2 It is appropriate to increase or decrease the elevated test temperature and related time periods (using the illustrated curves). The minimum temperature for the burn-in test shall be not less than 100°C (212°F).

SA4.3.3 The following examples illustrate the use of the curves in Figure SA4.1 for calculations of final and initial conditional acceptance at temperatures other than 125°C (257°F):

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

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

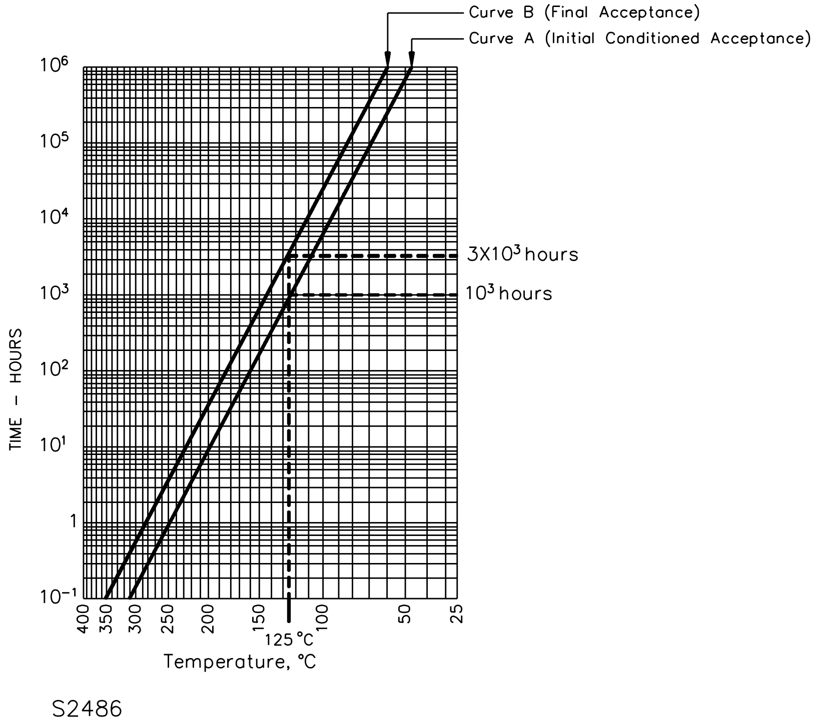
2) Time for Final Acceptance – 650 hours (using Curve B).

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

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

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

Figure SA4.1
Time-temperature regression and allowable time limits for test condition



SA4.4 Test conditions

SA4.4.1 Sockets or other mounting means shall be provided to make firm electrical contact to the terminals of devices under test in the specified circuit configuration. The mounting means shall be constructed so that they do not remove internally dissipated heat from the device by conduction, other than that removed through the device terminals and the required electrical contacts, which shall be maintained at or above the specified ambient temperature. The apparatus is to provide for maintaining the specified biases at the terminal of the device under test and, when specified, monitoring of the input excitation.

SA4.4.2 Power supplies and current-setting resistors shall be capable of maintaining the specified operating conditions throughout the testing period with intended variations in their source voltages and ambient temperatures. The test equipment is preferably to be arranged so that only natural convection cooling of the devices occur. When test conditions result in significant power dissipation, the test apparatus is to be arranged so as to result in the average power dissipation for each device whether devices are tested individually or in a group. The test circuits do not have to compensate for intended variations in individual device characteristics and shall be arranged so that the existence of failed or excessed (for example, open or short) devices in a group does not negate the effect of the test for other devices in the group.

Table SA4.1
Sample lot size for burn-in test

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

SA4.5 Failure rate number calculation

SA4.5.1 The following equation is to be used in determining the initial conditional and final failure rates for the device in concert with the burn-in test:

Extrapolations are made from the chosen elevated test temperature to the 38°C (100°F) smoke detector operating condition by use of the Arrehenius Equation:

$$\lambda = A\, e^{\left(\frac{-E}{KT}\right)}$$

in which:

λ is failure rate per million hours,

A is constant,

e is the base of natural logarithim (2.7183),

E is activation energy in electron volts (ev) (varies between 0.65 ev to 1.1 ev for a large number of integrated circuits). A value of 0.65 ev is to be used unless documentation is provided which justifies using a different value,

K is Boltzman's constant (8.62×10^{-5} ev/°K), and

T is absolute temperature in degrees Kelvin.

Example:

A. Numerical failure rate λ_2 = 0.1 Failure per 10^6 hours.

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

C. Required test time from Figure SA4.1 for conditional acceptance is 1000 hours and for final acceptance is 3000 hours.

D. Using the equation in SA4.5.1 and assuming an Activation Energy (E) of 0.65 ev, the following calculations are performed:

$$\lambda_1 = A\, e^{\left(\frac{-E}{KT_1}\right)} \text{ for } 125°C$$

$$\lambda_2 = A\, e^{\left(\frac{-E}{KT_2}\right)} \text{ for } 38°C$$

Then

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

in which:

λ_2 *is 0.1 Failure per* 10^6 *hours*

E is 0.65 ev

T_1 *is 398°K*

T_2 *is 311°K*

K is 8.62×10^{-5} *ev/°K*

Then

$$\lambda_1 = ln^{-1}\left[\frac{-0.65}{8.62} \times 10^{-5}\left(\frac{1}{398} - \frac{1}{311}\right)\right]$$

in which:

λ^1 is 20×10^{-6} failure/hour.

λ_1 is 20 failures/10^6 hours.

λ_1 is 0.02 failure/1000 hours.

λ_1 is 2.0 percent/1000 hours.

E. Referring to Table SA4.1, the following sample lot size for the appropriate accept number (C – the number of failures or less) is used at the conditional acceptance point (1000 hours). For 2.0 percent/1000 hours:

C = 0 N = 47

C = 1 N = 109

C = 2 N = 155.

From the equation and Table SA4.1, with no failures from a sample lot size of 47 at a test ambient of 125°C, the failure rate is 0.1 Failure/10^6 hours at the conditional acceptance point of 1000 hours. It is possible that the failure rate be less at the final acceptance point of 3000 hours.

APPENDIX A

Standards for Components

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

Title of Standard − UL Standard Designation

Control Units for Fire-Protective Signaling Systems – UL 864
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Heat Detectors for Fire Protective Signaling Systems – UL 521
Motors, Overheating Protection for – UL 2111
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape – UL 510
Printed-Wiring Boards – UL 796
Switches, General-Use Snap – UL 20
Transformers, Specialty – UL 506
Tubing, Extruded Insulating – UL 224
Wire Connectors – UL 486A – 486B
Wires and Cables, Thermoplastic-Insulated – UL 83
Wires and Cables, Thermoset-Insulated – UL 44

No Text on This Page

APPENDIX B – OBSCURATION – OPTICAL DENSITY CHART

Obscuration – Optical density chart Based on a 5 foot (1.52 m) light beam

Light transmission (meter reading), microamperes	Obscuration (Ou)		Total obscuration Od	Optical density (OD)		Total optical density, ODt
	Percent per foot	Percent per meter		Per foot	Per meter	
100.0	0.000	0.000	0.000	0.0000	0.0000	0.0000
99.5	0.100	0.328	0.500	0.0004	0.0014	0.0022
99.0	0.201	0.657	1.000	0.0009	0.0029	0.0044
98.5	0.302	0.987	1.500	0.0013	0.0043	0.0066
98.0	0.403	1.317	2.000	0.0018	0.0058	0.0088
97.5	0.505	1.648	2.500	0.0022	0.0072	0.0110
97.0	0.607	1.979	3.000	0.0027	0.0087	0.0132
96.5	0.710	2.311	3.500	0.0031	0.0102	0.0155
96.0	0.813	2.643	4.000	0.0036	0.0116	0.0177
95.5	0.917	2.976	4.500	0.0040	0.0131	0.0200
95.0	1.021	3.310	5.000	0.0045	0.0146	0.0223
94.5	1.125	3.644	5.500	0.0049	0.0161	0.0246
94.0	1.230	3.979	6.000	0.0054	0.0176	0.0269
93.5	1.335	4.314	6.500	0.0058	0.0192	0.0292
93.0	1.441	4.650	7.000	0.0063	0.0207	0.0315
92.5	1.547	4.987	7.500	0.0068	0.0222	0.0339
92.0	1.654	5.324	8.000	0.0072	0.0238	0.0362
91.5	1.761	5.662	8.500	0.0077	0.0253	0.0386
91.0	1.869	6.001	9.000	0.0082	0.0269	0.0410
90.5	1.977	6.340	9.500	0.0087	0.0285	0.0434
90.0	2.085	6.680	10.00	0.0092	0.0300	0.0458
89.5	2.194	7.020	10.50	0.0096	0.0316	0.0482
89.0	2.304	7.362	11.00	0.0101	0.0332	0.0506
88.5	2.414	7.703	11.50	0.0106	0.0348	0.0531
88.0	2.524	8.046	12.00	0.0111	0.0364	0.0555
87.5	2.635	8.389	12.50	0.0116	0.0381	0.0580
87.0	2.747	8.733	13.00	0.0121	0.0397	0.06050
86.5	2.859	9.077	13.50	0.0126	0.0413	0.0630
86.0	2.971	9.423	14.00	0.0131	0.0430	0.0655
85.5	3.085	9.768	14.50	0..0136	0.0446	0.0680
85.0	3.198	10.12	15.00	0.0141	0.0463	0.0706
84.5	3.312	10.46	15.50	0.0146	0.0480	0.0732
84.0	3.427	10.81	16.00	0.0152	0.0497	0.0757
83.5	3.542	11.16	16.50	0.0157	0.0514	0.0783
83.0	3.658	11.51	17.00	0.0162	0.0531	0.0809
82.5	3.774	11.86	17.50	0.0167	0.0548	0.0836
82.0	3.891	12.21	18.00	0.0172	0.0566	0.0862
81.5	4.009	12.56	18.50	0.0178	0.0583	0.0889
81.0	4.127	12.91	19.0	0.0183	0.0600	0.0915
80.5	4.246	13.27	19.50	0.0188	0.0618	0.0942
80.0	4.365	13.62	20.00	0.0194	0.0636	0.0969
79.5	4.48	13.48	20.5	0.0199	0.0654	0.0996
79.0	4.61	14.33	21.0	0.0204	0.0672	0.1023

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

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

Light transmission (meter reading), microamperes	Obscuration (Ou)		Total obscuration Od	Optical density (OD)		Total optical density, ODt
	Percent per foot	Percent per meter		Per foot	Per meter	
78.5	4.73	14.64	21.5	0.0210	0.0690	0.1051
78.0	4.85	15.04	22.0	0.0215	0.0708	0.1079
77.5	4.97	15.40	22.5	0.0221	0.0726	0.1107
77.0	5.09	15.76	23.0	0.0227	0.0745	0.1135
76.5	5.22	16.12	23.5	0.0232	0.0763	0.1163
76.0	5.34	16.48	24.0	0.0238	0.0782	0.1191
75.5	5.47	16.84	24.5	0.0244	0.0801	0.1220
75.0	5.59	17.20	25.0	0.0249	0.0820	0.1249
74.5	5.72	17.56	25.5	0.0255	0.0839	0.1278
74.0	5.84	17.93	26.0	0.0261	0.0858	0.1307
73.5	5.97	18.29	26.5	0.0267	0.0877	0.1337
73.0	6.10	18.66	27.0	0.0273	0.0897	0.1366
72.5	6.23	19.02	27.5	0.0279	0.0916	0.1396
72.0	6.36	19.39	28.0	0.0285	0.0936	0.1426
71.5	6.49	19.76	28.5	0.0291	0.0956	0.1456
71.0	6.62	20.13	29.0	0.0297	0.9976	0.1487
70.5	6.75	20.50	29.5	0.0303	0.0996	0.1518
70.0	6.89	20.87	30.0	0.0309	0.1016	0.1549
69.5	7.02	21.24	30.5	0.0316	0.1037	0.1580
69.0	7.15	21.61	31.0	0.0322	0.1057	0.1611
68.5	7.29	21.98	31.5	0.0328	0.1078	0.1643
68.0	7.42	22.36	32.0	0.0335	0.1099	0.1674
67.5	7.56	22.73	32.5	0.0341	0.1120	0.1707
67.0	7.70	23.11	33.0	0.0347	0.1141	0.1739
66.5	7.84	23.49	33.5	0.0354	0.1163	0.1771
66.0	7.97	23.86	34.0	0.0360	0.1184	0.1804
65.5	8.11	24.24	34.5	0.0367	0.1206	0.1837
65.0	8.25	24.62	35.0	0.0374	0.1228	0.1870
64.5	8.40	25.00	35.5	0.0380	0.1250	0.1904
64.0	8.54	25.39	36.0	0.0387	0.1272	0.1938
63.5	8.68	25.77	36.5	0.0394	0.1294	0.1972
63.0	8.83	26.15	37.0	0.0401	0.1317	0.2006
62.5	8.97	26.54	37.5	0.0408	0.1339	0.2041
62.0	9.12	26.92	38.0	0.0415	0.1362	0.2076
61.5	9.26	27.31	38.5	0.0422	0.1385	0.2111
61.0	9.41	27.70	39.0	0.0429	0.1409	0.2146
60.5	9.56	28.09	39.5	0.0436	0.1432	0.2182
60.0	9.71	28.48	40.0	0.0443	0.1456	0.2218
59.5	9.86	28.87	40.5	0.0451	0.1480	0.2254
59.0	10.01	29.26	41.0	0.0458	0.1504	0.2291

NOTE – See 31.4.1 for description of obscuration measurement