UL 268A

STANDARD FOR SAFETY

Smoke Detectors for Duct Application

UL Standard for Safety for Smoke Detectors for Duct Application, UL 268A

Fourth Edition, Dated December 11, 2008

Summary of Topics

This revision of ANSI/UL 268A dated August 25, 2023 is being issued to incorporate the following requirements:

– Electronic Installation Instructions, 55.1

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated July 7, 2023.

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ANSI/UL 268A-2023

UL 268A

Standard for Smoke Detectors for Duct Application

Some requirements specified in this standard were previously covered in the Standard 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.

First Edition – May, 1983
Second Edition – March, 1993
Third Edition – May, 1998

Fourth Edition

December 11, 2008

This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through August 25, 2023.

The most recent designation of ANSI/UL 268A as an American National Standard (ANSI) occurred on August 22, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover air duct smoke detectors intended for indoor use within or protruding into a duct, or mounted in a housing with sampling tubes extending into or traversing a duct. Air duct smoke detectors are intended to be installed in ducts where the maximum air temperature inside the duct does not exceed 100°F (38°C), nor does the minimum temperature become less than 32°F (0°C), in accordance with the Standard for Automatic Fire Detectors, NFPA 72, and the Standard for the Installation of Air Conditioning and Ventilating Systems, NFPA 90A.

1.2 An air duct smoke detector unit, as covered by these requirements, is intended to detect smoke for the primary purpose of controlling blowers and dampers of air conditioning and ventilating systems to reduce the risk of panic and damage from distribution of smoke and gaseous products. Each unit consists of an assembly of electrical components, including a sensing means to detect smoke (sensing head or projected beam assembly), sampling tubes or equivalent (based on design), provision for connection to a source of power, and means for generating a signal when smoke is detected. It is not prohibited that remote control circuits be provided. A detector shall be powered from a commercial power source, separate power supply, or be connected to a control unit as part of a fire protection signaling system. Duct detectors are not intended as a substitute for open area protection.

1.3 These requirements cover detectors:

a) Intended to control air conditioning and ventilating systems,

b) Intended for control of releasing devices, such as fire and smoke dampers, or

c) Both (a) and (b).

1.4 These requirements do not cover:

a) Control units that are covered by the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864, to which the air duct smoke detectors are connected.

b) Single and multiple station smoke detectors covered by the Standard for Smoke Alarms, UL 217.

c) Smoke detectors intended for open area protection or releasing device service, or both, covered by the Standard for Smoke Detectors for Fire Alarm Systems, UL 268.

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

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

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 usually used in the products covered by this standard.

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

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

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

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

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

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 purposes of this standard the following definitions apply.

3.2 COMBINATION SMOKE DETECTOR – A smoke detector that employs more than one smoke detecting means in one unit. In a combination smoke detector either each principle predominates, or contributes in response to at least one of the fire tests described in Fire Tests, Section 36.

3.3 COMPONENT, LIMITED-LIFE – A component that is expected to malfunction and be periodically replaced, and the malfunction of which is monitored when malfunction of the component affects detector operation or sensitivity or both.

3.4 COMPONENT, RELIABLE – A component that is not expected to malfunction or be periodically replaced and therefore is not monitored. A reliable component has a predicated failure rate of 2.5 or less failures per million hours. See Supplement SA.

3.5 PHOTOELECTRIC LIGHT OBSCURATION SMOKE DETECTION – The principle of using a light source and photosensitive sensor onto which the principal portion of the source emissions is focused.

When smoke particles enter the light path, some of the light is scattered and some is absorbed, thereby reducing the light condition when it meets preset criteria.

3.6 PHOTOELECTRIC LIGHT-SCATTERING SMOKE DETECTION – The principle of using a light source and photosensitive sensor arranged so that the rays from the light source do not normally fall onto the photosensitive sensor. When smoke particles enter the light path, some of the light is scattered by reflection and refraction onto the sensor. The light signal is processed and used to convey an alarm condition when it meets preset criteria.

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

3.8 SPOT TYPE SMOKE DETECTOR – A device with the detecting element concentrated at a particular location. A spot type detector is usually employed with a velocity shield or within a duct housing, and serves as the smoke sensing component.

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

3.10 VOLTAGE CIRCUITS: (For purposes of this standard only)

a) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts AC (42.4 volts peak or DC), and supplied from a circuit that is limited to a maximum of 100 volt-amperes.

b) Line-Voltage Circuit – A circuit having characteristics in excess of those of a low-voltage circuit.

3.11 MANUFACTURER'S PUBLISHED INSTRUCTIONS – Published installation and operating documentation provided for each product or component. The documentation includes directions and necessary information for the intended installation, maintenance, and operation of the product or component.

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4 Manufacturer's Published Instructions

4.1 A copy of the manufacturer's published instructions, which includes installation and operating instructions, 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. The information may be included in a manual or technical bulletin. See Marking, Section 54, Installation Wiring Diagram, Section 55, and Technical Bulletin, Section 56.

4.2 The manufacturer's published 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

5 Enclosure

5.1 General

5.1.1 An electrical part of a product shall be enclosed so as to reduce the risk of contact with uninsulated live parts. A separate enclosure for field-wiring terminals enclosed by a back box is not required.

5.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two are to be considered in determining compliance with the requirement in 5.1.1.

5.1.3 An enclosure of an air duct smoke detector assembly shall resist total or partial collapse with the subsequent reduction of spacings, loosening or displacement of parts, and other defects, that alone or in combination result in a risk of fire, electric shock, or injury to persons, or affect operation.

5.1.4 An enclosure of an air duct smoke detector shall be provided with means for mounting in the intended manner. Any fittings, such as brackets and hangers, required for mounting shall be furnished with the detector. The mounting means shall be accessible without disassembling any operating part of the assembly. The removal of a completely assembled panel, cover, sensing head, or equivalent, to mount the assembly is not considered to be disassembly of any operating part.

5.1.5 With reference to the requirements of 5.1.4, the sensing area unit is to be installed remote from the sampling tube assembly only when air-tight metal-protected tubing and compatible fittings are employed.

5.2 Cast metal enclosures

5.2.1 The thickness of cast metal used for an enclosure shall be as specified in Table 5.1. Cast metal having a thickness 1/32 inch (0.8 mm) less than that specified in Table 5.1 shall be employed only when the surface under consideration is curved, ribbed, or otherwise reinforced, or when the shape, size, or both, of the surface is such that the mechanical strength is equivalent to that of material specified in Table 5.1.

Table 5.1
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) in thickness is obtained by reinforcing ribs subdividing a larger area.

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

5.2.3 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.

5.3 Sheet metal enclosures

5.3.1 The thickness of sheet metal for an enclosure shall not be less than that specified in Table 5.2.

Exception: Sheet metal of lesser thickness is not prohibited from being employed when the surface under consideration is curved, ribbed, or otherwise reinforced, or the shape, size, or both, of the surface provides mechanical strength equivalent to that provided by the values of Table 5.2.

Table 5.2
Sheet metal enclosures

Maximum dimensions of enclosure				Minimum thickness of sheet metal								
Length or width,		Area,		Steel, zinc-coated,			Steel, uncoated,			Brass or aluminum,		
inch	(mm)	inch^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

5.3.2 Sheet metal shall not be less than 0.032 inch thick (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 at any point where conduit or metal-cable is to be attached.

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

5.3.4 A closure for a hole larger than 1-3/8 inch (34.9 mm) diameter shall either have a thickness equal to that required for the enclosure of the detector or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

5.3.5 A knockout in a sheet metal enclosure shall be secured, and shall be removable without permanent deformation of the enclosure.

5.3.6 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 required in (Spacings) General, Section 23.

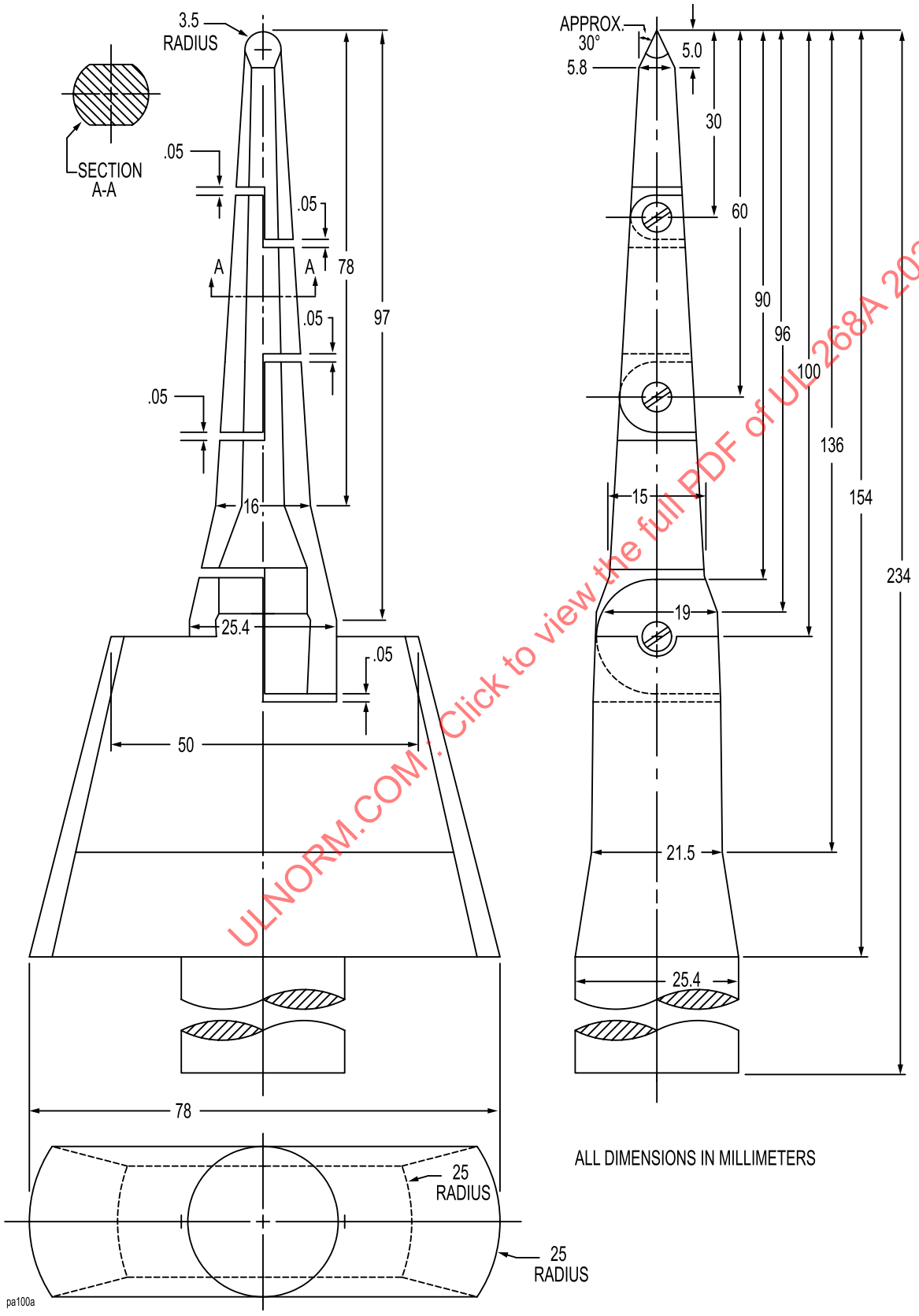
5.4 Nonmetallic enclosures

5.4.1 An enclosure or parts of an enclosure of nonmetallic material shall have the mechanical strength required to comply with Tests of Polymeric Materials, Section 49, and Tests of Elastomeric Materials, Section 50.

5.4.2 Openings in an enclosure for line-voltage circuits, including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or a perforated cover, shall be of such size or shape and so arranged that a probe, as illustrated in Figure 5.1, is incapable of being made to contact any line-voltage, uninsulated live electrical parts when inserted through the opening in a straight or articulated position.

Figure 5.1

Articulate probe



5.4.3 An enclosure for a fuse(s) or other overload protective device that is provided with openings shall afford protection against the emission of flame or molten metal.

5.4.4 Openings provided for cleaning shall be such that no damage to functional internal components occurs during such cleaning operations.

5.4.5 Perforated sheet metal and sheet metal employed for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) thick when uncoated, and not less than 0.046 inch (1.17 mm) when zinc coated.

Exception: When the indentation of the guard or enclosure does not alter the spacing between uninsulated live parts and grounded metal so as to reduce spacings below the minimum value required, 0.021 inch (0.53 mm) expanded metal mesh or perforated sheet metal [0.024 inch (0.61 mm) when zinc coated] is employable under the following conditions:

a) The exposed area on any one side or surface of the product is not more 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).

5.4.6 The wires of a screen protecting line-voltage current-carrying parts shall be not smaller than 16 AWG (1.3 mm^2), and a screen opening shall be not larger than 1/8 square inch (0.81 mm^2) in area.

5.5 Covers

5.5.1 An enclosure cover or door of an air duct smoke detector shall be hinged, sliding, pivoted, or similarly attached when:

a) It provides ready access to circuit protective devices that require renewal, such as fuses or circuit breakers or

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

For the purpose of this requirement, intended operation is considered to be operation of a switch for testing, connection of equipment to measure air flow through the assembly, or operation of any other component of the assembly that requires such action in connection with its intended performance.

5.5.2 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 equivalent means: positive snap catch, plug-in or twist action, snap tab with two screws, or four screws.

Exception: A ready-access cover or door is not required where the only circuit protective device(s) enclosed is intended to provide protection to portions of internal circuits to prevent excessive circuit damage resulting from a fault. The outside of an assembly employing line-voltage circuits shall be marked with the word "DANGER " and the following or equivalent text: "Risk of Electric Shock. Disconnect Power Prior to Servicing." This marking is not required when only low-voltage circuits are involved.

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

5.6 Glass panels

5.6.1 Glass covering an opening in an enclosure shall be held in place so that it is not displaced in service and shall provide mechanical protection of the enclosed parts. The thickness of a glass cover shall be not less than that indicated in Table 5.3.

Table 5.3
Thickness of glass covers

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

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

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

5.6.3 A transparent material other than glass employed as a cover over an opening in an enclosure shall have mechanical strength equivalent to that of glass and not distort or become less transparent at the temperature to which it is subjected under all anticipated conditions of use.

5.6.4 The transparency of a lens, light filter, or similar part of an air duct smoke detector shall not be affected by service conditions as represented by the tests described in the Performance sections of this standard.

6 Remote Accessories

6.1 General

6.1.1 Unless specifically indicated otherwise, the construction requirements specified for a duct detector shall apply also for any accessories intended to be employed with the detector.

6.2 Sensitivity indicating means

6.2.1 A 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 with 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 not appropriate when high-voltage parts are exposed or capable of being contacted by the user.

6.2.2 The measuring or indicating means shall be:

a) A jack or terminals for connection of a meter;

b) A visual indication such as a change in frequency of a pulsing light which is visible with the detector installed;

c) A mechanical device as described in 6.2.3; or

d) an equivalent arrangement.

The use of an adapter that is connected to metering equipment, and that is able to be inserted between the base and plug-in head of a detector assembly, is not prohibited. A plug-in type detector that is readily removed and connected to metering equipment is also not prohibited.

6.2.3 It is not prohibited that the test feature consist of an electrical or mechanical means to simulate a specified level of smoke in the detector sensing chamber. The test feature is to be calibrated to simulate gray smoke having an obscuration of not more than 6 percent per foot [0.027 optical density per foot (OD/ft) (0.088 OD/m)] using gray smoke as measured in the sensitivity test smoke box referenced in 53.1a)(1).

6.2.4 A detector that incorporates a variable sensitivity control intended to be field adjusted shall have a mechanical stop on the adjusting means at 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 the U. S. Nuclear Regulatory Commission, of local or state radiation control agencies, or of both.

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

7 Air Flow Monitoring

7.1 General

7.1.1 To corroborate the operation of the detector during the Fire Tests, Section 36, and to verify intended operation after field installation, a duct detector employing sampling tubes or other arrangement to divert air flow from the duct to a sensing area inside the duct housing shall be provided with a means or instructions for measuring the air flow in the sensing area or for measuring pressure differential between sampling tubes, or equivalent. See 54.7 for marking information required.

7.1.2 The measuring or indicating means shall be metering equipment, visual indicators, operation of a mechanical device, or an equivalent arrangement.

7.1.3 The air flow or pressure measurement shall apply through the entire range of air velocities and tube lengths with which the detector is to be employed in service. See Fire Tests, Section 36. To simulate the use of a length of sampling tube longer than 1 foot (0.30 m), the total hole area of the longest tube to be employed in service is to be drilled into the tube under test using the same size holes spaced equal distances apart.

7.2 Alignment and secureness

7.2.1 Sampling tubes shall be provided with positive alignment means, such as a pin/slot arrangement or equivalent, to prevent turning. The use of only a lock washer is prohibited.

8 Protection Against Corrosion

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

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

8.2 The requirement of 7.1.1 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, or bolts, when the corrosion of such unprotected parts does not affect the intended operation of the product.

8.3 Bearing surfaces shall be of materials that do not bind as a result of corrosion.

8.4 Metals shall not be used in combinations that result in galvanic action to the extent that the intended function of cabinets or enclosures are affected.

8.5 Hinges and other attachments shall be resistant to corrosion.

8.6 Nonferrous cabinets and enclosures are able to be employed without corrosion protection.

9 Field-Wiring Connections

9.1 General

9.1.1 An air duct smoke 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 system.

9.1.2 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 when specified, one for each incoming and one for each outgoing wire. It is permissible 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 55.3(e) shall be provided. In addition, terminals intended only for connection to an initiating device circuit of a system control unit shall be marked in accordance with 55.3(e).

9.2 Field wiring compartment

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

9.2.2 An enclosure shall have provision for the connection of metal-clad cable, conduit, or nonmetallic sheathed cable.

Exception: An enclosure without such provision is not prohibited when instructions are provided that indicate the sections of the enclosure that are intended to be drilled in the field for the connection of raceways, or when the assembly is intended for mounting on an outlet box.

9.2.3 An outlet box or compartment in which field wiring connections are to be made shall be located so that the connections are able to be inspected after the system is installed as intended. The removal of not more than two mounting screws, or an equivalent arrangement, to view the field wiring connections, is considered to comply with this requirement.

9.2.4 Protection from sharp edges for internal components in the wiring area and wire insulation shall be provided by insulating or metal barriers having smooth, rounded edges or equivalent means of protection.

9.3 Field wiring terminals (general)

9.3.1 A field-wiring terminal to which field-wiring connections are made shall comply with the requirements in:

a) 9.3.2 – 9.3.5;

b) The field-wiring requirements in the Standard for Electrical Quick-Connect Terminals, UL 310;

c) The Standard for Wire Connectors, UL486A-486B;

d) The Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E; or

e) The Standard for Terminal Blocks, UL 1059, rated for field-wiring (FW) Code 2 applications and also suitable for the voltage, current, wire range, and wire type of the intended application.

9.3.2 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 10 AWG (5.3 mm^2) and larger wires. When the connectors or lugs are secured to a plate, the plate thickness shall not be less than 0.050 inch (1.3 mm) thick. Securing screws of plated steel have been determined to meet the requirements.

9.3.3 A wire-binding screw used at a wiring terminal shall not be smaller than No. 8 (4.2 mm) diameter. Plated screws are not prohibited.

Exception: A No. 6 (3.5 mm) diameter screw is appropriate for use for the connection of a 14 AWG (2.1 mm^2) and a No. 4 (2.8 mm) diameter screw is appropriate for use for the connection of a 19 AWG (0.65 mm^2) or smaller conductor.

9.3.4 Terminal plates tapped for wire-binding screws shall:

a) Have not less than two full threads in the metal (the terminal plate metal may be extruded to provide the two full threads) and shall have upturned lugs, clamps, or the equivalent, to hold the wires in position. Other constructions may be used if they provide equivalent thread security of the wire-binding screw.

b) Be of a nonferrous metal not less than 0.050 inch (1.3 mm) thick when used with a No. 8 (4.2 mm) diameter or larger screw, and not less than 0.030 inch (0.76 mm) thick when used with a No. 6 (3.5 mm) diameter or smaller screw.

9.3.5 When two or more conductors are intended to be connected by wrapping under the same screw, a nonferrous intervening metal washer shall be used for each additional conductor. A separator washer is not required when two conductors are separated and intended to be secured under a common clamping plate. When the wires protrude above terminal barriers, the nonferrous separator shall include means, such as upturned tabs or sides, to retain the wire.

9.4 Field wiring leads

9.4.1 Leads provided for field connections shall be not less than 6 inches (152 mm) long, shall be provided with strain relief, and shall not be smaller than 18 AWG (0.82 mm^2). The insulation, when rubber or thermoplastic, shall be not less than 1/32 inch (0.8 mm) thick. Wire shall be of stranded copper.

9.5 Grounding terminals and leads

9.5.1 A line-voltage air duct smoke detector, that:

a) Is provided with an overall nonmetallic enclosure and cover,

b) Is intended to be internally serviced, and

c) Employs internal dead metal parts that are able to become energized under a fault condition,

shall have an equipment grounding terminal or lead or the equivalent.

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

a) A low-voltage detector,

b) A line-voltage detector that is provided with an overall nonmetallic enclosure and cover and that:

1) Is not intended to be internally serviced; or

2) Does not employ internal dead metal parts that become energized under a fault condition and are able to be contacted during servicing, or dead metal parts that are insulated; or

2A) Has internal dead metal parts that are insulated; or

3) Includes internal dead metal parts that are able to be contacted during servicing, and employs a two-pole disconnect switch that de-energizes both legs of the supply circuit upon removal of the cover.

9.5.3 The grounding means shall be connected to all exposed dead metal parts that are capable of being energized and all dead metal parts within the enclosure that are exposed to contact during servicing and maintenance. See Bonding for Grounding, Section 11.

9.5.4 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 lead visible to the installer, other than grounding conductors, shall be so identified.

9.5.5 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 is not removed during servicing or installation of the assembly.

9.6 Grounded supply terminals and leads

9.6.1 A field wiring terminal for the connection of the grounded supply conductor of a line-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 shown in some other manner, such as on an attached wiring diagram.

9.6.2 A field wiring lead provided for connection of the grounded supply conductor of a line-voltage circuit shall be finished to show a white or 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.

9.6.3 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 that has an OFF position or to a single-pole, nonthermal, overcurrent-protective device.

9.7 Isolated (nongrounded) detectors

9.7.1 When an air duct smoke detector is constructed so 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.

9.7.2 The arrangement described in 9.7.1 is permissible only on a detector intended for connection to a low-voltage circuit. In addition, the detector shall be marked adjacent to the detector wiring area with the word "CAUTION," and the following or the equivalent text, in letters at least 1/8 inch (3.2 mm) high: "INSTALL ENCLOSURE ISOLATED FROM GROUND ACCORDING TO THE MANUFACTURER'S INSTRUCTIONS AND USING HARDWARE PROVIDED. GROUNDING COULD RESULT IN A FALSE ALARM OR NONOPERATION."

9.8 Special field-wiring terminals (qualified application)

9.8.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in 9.8.2 are met:

a) Quick-Connect Terminals – Nonferrous, quick-connect (push-type) terminals consisting of male posts permanently secured to the device and provided with compatible, female connectors for connection to field wiring. These require a special tool for crimping of field wires. Mating terminals shall be shipped with the control unit with instructions for their installation;

b) Push-In Terminals – Nonferrous (screwless), push-in terminals of the type used on some switches and receptacles. Solid conductors are pushed into slots containing spring-type contacts. The leads are removable by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals are not to be used with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used; and

c) Other Terminals – Other terminal connections are not prohibited when determined to be equivalent to (a) and (b) and are limited to the same restrictions.

9.8.2 Any of the terminal configurations listed in 9.8.1 are appropriate for connection of field wiring provided all of the following conditions are met:

a) When a special tool is required for connection, it shall be provided and its use indicated on the installation wiring diagram by name of the manufacturer and the model number or equivalent.

b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size to be used shall not be less than 26 AWG (0.13 mm^2) for a jacketed, multi-conductor cable or 18 AWG (0.82 mm^2) for a single conductor wire.

c) The wire size to be used shall be rated for the current-carrying capacity of the circuit application.

d) The special field-wiring terminal assembly shall comply with the strain relief test as outlined in 51.3.

10 Internal Wiring

10.1 General

10.1.1 The internal wiring of an air duct smoke 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.

10.1.2 The wiring shall be routed away from 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.

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

10.1.4 When the use of a short length of insulated conductor is not feasible, such as a short coil lead, electrical insulating tubing shall be used. 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 requirements for electrical insulating tubing, except that the wall thickness of polyvinyl chloride tubing of 3/8 inch (9.5 mm) diameter or less shall be not less than 0.017 inch (0.43 mm). For electrical 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.

10.1.5 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 by an equivalent means, that ensures permanent separation. See 10.4, Barriers.

10.1.6 Stranded conductors clamped under a wire binding screw or under a similar part shall have the individual strands soldered together or shall be equivalently arranged to provide secure connections.

10.2 Wireways

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

10.3 Splices

10.3.1 Each splice and connection shall be mechanically secured and bonded electrically. Tack soldering of components or electrical leads is permitted where the construction precludes mechanical security only when 5 samples resist a pull-force of 8.9 N (2 lb) applied for 3 seconds and the connection is subjected to 100 percent inspection and testing with the same pull force by the manufacturer.

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

10.3.3 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.

10.4 Barriers

10.4.1 A metal barrier shall have a thickness at least equal to that required by Table 5.2 as determined by the size of the barrier.

10.4.2 A barrier of insulating material shall be not less than 0.028 inch (0.71 mm) thick.

10.4.3 The clearance between the edge of a barrier and a compartment wall shall be not more than 1/16 inch (1.6 mm).

10.4.4 Internal components and wire insulation shall be shielded from sharp edges by insulating barriers or metal barriers having smooth rounded edges.

10.5 Strain relief

10.5.1 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 required electrical spacings. See Strain Relief Test, Section 51.

11 Bonding for Grounding

11.1 An exposed noncurrent-carrying metal part of a detector operating at more than 30 Vrms that is liable to become energized shall be reliably bonded to the point of connection of the field-equipment grounding terminal or lead, if provided or required, and to the metal surrounding the knockout, hole, or bushing provided for field powersupply connections. This requirement also applies to a detector equipped with auxiliary function contacts rated at more than 30 Vrms. Bonding for Grounding is not applicable if the criteria defined in 9.5.2 are met.

11.2 Except as indicated in 11.2A, 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 service person servicing or operating the equipment.

11.2A Metal parts as described below are not required to comply with the requirement specified in 11.2:

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 do not become energized.

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

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

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

11.3 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 be not 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 so that it is protected from mechanical damage.

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

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

11.6 When the bonding means depends upon screw threads, two or more screws, or two full threads of a single screw engaging metal is considered to meet the intent of the requirement.

11.7 The continuity of any grounding system to which an air duct smoke detector is to be connected shall not rely on the dimensional integrity of nonmetallic material.

11.8 Metal-to-metal hinge-bearing members of doors or covers are considered as a means for bonding the door or cover for grounding only when a multiple bearing-pin type hinge is employed.

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

11.10 Splices shall not be employed used for conductors used to bond electrical enclosures or components.

COMPONENTS

12 General

12.1 Mounting of components

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

Exception No. 1: It is not required that a switch be prevented from turning when all of the conditions specified in (a) – (d) are complied with:

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 rotate the switch during operation of the switch.

b) The means for mounting the switch makes it doubtful that the operation of the switch shall loosen it.

c) The spacings are not reduced below the minimum required values in cases where the switch rotates.

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

Exception No. 2: A lampholder of the type in which the lamp is not able to 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 required values.

12.1.2 Uninsulated live parts, such as field wiring terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they are prevented from turning or shifting in position when such motion results in reduction of spacings below the minimum required values. This is accomplished by two screws or rivets, by square shoulders or mortises, by a dowel pin, lug, or offset, by a connecting strap or clip fitted into an adjacent part, or by some other equivalent method. A toothed lock washer with spring takeup complies with this requirement.

12.2 Operating components

12.2.1 Operating components and assemblies, such as switches, relays, and similar devices, shall have individual dust covers or dust-tight cabinets, to protect them against fouling by dust or by other material that impairs their intended operation.

12.2.2 Adjusting screws and similar adjustable parts shall be prevented from loosening under all conditions of intended use. The use of a toothed lock washer with spring takeup meets the intent of the requirement.

12.3 Current-carrying parts

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

12.3.2 Bearings, hinges, and similar items are not to be used for carrying current between fixed and moving parts.

13 Bushings

13.1 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 secured in place and shall have a smooth rounded surface against which the wire tends to bear.

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

13.3 Ceramic materials and some molded compositions are appropriate for use for insulating bushings. Separate bushings of wood or of hot-molded shellac are not to be used.

13.4 Fiber is employable where:

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

b) The bushing is not less than 3/64 inch (1.2 mm) thick; and

c) It is not affected by ordinary ambient humidity conditions.

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

13.6 An insulating metal grommet is appropriate 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.

14 Electrical Insulating Material

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

14.2 Polymeric materials are usable as the sole support of uninsulated live parts when found to have insulating characteristics equivalent to the materials indicated in 14.1.

14.3 Vulcanized fiber is usable for insulating bushings, washers, separators, and barriers. It shall not be used as the sole support of uninsulated current-carrying parts of other than low-voltage circuits.

14.4 The thickness of a flat sheet of insulating material such as phenolic composition employed for panel mounting of parts shall be not less than that indicated in Table 14.1.

Table 14.1
Thickness of flat sheets of insulating material

Maximum dimensions				Minimum thickness,	
Length or width,		Area,			
inch	(mm)	inch^2	(cm^2)	inch	(mm)
6	152	36	232.4	1/16	0.16
12	305	144	928.8	1/8	3.2
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 1728	–	3/4	19.1

NOTE – Material less than the minimum thickness shown is to be employed for a panel only when the panel is supported or reinforced to provide equivalent rigidity.

14.5 A terminal block mounted on a metal surface that 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 of the terminal block unless the parts are staked, inset, sealed, or equivalently prevented from loosening so as to prevent the parts and the ends of replaceable terminal screws from causing a reduction of spacings below the minimum required values.

14.6 A countersunk sealed part shall be covered with a waterproof insulating compound that 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 of thickness of sealing compound shall be not less than 1/8 inch (3.2 mm)

15 Lampholders and Lamps

15.1 An air duct smoke detector intended to be connected to a commercial alternating current power source shall be provided with a "power on" lamp to indicate energization of the unit.

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

15.3 A lampholder employing a metal shell, such as a screw shell, and used in a line-voltage circuit, shall be wired so that the metal shell is connected to a 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.

15.4 A lampholder shall be installed so as to reduce the risk of uninsulated line-voltage live parts being contacted by a person removing or replacing lamps.

15.5 When more than one lamp is provided on the detector the following shall apply:

a) Except as permitted by (c), the "power-on" lamp shall be white or green,

b) An alarm-indicating lamp shall be red,

c) A trouble-indicating lamp shall be amber or yellow, and

d) The "power-on" lamp shall be permitted to be a color other than white, green, red, amber or yellow if the lamp is marked to identify the function.

15.6 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. Use of alternative colors or indication flash rates for non-alarm conditions shall not be prohibited.

15.7 A lamp or equivalent means shall be provided on a duct housing to identify it as the unit from which the alarm was initiated.

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

15.8 An air duct smoke detector accessory that indicates the "power on", alarm or other status of a specific unit, shall be an acceptable equivalent means to meet the requirements of this section.

16 Photocell Illuminating Lamps

16.1 General

16.1.1 A limited life component such as an incandescent lamp or a light emitting diode (LED) used as a light source of an air duct smoke detector photocell light assembly, shall comply with the requirements of the Electrical Supervision Test, Section 27, or a reliable component shall be employed.

16.1.2 To be considered reliable, an LED shall have a predicated failure rate of less than 0.25 percent per 1000 hours (2.5 failures per million hours), and shall comply with the operating conditions described in 16.2.1 – 16.2.4 and the Reduction in Light Output Test specified in 53.1(a)(4).

16.2 Operating conditions – LED

16.2.1 For DC operation, the drive current shall not exceed 75 percent of the DC forward current rating.

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

16.2.3 For pulsed operation, when the pulse duration exceeds 1 millisecond or the duty cycle is greater than 50 percent, the peak current shall not exceed 75 percent of the DC forward current rating.

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

17 Motors

17.1 A fan motor shall be protected against overheating by thermal or overcurrent protective devices or shall be of the impedance-protected type. See Locked Rotor Tests, Section 46. A thermal or overcurrent protective device shall not open the circuit during the Temperature Test, Section 31.

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

18 Protective Devices

18.1 All fuseholders, fuses, and circuit breakers shall be rated for the application.

19 Printed Wiring Boards

19.1 A printed wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796. The components of a printed wiring board shall be secured to the board and the spacings between circuits shall comply with the spacing requirements for rigidly clamped assemblies (see Table 23.1). The board shall be mounted so that deflection of the board during servicing does not result in damage to the board or in a reduction of electrical spacings below those required in this standard.

20 Switches

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

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

Exception: A nonself-restoring switch shall be employed only when a related audible trouble signal is obtained from the control unit to which the detector is connected, when the switch is in the OFF-NORMAL position.

21 Transformers and Coils

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

Exception: An autotransformer shall be employed only when the terminal or lead connected to the autotransformer winding that is common to both input and output circuits is identified for connection to ground and that the output circuits are located only within the enclosure containing the autotransformer.

21.2 The insulation of coil windings of relays transformers, and similar items, shall resist the absorption of moisture.

Exception: Film-coated or equivalently insulated wire is not required to be given additional treatment to resist moisture absorption.

22 Dropping Resistors

22.1 A carbon composition resistor shall not be used as a power dropping resistor in the line-voltage circuit of a detector.

SPACINGS

23 General

23.1 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;

c) Any dead metal part; and

d) An uninsulated live part of opposite polarity,

shall be maintained at not less than those indicated in Table 23.1.

Table 23.1
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]	0 – 30	1/32	0.8	1/32	0.8
Over 100 volt-amperes	0 – 30	3/64	1.2	3/64	1.2
	31 – 150	1/16	1.6	1/16	1.6
	151 – 300	3/32	2.4	3/32	2.4
Other parts	0 – 30	1/16	1.6	1/8	3.2
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5

[a] An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material employed where spacings are otherwise inadequate, shall not be less than 0.028 inch (0.71 mm) in thickness; except that a liner or barrier not less than 0.013 inch (0.33 mm) in thickness is usable in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it is not affected adversely by arcing. Insulating material having a thickness less than that specified is to be used only when it is intended for the particular application.

[b] Measurements are to be made with solid wire of the rated ampacity for the applied load connected to each terminal. In no case is the wire to be smaller than 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).

23.2 Film-coated or equivalently insulated wire is to be considered an uninsulated live part. Film-coating is capable of being used as turn-to-turn insulation in coils.

23.3 The "Through air" and "Over surface" spacings of Table 23.1 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.

23.4 The spacing requirements in Table 23.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the 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 those indicated in Table 23.1.

23.5 The "To walls of enclosure" spacings of Table 23.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

24 Servicing and Maintenance Protection

24.1 General

24.1.1 An uninsulated live part of a line-voltage circuit and moving parts that are able to induce injury to persons and that are located within the enclosure shall be located, guarded, or enclosed so as to minimize the possibility of unintentional contact by persons who perform service functions while the equipment is energized.

24.1.2 An electrical component that requires examination, adjustment, servicing, or maintenance while energized shall be located and mounted so that it is accessible for service without subjecting the user to the risk of electrical shock from adjacent uninsulated live parts.

24.1.3 The following are not considered to be 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 appropriate insulation; and

d) Insulated wire.

24.2 Sharp edges

24.2.1 An edge, projection or corner of an enclosure, opening, frame, guard, knob, handle, or similar part, of an air duct smoke detector shall be smooth and rounded so as to reduce the risk of a laceration injury when contacted during use or user maintenance. Such edges shall comply with the Standard for Tests for Sharpness of Edges on Equipment, UL 1439.

24.3 Maintenance (field cleaning)

24.3.1 If recommended by the manufacturer, the detector shall be cleaned without:

a) Degradation of performance, when tested in accordance with the Field Service Tests defined in UL 268; and

b) Disturbance of field wiring.

The procedures shall be described in the manufacturer's published instructions.

PERFORMANCE

25 General

25.1 Test units and data

25.1.1 Detectors that are fully representative of production units are to be used for the tests specified in Sections 26 – 53, unless otherwise specified. The sensitivity setting or range of sensitivities of the sensing chamber(s) provided on the units for test define the production sensitivity.

25.1.2 The devices to be tested are to be those specified by the wiring diagram of the system, except that substitute devices are not prohibited from being used when they produce functions and load conditions equivalent to those obtained with the devices intended to be used with the detector in service.

25.2 Test voltages

25.2.1 Unless otherwise specified, the test voltage and frequency for each test shall be as indicated in Table 25.1.

Table 25.1
Test specifications

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

[a] Systems rated at frequencies other than 60 hertz are to be tested at their rated nameplate voltage and frequency.

[b] The voltage rating shall be applied as the voltage wave form(s) specified in the markings. See 54.1(c).

25.3 Test samples and data

25.3.1 The following samples and data are required. The data required by (i) and (j) is not required to be in final printed form.

a) At least 6 assembled air duct smoke detector housings with 28 sensing heads; 12 heads to be preset (as close as is possible with the intended production calibration) to the nominal maximum anticipated production sensitivity, and 16 to be preset (as close as is possible with the intended production calibration) to the nominal minimum anticipated production sensitivity. The sensing heads are to be calibrated so that the sensitivity of any individual unit does not vary more than 25 percent from the sensitivity of any other unit in each setting, and the sensitivities of the units tested 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 specified in 53.1(a)(1).

Exception: When the sensing head used with the duct housing has been previously determined to be in compliance with the requirements of the Standard for Smoke Detectors for Fire Alarm Systems, UL 268, a total of only 12 sensing heads are to be tested; 6 are to be preset to minimum and 6 to maximum production sensitivity.

b) One additional unassembled sample.

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

d) Five additional samples of sensing heads employing a radioactive source. These are not prohibited from being incomplete assemblies consisting only of the radioactive source installation and the enclosure.

e) Three control units, or power supplies, or both when the system is intended to be employed only with a specific unit or power supply.

f) Three additional samples of sensing heads that operate on the photoelectric principle, provided with means to reduce the light output as required in 53.1(a)(4).

g) The monitoring instruments, or reference to readily available instruments, intended to monitor the sensitivity of the sensing chamber and airflow through the system.

h) Four samples of each type of sampling tubes intended for installation in a 1-foot square duct and plugs to be employed with the detector as well as twelve samples of any nonmetal type plugs or end caps to be used with the sampling tubes. Drawings of all sampling tubes in excess of 1 foot in length that are intended to be employed.

i) An installation wiring diagram and manufacturer's published instructions. See Manufacturer's Published Instructions, Section 4, and Installation Instructions – Wiring Diagram, Section 55.

j) A copy of the Technical Bulletin. See Technical Bulletin, Section 56.

k) Three samples of each thermoplastic enclosure.

l) Twelve samples of each elastomeric material, such as gaskets and stoppers.

25.4 Component reliability data

25.4.1 Data on system components, such as capacitors, resistors, and solid-state devices, shall be provided for evaluation of the components for the intended application. When a Military Specification is referenced, a copy of the specification is to be provided for review.

25.4.2 The data required by 25.4.1 shall include the following or equivalent information:

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

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

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

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 footnote b of Table 31.1.

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) LED operating conditions described in 16.2.1 – 16.2.4 for a sensing chamber employing a reliable LED as the photocell illuminating light source, and a description of the manufacturer's quality assurance program for the functional LED.

h) Limits to be applied during the Fire Tests of the indicating means for the Air Flow Monitoring. See 7.1.1.

25.5 Remote accessories

25.5.1 Unless specifically indicated otherwise, the performance requirements for an air duct smoke detector shall also apply to any remote accessories with which it is to be employed.

25.6 Detector head tests

25.6.1 In view of the infeasibility of conducting sensitivity tests on complete assemblies, many of the performance tests are limited to tests only on the detector sensing head.

25.6.2 Many of the performance tests specify that sensitivity measurements on the sensing heads or projected beam assemblies are required to be conducted in accordance with 53.1 which references tests described in the Standard for Smoke Detectors for Fire Alarm Systems, UL 268. When a sensing head in the duct housing has previously been determined to be in compliance with the requirements of UL 268, the referenced sensitivity test is not required to be conducted.

26 Normal Operation Test

26.1 An air duct smoke detector shall operate under all conditions of its intended performance and at all sensitivity settings and air velocities when connected within the system combination covered by the installation wiring diagram and by any supplementary information provided.

26.2 The test voltage is to be in accordance with 25.2.1 and the system is to be in the standby condition and prepared for its intended signaling operation when it is connected to related devices and circuits.

26.3 The introduction of an abnormal level of smoke into the sensing chamber, such as from a smoldering cotton lamp wick, shall result in the operation of the system in its intended manner.

26.4 Neither principle of operation of a combination air duct smoke detector shall be rendered inoperative by any of the performance tests of this standard. Electrical measurements are to be made, supplemented by circuit analysis when required, to determine that both principles of operation contribute to detector operation.

27 Electrical Supervision Test

27.1 General

27.1.1 The electrical circuits formed by conductors extending from the installation wiring connections of an air duct smoke detector for interconnection to a 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 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 3.3.

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

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

Exception: These requirements do not apply to the following:

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

b) Circuits for trouble-indicating devices.

c) The neutral of a three-, four-, or five-wire alternating current or direct current light-and-power-supply circuit.

d) A supplementary source of power used as an auxiliary means for maintaining intended operation of a system 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 or a ground fault in no way affects the operation of the air duct smoke detector, except for omission of the supplementary feature.

27.1.2 A motor included in an air duct smoke 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.

27.1.3 Interruption and restoration of any source of electrical power connected to an air duct smoke detector shall not produce an alarm signal.

27.1.4 The operation of any nonself-restoring manual switching part of an air duct smoke detector to 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 intended operation of the detector.

27.1.5 De-energization of the power supply or failure of a limited life component of a duct detector not intended to be connected to the initiating device circuit of a system control unit is not required to be indicated by a trouble signal, only when the condition results in shutdown of the ventilating equipment it is intended to control.

27.1.6 In determining compliance with the requirements in 27.1.1, 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 are to be noted and the fault is to be removed. The system combination then is to be restored to the standby condition prior to establishing the next fault.

27.2 Component failure

27.2.1 Failure of a limited life electronic component, such as opening or shorting of an electrolytic capacitor, shall be indicated by a trouble or alarm signal, or a reliable component shall be used.

27.2.2 The heaters of functional heating elements in the detector shall be electrically monitored to indicate an open circuit fault by a trouble signal when the malfunction prevents operation of the detector or result in loss of sensitivity.

27.2.3 In determining compliance with the requirements in 27.2.1, each fault condition is to be applied, in turn, with the detector connected to a source of supply in accordance with 25.2.1. See also Abnormal Operation Test, Section 45.

27.3 Photocell illuminating lamps

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

27.3.2 In a detector that employs a limited life LED light source, the source shall be monitored for an open, short, or 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 3.3.

Exception: 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 shall not reach 50 percent light output at the end of the failure rate prediction described in 16.1.2.

27.3.3 When the light output of an LED source lamp is reduced to the 50 percent level, or to the level reflected in the light degradation data supplied by the manufacturer and described in the exception to 27.3.2, the sensitivity of the detector shall not vary more than 1 percent per foot obscuration using gray smoke from the value at full output. In no case shall it exceed 4 percent per foot (13.1 percent/m) for gray smoke and 10 percent per foot (32.8 percent/m) for black smoke. See 53.1(a)(4).

27.3.4 In detectors employing an LED light source considered reliable, the source is not required to be monitored. Failure of the reliable LED sometimes results in an alarm signal at the end of the failure rate prediction described in 16.1.2.

28 Circuit Measurement Test

28.1 The input and output current of each circuit of an air duct smoke detector system shall not exceed the marked rating of the system by more than 10 percent when operated under conditions of intended use and with the detector connected to a source of supply in accordance with 25.2.1. Measurements also shall be made of the operating parameters of components such as capacitors to determine that they are being employed within the manufacturer's ratings. See 54.1(c) for other measurements to be made.

29 Air Leakage Test

29.1 There shall be no leakage of air, in excess of that indicated in 29.3, between the sensing area and the room air of a duct detector employing sampling tubes or equivalent, when the pressure inside the sensing area is increased to 3.7 millimeters of mercury (2 inches of water) greater than the room ambient.

29.2 Two samples are to be subjected to this test. The duct housing cover is to be assembled to the housing as intended in service. Sampling tubes are not to be connected. A pump assembly and pressure reading instrument are to be connected to the duct housing. All holes are to be blocked to prevent the escape of air.

29.3 The pressure inside the housing is to be increased slowly at a rate of 0.075 millimeter of mercury (0.04 inch of water) per second until a pressure of 3.7 millimeters of mercury (2 inches of water) greater than the room ambient pressure is reached. The drop in pressure (air leakage) during the next 60 seconds shall not exceed 0.37 millimeters of mercury (0.2 inch of water).

30 Overvoltage and Undervoltage Test

30.1 Overvoltage test

30.1.1 An air duct smoke detector shall:

a) Withstand the continuous application of 110 percent of the test voltage specified by 25.2.1, in the standby condition without its operation being impaired and

b) Operate for its intended signaling performance at the specified increased voltage.

30.1.2 Three units are to be energized from a source of supply in accordance with 25.2.1, and then subjected to the specified increased voltage in the standby condition for at least 16 hours, and tested again for signaling operation.

30.1.3 The sensitivity of the sensing head at rated voltage and at overvoltage, shall comply with the limits for the Overvoltage Test referenced in 53.1(a)(6).

30.2 Undervoltage test

30.2.1 An air duct smoke detector shall operate for its intended signaling performance while energized from a source of supply of 85 percent of the test voltage specified by 25.2.1.

30.2.2 Three units are to be energized from a source of supply in accordance with 25.2.1, following which the voltage is to be reduced to 85 percent of nameplate rating and tested again for signaling operation.

30.2.3 Upon conclusion of the Undervoltage Test, reduction of the supply voltage to zero at a rate of not greater than 5 volts per minute shall not result in energization of the alarm circuit.

30.2.4 The sensitivity of the sensing head at rated voltage and undervoltage shall be in compliance with the limits for the Undervoltage Test referenced in 53.1(a)(6).

31 Temperature Test

31.1 The temperature rise on materials or components employed in an air duct smoke detector shall not be greater than indicated in Table 31.1 under any condition of intended operation. It is not prohibited for the temperature rise of a component in Table 31.1 in the standby condition to be exceeded. In no case shall it be greater than that sanctioned under an alarm condition, when malfunction of that component results in a trouble signal.

Table 31.1
Maximum temperature rises

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

Table 31.1 Continued on Next Page

Table 31.1 Continued

Device or material	Normal standby, °C	Normal standby, (°F)	Alarm condition, °C	Alarm condition, (°F)
(2) Greater than 60 percent of rated volts	25	45	75	135
4. Relays and other coils with:[a]				
a. Class 105 insulated windings				
Thermocouple method	25	45	65	117
Resistance method	35	63	75	135
b. Class 130 insulated windings				
Thermocouple method	45	81	85	153
Resistance method	55	99	95	171
5. Resistors[b]				
a. Carbon	25	45	50	90
b. Wire wound	50	90	125	225
c. Other	25	45	50	90
6. Sealing compounds	15°C (27°F) less than its melting point			
7. Solid state devices	See footnote c			
B. INSULATED CONDUCTORS[d]				
1. Appliance wiring material	25°C (45°F) less than the temperature limit of the wire			
2. Flexible cord (for example, SJO, SJT)	35	63	35	63
C. ELECTRICAL INSULATION – GENERAL				
1. Fiber used as electrical insulation or cord bushings	25	45	65	117
2. Phenolic composition used as electric insulation or as parts where malfunction results in a risk of fire or electric shock	25	45	125	225
3. Varnished cloth	25	45	60	108
D. GENERAL				
1. Mounting surfaces	25	45	65	117
2. Wood or other combustible material	25	45	65	117

[a] The classes of material used for electrical insulation referred to include the following materials:

Class 105 (Class A) – Cotton, silk, paper, and similar organic materials when impregnated, and enamel as applied to conductors.

Class 130 (Class B) – Inorganic materials, such as mica and asbestos, in built-up form combined with binding substances.

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

[c] 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 it components. For reference purposes 0°C (32°F) shall be considered as 0 percent. For integrated circuits the loading factor shall not exceed 50 percent of its rating under the Normal Standby Condition and 75 percent under any other condition of operation. It is allowable for both solid state devices and integrated circuits to be operated up to the maximum ratings under any one of the following conditions:

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

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

Table 31.1 Continued on Next Page

Table 31.1 Continued

Device or material	Normal standby, °C	Normal standby, (°F)	Alarm condition, °C	Alarm condition, (°F)
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) and retested.				
[d] For standard insulated conductors other than those specified, reference shall be made to the National Electrical Code, ANSI/NFPA 70; the maximum allotted temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.				

31.2 All values for temperature rises referenced in 31.1 are to apply to equipment intended for use in ambient temperatures not greater than 25°C (77°F).

Exception: When equipment is intended specifically for use with a prevailing ambient temperature constantly greater than 25°C (77°F), the test of the equipment is to be made at the higher ambient temperature, and allotted temperature rises specified in Table 31.1 are to be reduced by the amount of the difference between that higher ambient temperature and 25°C.

31.3 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 the front extended to be flush with the enclosure cover and clearances of 2 inches (50.8 mm) at the top, sides, and rear.

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

31.5 Temperatures are to be measured by means of thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2). A temperature measurement by either the thermocouple or resistance method is appropriate for use, except that the thermocouple method is not to be employed for a temperature measurement at any point where supplementary thermal insulation is employed.

31.6 Thermocouples consisting of 30 AWG (0.06 mm^2) iron and constantan wires and a potentiometer-type indicating instrument are to be used whenever reference temperature measurements by thermocouples are required.

31.7 The thermocouple wire is to conform with the requirements for special thermocouples as listed in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

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

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

in which:

T is the temperature to be determined in degrees C;

R is the resistance in ohms at the temperature to be determined (see 31.9);

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

t is the known temperature in degrees C.

31.9 As it is usually required to de-energize the winding before measuring R, the value of R at shutdown is determined by taking several resistance measurements at short intervals 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.

31.10 To determine compliance with this test, a detector is to be connected to a source of supply in accordance with 24.1.3 and operated under the following conditions:

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

b) Alarm – (1 hour).

c) Alarm – (7 hours abnormal test).

31.11 For the test condition in 31.10(c), the temperature limits are not prohibited from being exceeded; however, there shall be no manifestation of a fire or impending malfunction, and the detector shall operate as intended following the test.

31.12 The detector is to be subjected to the Dielectric Voltage-Withstand Test, Section 47, following the completion of the test specified in 31.10(c).

32 Vibration Test

32.1 An air duct smoke detector assembly shall withstand vibration without breakage or damage to parts. Following the vibration the detector shall operate for its intended signaling operation.

32.2 Two samples are to be secured in their intended mounting position on a wood mounting board bolted to a variable speed vibration machine capable of delivering a vertical vibration amplitude of 0.01 inch (0.25 mm). The frequency of vibration is to be varied from 10 to 35 hertz in increments of 5 hertz until a resonant frequency is obtained. The samples are then to be vibrated at the resonant frequency for a period of 8 hours. When no resonant frequency is obtained, the samples are to be vibrated at 35 hertz for 120 hours.

32.3 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.

32.4 The sensitivity of the sensing head, both prior to and following the test, shall be in compliance with the limits for the Vibration Test referenced in 53.1(a)(7).

33 Component Replacement Test

33.1 An air duct smoke detector enclosure employing a component intended to be removed, such as a plug-in sensor head, shall withstand 50 cycles of removal and replacement or opening and closing, and shall comply with the requirements of the Jarring Test, Section 34.

33.2 A detector is to be installed as intended in service and the component removed and replaced, or opened and closed, as applicable, as specified by the manufacturer. The unit is then to be subjected to the Jarring Test, Section 34.

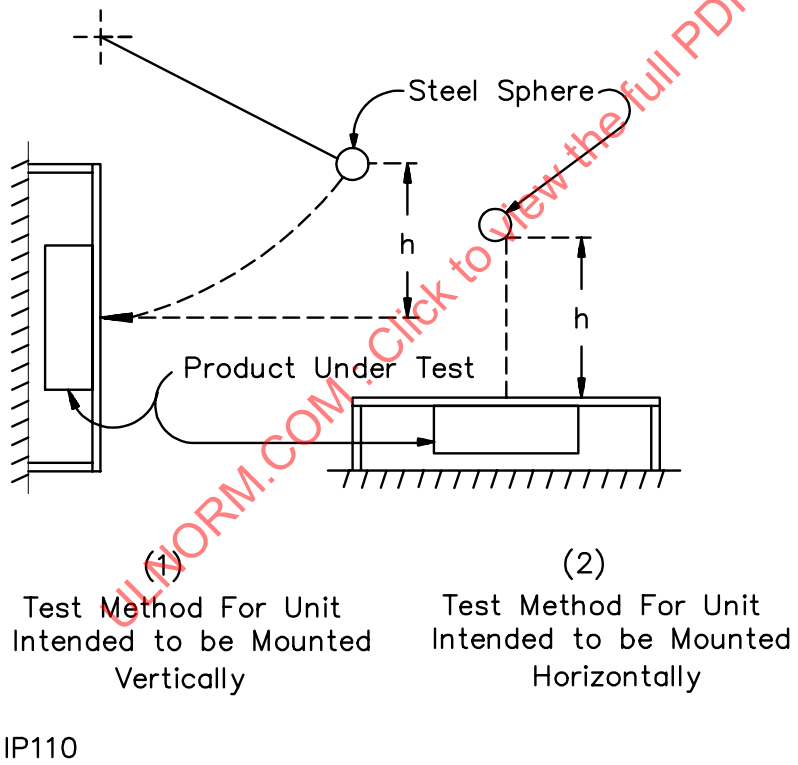
34 Jarring Test

34.1 An air duct smoke detector shall withstand jarring resulting from impact and vibration such as experienced in service, without such jarring causing an alarm signal or dislodgment of any parts, or affecting the subsequent intended operation of the detector. A momentary trouble signal, resulting from the jarring, shall occur only when intended operation is not affected. Dislodgment of parts shall occur only when the dislodged part(s) does not affect the intended operation of the unit and there are no line-voltage parts exposed.

34.2 Two detector assemblies, one at maximum and one at minimum sensitivity, along with any associated equipment, are to be mounted, in turn, as intended for use (see Figure 34.1) 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 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, based upon the mounting of the equipment.

Figure 34.1

Jarring test



34.3 The test is to be conducted with the detector in the standby condition and connected to a rated source of supply in accordance with 25.2.1.

34.4 The sensitivity of the sensing head, both prior to and following the test, shall be in compliance with the limits for the Jarring Test referenced in 53.1(a)(8).

35 Cover Replacement Test

35.1 An air duct smoke detector enclosure employing a cover over the sensing area which is intended to be removed by a snap type or equivalent action, or opened, such as by an access door, shall withstand 50 cycles of removal and replacement, or opening and closing, as applicable, and shall comply with the requirements of the Fire Tests, Section 36.

35.2 A detector assembly is to be installed as intended in service and the cover removed and replaced, or door opened and closed, as applicable, as specified by the manufacturer. The unit is then to be subjected to the Fire Tests, Section 36.

36 Fire Tests

36.1 General

36.1.1 Each duct detector assembly shall operate for alarm within the smoke obscuration limits specified in Table 36.1 and Table 36.2 when subjected to test fires as specified in 36.5.1.1 – 36.5.3.1 using the materials and equipment described in 36.2.1.1 – 36.4.1. Typical test velocities include 300, 1000, 2000, 3000, and 4000 feet per minute (1.52, 5.08, 10.16, 15.24, and 20.32 m/s). Prior to conducting these tests, the air flow monitoring data is to be recorded for each velocity and each sampling tube configuration at which the test is to be run. See Air Flow Monitoring, Section 7. In view of the vagarious nature of fires, it is not prohibited that the:

a) Number of sticks,

b) Diameter of the pan, and

c) Hot plate temperature build up,

vary from the indicated values in order to obtain the required smoke buildup rate.

Table 36.1
Visible smoke obscuration limits (gray smoke)

Percent per foot	Percent per meter	OD per foot	OD per meter	Percent light	
7.0	23.0	0.031	0.103	69.6	Maximum
0.5	1.65	0.0022	0.0072	97.5	Minimum

Table 36.2
Visible smoke obscuration limits (black smoke)

Percent per foot	Percent per meter	OD per foot	OD per meter	Percent light transmission	
10.0	32.81	0.0458	0.1504	59.0	Maximum
0.5	1.65	0.0022	0.0072	7.5	Minimum

36.2 Combustibles

36.2.1 Gray smoke

36.2.1.1 The combustible for this test is to be a group of Ponderosa pine sticks placed on a hot plate.

Note – The following wood stick and test parameters have been found to be suitable. The Ponderosa pine sticks should be nonresinous and free from knots or pitches, placed in a spoke pattern on the hot plate so that the sticks are equiangular from each other. The end of each stick should be flush with the edge of the hot plate. Each stick should be roughly 3 by 1 by 0.75 inches (76.2 by 25.4 by 19.1 mm) with the 1 by 3 inch face in contact with the hot plate. All surfaces of each stick should be smooth and free from burrs or holes. The grain of the wood should be parallel to the stick length. Each stick should be conditioned for not less than 48 hours at 125°F (52°C) in an air-circulating oven. The stick weight should be 16 ±2 grams following the oven conditioning. The number of sticks used may be varied with the duct air speed as shown in Table 36.3. It is appropriate to use two hot plates for higher gray smoke generation. The above stick dimensions, conditioning times and temperatures, and the number and placement of sticks, are variable as long as the correct smoke build up rates are achieved.

Table 36.3
Gray smoke parameters

Duct air speed		Number of sticks used in test	Smoke buildup rate, percent per foot obscuration per minute
FPM	Meters/sec		
300	1.52	5	2.9 ±0.5
1000	5.08	5	2.2 ±0.8
2000	10.2	6	2.1 ±0.5
3000	15.2	7	1.3 ±0.4
4000	20.3	8	0.8 ±0.2

36.2.2 Black smoke

36.2.2.1 The combustible for this test is to be 100 percent, n-type heptane burned in a metal receptacle. The size of the metal receptacle is to vary with the duct air speed as shown in Table 36.4.

Table 36.4
Black smoke parameters

Duct air speed		Receptacle size				Amount of combustible (ml)	Smoke buildup rate, percent per foot obscuration per minute
		Diameter,		Depth,			
FPM	Meters/sec	inches	(mm)	inches	(mm)		
300	1.52	3-3/8	85.7	1-7/8	47.6	30	4 ±1.5
1000	5.08	3-3/8	85.7	1-7/8	47.6	30	4 ±1.5
2000	10.2	3-3/8	85.7	1-7/8	47.6	30	4 ±1.5
3000	15.2	4	101.6	2	50.8	40	4 ±1.5
4000	20.3	4	101.6	2	50.8	40	4 ±1.5

36.3 Test equipment

36.3.1 The fire tests are to be conducted in an air duct test facility shown in Figure 36.1 in which the combustible is able to be recirculated. The test apparatus is 30 feet, 7 inches (9.3 m) long with a 1 foot (0.3 m) square cross-sectional area for mounting of the detectors under test. The system is to be provided with an air blower capable of providing air velocities between 300 to 4000 feet per minute (91.4 – 1220 m per minute). The facility is to be provided with a damper control for smoke exhaust. The visible smoke obscuration (optical density) inside the duct near the test area is to be measured by means of hermetically sealed, barrier type, selenium photovoltaic cell[a] used with a DC millivoltmeter having a minimum of 10 megohms input impedance. The meter and cell are to be used in conjunction with the light produced by a tungsten filament automotive type lamp energized from a constant voltage. The distance from the lamp

lens face to the photocell is to be 5.0 feet (1.52 m). The following equations are to be used in conjunction with the lamp-photocell measurements.

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 the percent obscuration per foot (or per meter);*

T_s *is the smoke density meter reading with smoke;*

T_c *is the smoke density meter reading with clear air; and*

d is the 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 the percent obscuration at distance d;*

T_s *is the smoke density meter reading with smoke; and*

T_c *is the smoke density meter reading with clear air.*

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

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

in which:

O_d *is the percent obscuration at distance d;*

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

d is the distance in feet (or meters).

d) 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 the optical density;

T_c is the smoke density meter reading with clear air; and

T_s is the smoke density meter reading with smoke.

e) 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 the optical density per foot (or per meter);

T_c is the smoke density meter reading with clear air;

T_s is the smoke density meter reading with smoke; and

d is the distance in feet (meters).

f) At any distance, the percent transmission of light for the full length beam shall be:

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

in which:

T_d is the percent transmission at distance d;

T_s is the smoke density meter reading with smoke; and

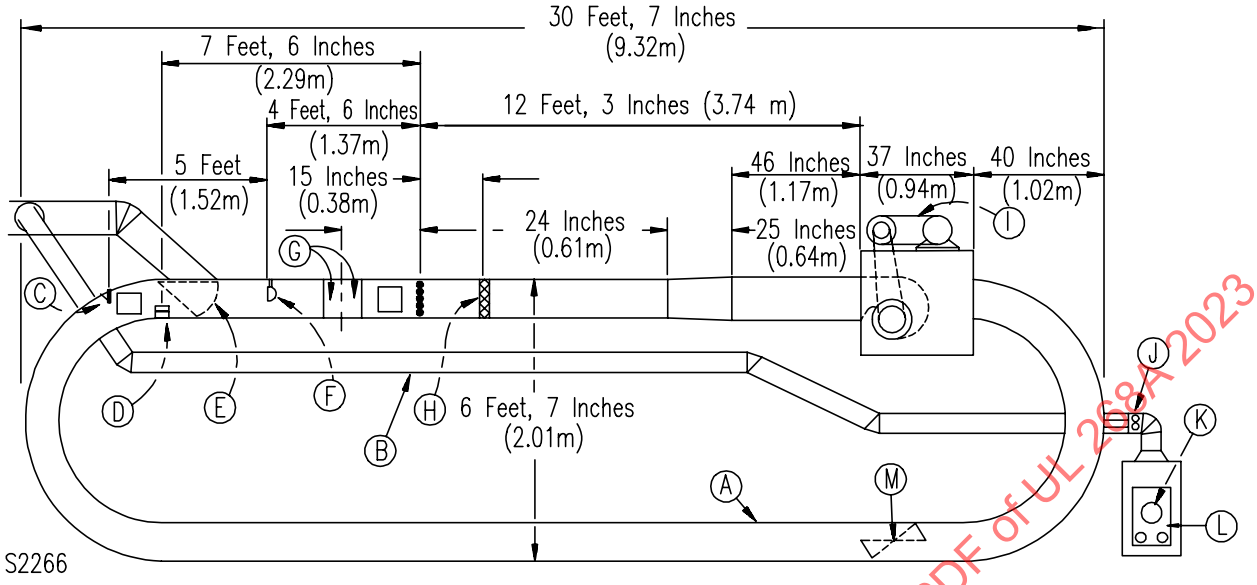
T_c is the smoke density meter reading with clear air.

[a] A cell intended for this purpose is a Weston Instrument Model 594RR Photronic Cell.

36.3.2 A measuring ionization chamber (MIC) [see 36.4.1(d) for description] is to be used to measure the relative buildup of particles of combustion in the area of the detector under test. The MIC is to utilize the ionization principle with air drawn through the chamber at a rate of 30 ±5 liters per minute by a regulated vacuum pump. The monitoring head is to be located as shown in Figure 36.1. Prior to each test, the MIC is to be calibrated to indicate 100 picoamperes in clean air. As the smoke level increases during the test, the meter reading is to decrease.

Figure 36.1

Air duct fire test facility



36.4 Typical duct testing facility

36.4.1 The following items refer to Figure 36.1. Other configurations are usable as long as they provide a homogeneous mixture of smoke and a laminar air flow across the detector head or sampling tubes, adjustable from 300 to 4000 feet per minute (1.52 to 20.3 meters per second). At the detector test location the cross section is to be 1 foot square (0.093 m^2) and the detector is to be located at least eight duct widths downstream [8 feet (2.44 m)] from the nearest bend.

a) Test Duct – An oval-shaped duct assembly 30 feet, 7 inches (9.3 m) long and 6 feet, 7 inches (2.0 m) high, with a total effective duct length of 69 feet (21.0 m), constructed of galvanized sheet metal.

b) Supplementary Exhaust – Circular duct work, 6 inches (152.4 mm) overall diameter, provided as supplementary exhaust from smoke chamber. A motor-operated blower is positioned in line to aid in exhaust.

c) Photocell – Selenium barrier-layer type, 1.5 inch (33 mm) diameter active area. Photovoltaic cell active material is sealed against environment and mounted on a metal bracket attached to the top wall of the duct. Photocell has a 25 percent maximum deviation from truelinearity 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 (0.409 ±0.028 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 ohms, 1 percent load, trimmed with a 5000 ohm, ten turn potentiometer, and is nominally illuminated at 22 foot candles (236.7 lm/m^2). Spectral response peak is between 530 and 580 nanometers with 30 percent sensitivity response at 350 and 660 nanometers.

d) Measuring Ionization Chamber – Type EC23045-1 manufactured by Electronikcentralen, Horsholm, Denmark, mounted on the underside wall, provided with a metal cylinder velocity shield

over the detector head that has a 1/4 inch (6.35 mm) opening around the circumference of the sampling screen at the center of the MIC. Air is to be drawn through the chamber at a rate of 30 ±5 liters per minute by a regulated vacuum pump.

e) Exhaust – Metal damper provided for control of smoke exhaust. Provided with a locking feature in both open and closed positions.

f) Lamp – Low-voltage automotive spotlight, Type 4515, rated 6 volts dc. Mounted from the top of the duct 4 inches (101.6 mm) from the duct wall and in line with the photocell. The distance from the lamp lens face to photocell is to be 5.0 feet (1.52 m). The lamp is operated from a regulated voltage supply at 2.40 volts DC, to yield a lamp color temperature of 2373 ±50°K. At that level, the photocell current flowing into 100 ohms resistance is to be 100 ±25 microamperes. There are to be no random meter fluctuations.

g) Test Samples – Removable mounting plates are provided on the top and side of the duct for installation of test samples. Five velocity probe inlets, spaced 2 inches (50.8 mm) apart, are located 2 feet (0.6 m) upstream from the samples under test.

h) Air Stream Straightener[b] – Aluminum honeycomb, 1/4 inch (6.4 mm) cell size. Overall dimensions are to be 12 by 12 by 3 inches (304 by 304 by 76 mm). An equivalent honeycomb shall be employed only when the cell size length-to-diameter ratio greater than 10.

i) Motor and Belt Drive[c] – Single-phase, capacitor type motor rated 240 volts AC, 3 horsepower, 1750 rpm used in conjunction with an adjustable belt, drive-speed selector.

j) Smoke Intake Control – Fan inserted in line with the duct between the smoke chamber and the test duct. Fan is connected to a variable autotransformer for adjustment of smoke injection rate. Fan is rated 117 volts AC, 60 hertz, 0.78 amperes, 3000 rpm.

k) Smoke Chamber – 30 gallon (0.113 m^3) drum 29 inches (0.74 m) high and 18 inches (0.46 m) overall diameter connected to the test duct by 3 inch (76.2 mm) and 6 inch (152.4 mm) circular duct work. Access door provided with adjustable air intakes.

l) Hotplate[d] – Located inside the smoke chamber, used for gray smoke generation, rated 240 volts, 1550 watts, having an 8-1/2 inch (216 mm) diameter by a 1/4 inch (6.4 mm) thick steel plate, the topmost portion of which is 8 inches (200 mm) above the floor of the smoke chamber. The temperature of the hotplate is monitored by an iron-constantan 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 the junction. The thermocouple is connected to a proportioning temperature controller that is adjusted to result in the required hotplate temperature. The controller sensitivity is adjustable for all required test conditions. Once set for a specific temperature, the hotplate is to be maintained at that temperature and monitored by a temperature measurement meter.

m) Velocity Damper – Manually controlled, secondary velocity adjustment damper provided in lower portion of test duct for adjustment of air velocity at the low end of the range. A locking feature is provided.

[b] A blower intended for this purpose is No. 412-12A manufactured by Lau Inc.

[c] Expanded Commercial Grade Honeycomb 1/4 CGH-5.2N American Cyanamid Co., is intended for this purpose.

[d] A hotplate intended for this purpose is Emerson Electric Co. Series PH-400 Chromolox .

36.5 Test methods

36.5.1 General

36.5.1.1 Each test is to be conducted in an ambient temperature of 23 ±2°C (73.4 ±3°F) at a relative humidity between 30 – 70 percent, and a barometric pressure of not less than 700 millimeters of mercury. The duct detector samples are to be energized from a source of supply in accordance with 25.2.1. For unit type detectors two minimum-sensitivity detectors are to be tested. One detector is to be mounted in a vertical position and the other two mounted in a horizontal position. For projected beam type detectors, two assemblies are to be tested; one mounted in a vertical plane, the other in a horizontal plane and preset to the minimum sensitivity. When the detector head is intended to be mounted directly in the duct, each detector is to be placed in the least favorable position of smoke entry with respect to the oncoming smoke flow, unless the manufacturer's published instructions indicate a specific mounting arrangement, or the mounting position is obvious. On units intended to be employed with various lengths of sampling tubes, the test is to be conducted first using 1-foot (305-mm) long tubes representative of the smallest total hole area and then with 1-foot long tubes representative of the largest total hole area.

36.5.2 Gray smoke

36.5.2.1 Prior to the start of the test, the hot plate temperature is to be 350 ±3°C (662 ±5.4°F). The proportioning controller setting is to be increased to obtain the temperature sequence included in Table 36.5 and Figure 36.2. Each detector shall respond to the test trial within the smoke obscuration limits 36.1.1(a). Flaming of the wood is not to occur before the maximum obscuration level is attained. For this test, the visible smoke buildup rate is to be maintained within the limits illustrated in Table 36.3 for each duct air velocity. To determine the acceptability of the test trial, the relationship between the MIC output (ordinate) and the percent light transmission and obscuration (abscissa) is to remain within the curves illustrated in Figure 36.3.

Table 36.5
Hotplate temperature

Time, minutes	Hotplate temperature, °C	(°F)
0 – 1	350 ±3	662 ±5.4
2 or more	increased 10°/minute to 425	increased 50°/minute to 797

Figure 36.2

Hotplate temperature profile gray smoke fire test

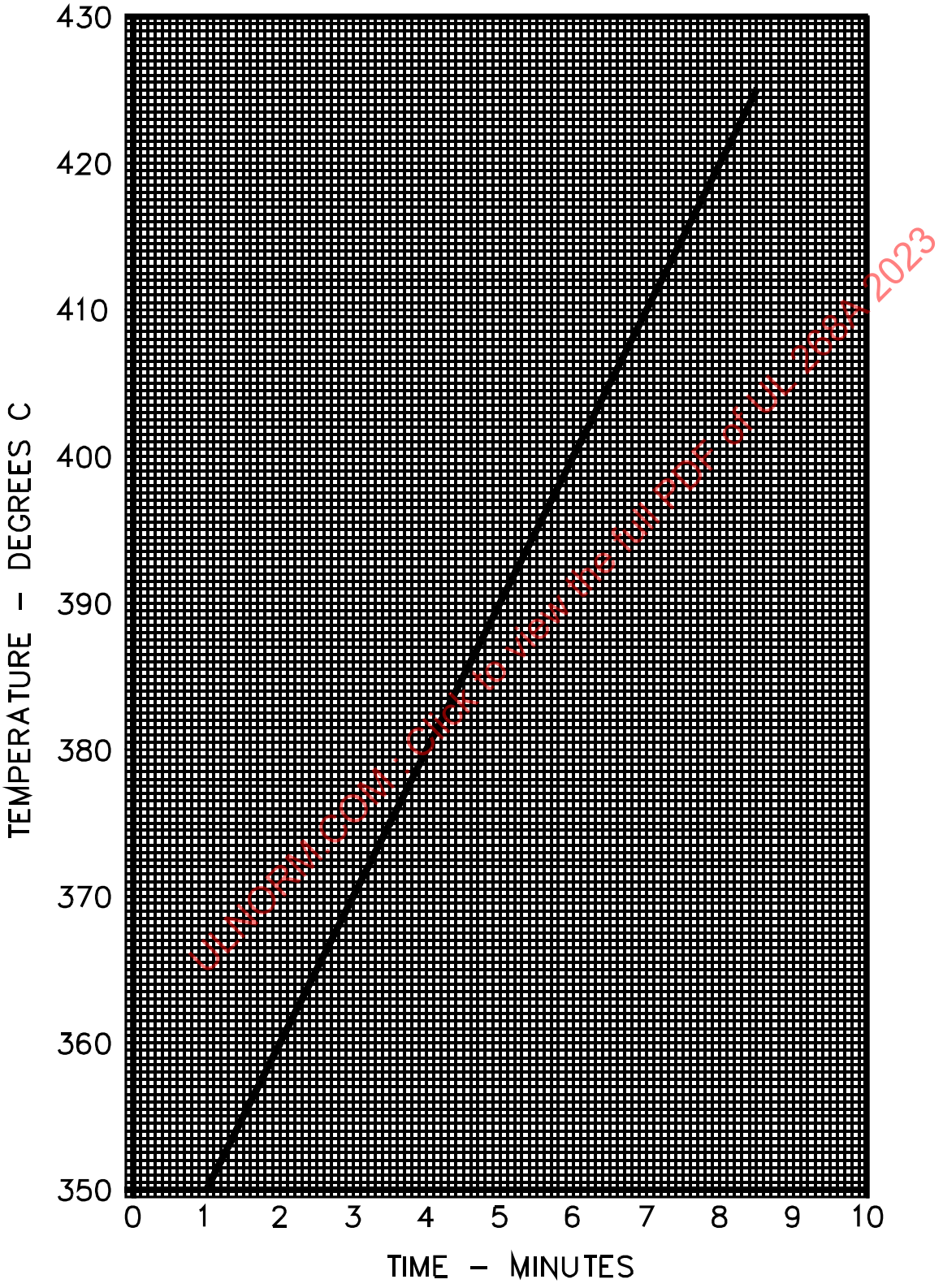
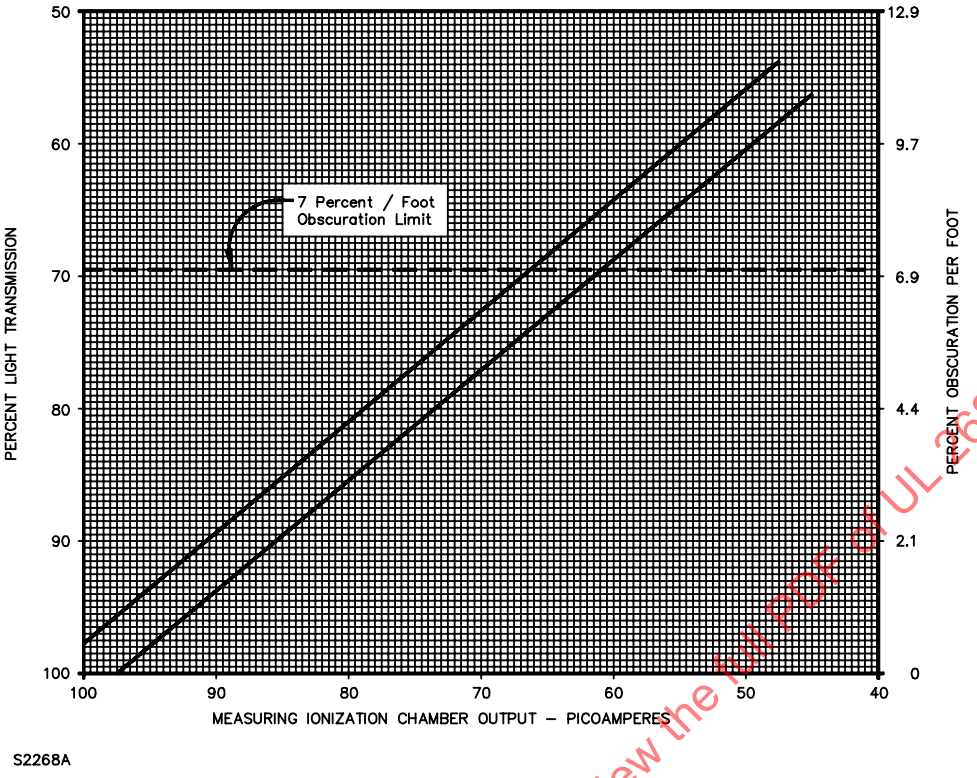


Figure 36.3

Measuring ionization chamber/light beam limits gray smoke fire test

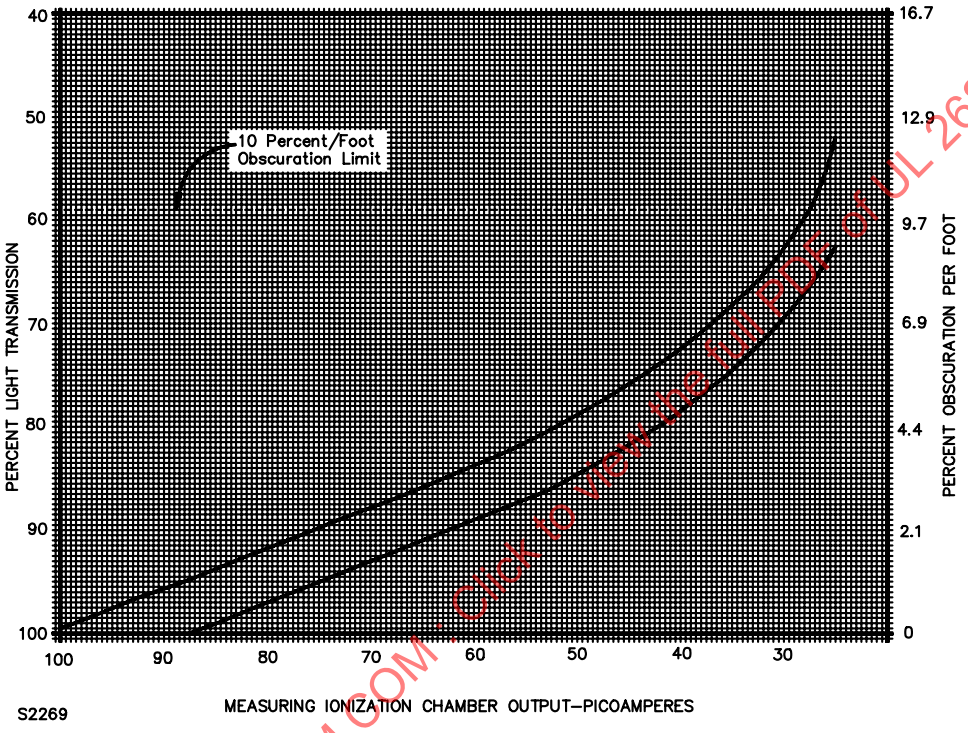


36.5.3 Black smoke

36.5.3.1 Heptane is to be poured into the metal receptacle 30 seconds prior to ignition. The amount of heptane and the receptacle size are both to be determined according to air duct velocity as shown in Table 36.4. The visible smoke buildup rate is to be maintained within the limits illustrated in Table 36.4 for each air velocity. To determine the acceptability of the test trial, the relationship between the MIC output (ordinate) and the percent light transmission (abscissa) shall be continuously plotted during the test. The curve generated shall remain within the curves illustrated in Figure 36.4.

Figure 36.4

Measuring ionization chamber/light beam limits black smoke fire test



37 Stability Tests

37.1 There shall be no false alarms of an air duct smoke detector set at the maximum production sensitivity when two representative samples, oriented so that the most favorable position for smoke entry faces the oncoming air flow, are subjected to the test conditions specified in 37.2.

Exception: A test is not required when the principle of operation of the detector is such that the detector operation is not affected by the air velocities specified in 37.2.

37.2 The detectors are to be mounted in a position of intended use (see Figure 36.1), one in the horizontal plane and one in the vertical plane, energized from a source of supply in accordance with 25.2.1, and subjected to the test conditions specified in (a) and (b).

a) Twenty-five cycles of change in duct air velocity from 0 fpm to 4000 ±200 fpm (20.3 ±1.0 m/s).

b) Operation for 2 hours in a duct air stream having a velocity of 4000 ±200 fpm (20.3 ±1.0 m/s).

37.3 For the test in 37.2(a), the change in air velocity is to require no more than 10 seconds. Each cycle of change is to consist of starting at zero velocity, reaching 4000 fpm in not more than 10 seconds, maintaining the velocity for at least 30 seconds, and returning to zero velocity in not more than 10 seconds.

38 Variable Ambient Temperature Test

38.1 Operation in high and low ambients

38.1.1 Two detectors, one at maximum and one at minimum sensitivity, or one projected beam assembly, tested while preset first to maximum and then tested at minimum sensitivity, are to be maintained, in turn, for a minimum of 3 hours, in an ambient temperature as determined by the following formulas and a relative humidity of 30 to 50 percent at each temperature. Each detector shall be tested individually and shall operate as intended in each ambient.

Low temperature = Proposed low end operating temperature

High temperature = $(T_{HI} – 38°C) + 49°C$ or $(T_{HI} – 100°F) + 120°F$

T_{LO} & T_{HI} are low and high end operating range respectively.

38.1.2 The sensitivity of the sensing head, both prior to and during each exposure, shall be in compliance with the limits for the Variable Ambient Temperature Test referenced in 53.1(a)(9).

38.2 Effect of shipping and storage

38.2.1 The intended operation of a detector shall not be affected by exposure to high and low temperatures representative of shipping and storage.

38.2.2 Two detectors, one at maximum and one at minimum sensitivity, or one projected beam assembly, tested while preset first to the maximum and then tested at minimum sensitivity, packaged as intended for shipping, are to be subjected to a temperature of 70°C (158°F) for a period of 24 hours, cooled 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 warmed to room temperature for a minimum of 3 hours. The detectors are then to be tested for intended operation.

38.2.3 The sensitivity of the sensing head or projected beam assembly, obtained both prior to and following the exposure, shall be in compliance with the limits for the Variable Ambient Temperature Test referenced in 53.1(a)(9).

39 Humidity Test

39.1 Two air duct detectors, one at maximum and one at minimum sensitivity, or one projected beam assembly, tested while preset first to the maximum and then tested at minimum sensitivity, shall operate for their intended signaling performance while energized from a source of supply in accordance with 25.2.1 during exposure for 168 hours to air having a relative humidity of 85 ±5 percent and at a temperature of 30 ±2°C (86 ±3.6°F). There shall be no false alarms during the exposure.

39.2 The sensitivity of the sensing head or projected beam assembly, both prior to and during the exposure, shall be in compliance with the limits for the Humidity Test referenced in 53.1(a)(10).

40 Corrosion Test

40.1 An air duct smoke detector (complete assembly) shall operate in its intended manner after being subjected to the corrosive atmosphere tests described in 40.2 – 40.5. The samples are to be placed in the test chambers in the position of intended use on a platform 2 inches (50.8 mm) above the bottom of the exposure chamber.

40.2 MOIST HYDROGEN SULFIDE-AIR MIXTURE EXPOSURE– Two samples, one at the maximum and one at the minimum sensitivity setting, or one projected beam assembly, tested while preset first to the maximum and then tested at minimum sensitivity, are to be exposed to a moist hydrogen sulfide-air mixture in a closed glass chamber for a period of 10 days. On the first through fourth and seventh through tenth days, an amount of hydrogen sulfide equivalent to 0.1 percent of the volume of the chamber is to be introduced into the chamber from a commercial gas cylinder, and the required volume is to be measured with a flowmeter and stop watch. Prior to each introduction of gas, the gas-air mixture remaining from the previous day is to be thoroughly purged from the chamber. On the fifth and sixth day of the exposure, the chamber is to remain closed and no purging or introduction of gas is to be provided. During the exposure, the gas-air mixture is to be gently stirred by a small motor-driven fan located in the upper middle portion of the chamber. A small amount of water (3.34 l/m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

40.3 A typical test apparatus the for carbon dioxide-sulfur dioxide-moist air exposure test and the hydrogen sulfide-moist air exposure test consists of:

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

b) Needle Valves (to adjust flow).

c) Selector Valve (selects CO_2 or SO_2).

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

e) Gas inlets to exposure chamber.

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

g) Small motor and fan blade (1550 rpm motor with aluminum fan blade, 3-1/2 inches, 10 wings providing air movement toward motor. Neoprene gasket used to seal shaft through hole in glass cover).

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

i) Test Sample. Normally, complete air duct smoke detector assembly (head and housing less sampling tubes) or components of a projected beam assembly are inserted in the chamber.

Different type chambers are not prohibited from being used when the equivalent gas concentrations and water volumes are maintained.

40.4 MOIST CARBON DIOXIDE-SULFUR DIOXIDE-AIR MIXTURE EXPOSURE – Two samples, one at the maximum and one at the minimum sensitivity setting, or one projected beam assembly tested while preset first to the maximum and then tested at minimum sensitivity, are to be exposed to a moist carbon dioxide-sulfur dioxide-air mixture in a closed glass chamber for a period of 10 days. On the first through fourth and seventh through tenth days, an amount of carbon dioxide equivalent to 1.0 percent of the volume of the chamber, plus an amount of sulfur dioxide equivalent to 0.5 percent of the volume of the chamber, is to be introduced and purged as described in 40.2. On the fifth and sixth days of the exposure period, the chamber is to remain closed and no purging or introduction of gas is to be provided. A small amount of water (3.34 l/m^3 of chamber volume) is to be maintained at the bottom of the chamber for humidity.

40.5 Following the corrosion exposures described in 40.2 and 40.4, the detectors are to be removed from the corrosion chamber and then dried in a circulating air oven at a temperature of 40°C (104°F) for a period of at least 24 hours, after which the detectors are to be again tested for their intended signaling performance. There shall be no false alarms as a result of the exposure.

40.6 The sensitivity of the sensing head or projected beam assembly, both prior to and following the test, shall be in compliance with the limits for the Corrosion Test referenced in 53.1(a)(11).

41 Transient Test

41.1 General

41.1.1 Two detectors, one at maximum and one at minimum sensitivity, or one beam assembly, tested while preset first to the maximum and then tested at minimum sensitivity, shall operate for their intended signaling performance and shall not initiate a false alarm or a trouble signal, after being subjected to internally induced, high-voltage, and extraneous transients while energized from a source of supply in accordance with 25.2.1 and connected to the devices intended to be used with the detector.

41.2 Internally induced transients

41.2.1 Each detector is to be energized in the standby condition from a source of supply in accordance with 25.2.1. The supply is to be interrupted for 1 second, then restored for 9 seconds, and this cycle repeated at a rate of not more than 6 cycles per minute for a total of 500 cycles. Following this test each detector is to be operated for its intended signaling performance.

41.3 Extraneous transients

41.3.1 An air duct smoke detector shall not false alarm and its subsequent intended operation shall not be impaired when it is subjected to extraneous transients generated by the devices and appliances described in 41.3.2.

41.3.2 To determine compliance with 41.3.1, two unit detectors or one projected beam assembly, all preset to the maximum sensitivity are to be energized from a source of supply in accordance with 25.2.1 and subjected to transients generated from the following devices located 1 foot (305 mm) except for the 10 foot (3 m) distance in the test described in 41.3.2 (b), from the detector or interconnecting wires or both. The time of application for condition (a) is to be at least 2 minutes. Conditions (b), (c), (d), and (e) are to be applied for 10 cycles, and each cycle is to consist of 2 seconds duration.

a) Sequential arc (Jacob's ladder) generated between two 15 inch (381 mm) long, 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 with a 1/8 inch (3.2 mm) separation at the bottom (adjacent to terminals) and a 1-1/4 inch separation (31.8 mm) at the top.

b) Individual energization of three transmitter-receiver units (walkie-talkies), from a distance of 10 feet (3 m), each having a 5 watt output and operating in the following nominal frequencies: 27, 150, and 450 megahertz. A total of six energizations are to be applied from each transmitter-receiver; five to consist of 5 seconds ON and 5 seconds OFF, followed by one consisting of a single 15-second energization.

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 an electromechanical buzzer rated 120 volts, 60 hertz.

41.4 High-voltage transients

41.4.1 An air duct smoke detector shall not false alarm, and its intended operation shall not be impaired by subjection to line-voltage transients induced on the power supply of a detector intended to be connected directly to a line-voltage commercial supply source.

41.4.2 For this test, each of two unit detectors, one at maximum and one at minimum sensitivity or one projected beam assembly, tested while preset first to the maximum and then tested at minimum sensitivity 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 41.4.3. The output impedance of the transient generator is to be 50 ohms.

41.4.3 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 by no less than 50 percent from the preceding peak until line-voltage is attained. Each transient is to have a total duration of 20 microseconds and is to be applied once every 10 seconds.

41.4.4 The detector is to be subjected to 500 transients at a rate of 6 cycles per minute. Each transient is to be induced 90 degrees into the positive half of the 60 hertz cycle.

41.4.5 The sensitivity of the sensing head or projected beam assembly, both prior to and following the test, shall be in compliance with the limits for the Transient Test referenced in 53.1(a)(12).

42 Static Discharge Test

42.1 The components of an air duct smoke detector shall be shielded so that its intended operation is not impaired or a false alarm obtained when they are subjected to static electric discharges. Operation of the trouble circuit during this test is not prohibited 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), a relative humidity of 10 ±5 percent and a barometric pressure less than 700 mm of mercury (93.07 kPa).

42.2 Each of two detectors, one at maximum and one at minimum sensitivity, or one projected beam assembly, tested while preset first to the maximum and then tested at minimum sensitivity, is to be mounted in its intended mounting position and connected to a source of supply in accordance with 25.2.1. 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 line-

voltage insulated leads, each 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 as monitored by an electrostatic voltmeter. One probe is to be touched to the detector and the other probe then is to be touched to earth ground.

42.3 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. Five discharges are to be made with one test probe connected to earth ground and the other probe on the detector surface, followed by five discharges with the polarity of the probes reversed. Ten additional discharges are to be applied on the exposed surfaces of the detector.

Exception: Discharges are not to be applied inside the detector when the detector is not intended to be serviced in the field, and is marked to be returned to the factory for servicing.

42.4 The sensitivity of the sensing head or projected beam assembly, both prior to and following the test, shall be in compliance with the limits for the Static Discharge Test referenced in 53.1(a)(13).

43 Overload Test

43.1 Internally energized circuits

43.1.1 An air duct smoke 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 cycles per minute, with the supply circuit to the detector at 115 percent of rated test voltage. Each cycle is to be started with the detector energized in the standby condition, then an alarm is to be initiated by smoke or equivalent means, and then restoration of the detector to the standby condition.

43.1.2 Rated test loads are to be connected to the output circuits of the detector that are energized from the detector power supply. The test loads are to be those devices, such as remote indicators, relays, or the equivalent loads, intended for connection to the output circuit. When the equivalent load consists of an inductive load, a power factor of 60 percent is to be employed. The rated test loads are to be established initially while the detector is connected to a source of supply in accordance with 25.2.1. Following determination of equivalent loads, the voltage is to be increased to 115 percent of rating.

43.1.3 For direct current rated signaling circuits, an equivalent inductive test load is to have the required DC resistance for the test current and the calibrated inductance to obtain a power factor of 60 percent when connected to a 60 hertz rms 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 shall be equal to 60 percent of the current measured with the load connected to a DC circuit when the voltage of each circuit is the same.

43.2 Separately energized circuits

43.2.1 Separately energized circuits of a detector, such as dry contacts, shall operate after being subjected to 50 cycles of signal operation at a rate of not more than 6 cycles per minute. The test is to be conducted while the circuit is connected to a source of supply in accordance with 25.2.1, and with 150 percent rated loads at 60 percent power factor applied. There shall not be electrical or mechanical malfunction of the switching circuit as a result of the test.

43.2.2 The test loads shall be set at 150 percent of rated current while connected to a separate source of supply in accordance with 25.2.1.

44 Endurance Test

44.1 Internally energized circuits

44.1.1 The same detector subjected to the test described in 43.1.1 – 43.1.3 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 cycles per minute while the detector is connected to a source of supply in accordance with 25.2.1 and related devices or equivalent loads are connected to the output circuits. There shall be no electrical or mechanical malfunction or evidence of malfunction of the detector components.

44.1.2 The sensitivity of the sensing head, or projected beam assembly, obtained both prior to and following the test, shall be in compliance with the limits for the Endurance Test referenced in 53.1(a)(15).

44.2 Separately energized circuits

44.2.1 The same separately energized circuits of the detector subjected to the test described in 43.2.1 and 43.2.2 shall operate as intended for 6000 alarm cycles at a rate of not more than 10 cycles per minute. Each cycle is to consist of 50 percent OFF and 50 percent ON. When an electrical load is involved, the contacts of the device shall make and break the intended current at the voltage specified in 25.2.1. The load shall represent that which the device is intended to control. It is appropriate to conduct this test in conjunction with the test described in 44.1.1 and 44.1.2. There shall be no electrical or mechanical malfunction of the detector nor pitting, burning, or welding of any electrical contacts.

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

45 Abnormal Operation Test

45.1 An air duct smoke detector shall operate continuously under abnormal (fault) conditions without resulting in a risk of fire. The shorting of an electrolytic capacitor(s) and operation in the alarm condition for more than 1 hour are typical abnormal conditions.

45.2 The detector is to be operated under the most severe abnormal circuit fault conditions to be encountered in service while connected to a source of supply in accordance with 25.2.1. There shall be no emission of flame or molten metal, or any other manifestation of a fire.

45.3 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. See 27.2.1 – 27.3.1 and 43.1.1.

46 Locked Rotor Test

46.1 General

46.1.1 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 specified in the Standard for Motor-Operated Appliances, UL 73, is considered to comply with these requirements without the necessity of further tests.

46.2 Thermal or overcurrent protection

46.2.1 When the rotor of the motor is locked, the temperature on a Class A insulated motor winding shall not exceed 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, determined by taking:

a) The arithmetic mean of the maximum temperatures and

b) The arithmetic mean of the minimum temperatures, and averaging them, shall not exceed 150°C (302°F).

46.2.2 Temperatures are to be measured by the thermocouples on the surface of coils of the motor. The test on 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. In such a case, the test is to be continued for the duration of the shorter interval. During the test, the motor is to be connected to a source of supply in accordance with 25.2.1.

46.2.3 An automatic-reset thermal protector of a motor shall operate as intended, with the rotor locked, for a period of 15 days, unless the detector includes other controls, such as a timer, that limits the operation to a shorter interval, or unless the device permanently opens the circuit prior to the expiration of that period, 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 be no permanent damage to the motor, such as excessive deterioration of the insulation, and when the device permanently opens the circuit, it shall do so without grounding to the motor frame, damage to 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.

46.2.4 There shall be no 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 1/2 horsepower (373 watt output) or less, and 250 volts or less, the current shall be 200 amperes. For motors having other ratings, not more than 1 horsepower (746 watt output), it shall be 1000 amperes. The power factor of the test circuit shall be 0.9 – 1.0, and the circuit capacity shall be measured without the device in the circuit. A nonrenewable cartridge fuse shall be connected in series with the device under test. The fuse rating shall be not less than four times the rated current of the detector except that the fuse rating is to be not 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, and the tests on the other two samples are to be made by closing the circuit on the device.

46.3 Impedance protection

46.3.1 While operated under locked-rotor conditions for 15 days:

a) A motor shall attain a temperature of not more than 150°C (302°F) during the first 72 hours of operation (see 46.3.3);

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: It is appropriate to terminate the test when the windings of the motor (of either the open or totally enclosed type) reach a constant temperature of not more than 100°C (212°F).

46.3.2 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.

46.3.3 To determine that a motor complies with the requirements of 46.3.1, temperature readings are to be taken as specified in (a) and (b):

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 the coils are wrapped. When the coil is encapsulated, the winding temperature is to be determined by the change-of-resistance method.

46.3.4 The rotor of the motor is to be locked in a stationary position. The motor is to be mounted on wood or other equivalent thermal insulating material. 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 with no fuse in the grounding conductor. A 30-ampere, time-delay fuse is to be connected in each ungrounded conductor of the supply circuit.

46.3.5 At the conclusion of the first 72 hours of the locked rotor test, the motor shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 47.

46.3.6 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.

47 Dielectric Voltage-Withstand Test

47.1 A detector shall withstand for 1 minute without breakdown, a 60-hertz, sinusoidal potential applied between:

a) Line-voltage live parts and dead metal parts,

b) Live parts of line- and low-voltage circuits, and

c) Live parts of different line-voltage circuits.

The test potential is to be 1000 volts plus twice rated voltage for line-voltage circuits.

Exception: For all motors rated 1/2 horsepower (373 watt output) or less, the test potential is to be 1000 volts.

47.2 A detector employing a low-voltage circuit shall withstand for 1 minute without breakdown, a 60-hertz, sinusoidal potential of 500 volts applied between low-voltage live parts of different circuits and between low-voltage live parts and dead metal parts.

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

47.4 A transformer, the output voltage of which is sinusoidal, variable, and able to maintain the specified high potential voltage at the equipment for the duration of the test, is to be used to determine compliance with 47.1 and 47.2. The applied potential is to be increased from zero at a rate of 100 volts per second until the required test value is reached, and is to be held at that value for 1 minute.

48 Polarity Reversal Test

48.1 A detector shall operate in its intended manner after being connected in each polarity of the supply source. Two samples of a unit detector, or one sample of a projected beam assembly, are to be subjected to this test. Each polarity is to be applied for at least 24 hours unless a trouble or alarm signal is obtained. A trouble or alarm signal is not prohibited under any incorrect polarity applied.

48.2 The sensitivity of the sensing head, both prior to and following the test, shall be in compliance with the limits for the Polarity Reversal Test referenced in 53.1(a)(16).

49 Tests of Polymeric Materials

49.1 General

49.1.1 Polymeric materials intended for the sole support of current-carrying parts or as an enclosure of a detector shall comply with the requirements of the tests in 49.2.1 – 49.4.4.2. When possible, a complete enclosure is to be used.

49.2 Temperature test

49.2.1 There shall not be exposure of line-voltage uninsulated current-carrying parts or warping to the extent that intended operation is impaired when three representative samples of a polymeric plastic material are mounted on supports as intended in service and aged in a circulating-air oven at a temperature and duration as determined per the Arrehenius equation (see below). Following this aging period, the samples are to be removed, cooled to room temperature, and then examined for distortion.

$$t_{test\text{-}time} = t_{real\text{-}time}/Q_{10}^{(T\,oven\,-\,T\,operating)/10}$$

In which:

Q_{10} = *2 and*

$t_{real\text{-}time}$ = *257 days*

For example $t_{test\text{-}time}$ for a 38°C rated product tested at 90°C

$t_{test\text{-}time} = 257/2^{(90\text{-}38)/10}$

$t_{test\text{-}time}$ = 7 days

49.2.2 Sensitivity measurements conducted in the event of questionable distortion, following the test, shall comply with the limits for the Temperature Test (Polymeric Materials) specified in 53.1(a)(18).

49.3 Flame test

49.3.1 When tested in accordance with 49.3.3 – 49.3.6, a polymeric plastic material employed as part of a detector for the sole support of current-carrying parts or as an enclosure shall not continue to burn for more than 1 minute after the fifth 5-second application of a test flame, with an interval of 5 seconds between applications of the test flame. There shall not be flaming or dripping of particles or complete consumption of the sample during the test, and the material shall not be destroyed in the area of the test flame to the extent that the integrity of the enclosure is affected. Three samples of the material or three test specimens consisting of a part or section of the enclosure are to be subjected to this test. Components and other parts that are capable of influencing the performance are not prohibited from being left in place.

49.3.2 When one of the three samples does not comply with the requirements in 46.2.3, the test shall be repeated on a new sample with the flame applied under the same conditions as for the noncomplying sample. When the new specimen complies with the requirements, the construction tested is capable of being used.

49.3.3 Prior to the flame test, the test samples are to be conditioned in a circulating-air oven as determined per the Arrhenius equation (see below).

$$t_{test\text{-}time} = t_{real\text{-}time}/Q_{10}^{(T\,oven\,-\,T\,operating)/10}$$

In which:

Q_{10} = *2 and*

$t_{real\text{-}time}$ = *257 days*

For example $t_{test\text{-}time}$ for a 38°C rated product tested at 90°C

$t_{test\text{-}time} = 257/2^{(90\text{-}38)/10}$

$t_{test\text{-}time}$ = 7 days

49.3.4 The following test equipment is to be used:

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

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

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

d) A stopwatch or clock.

e) Circulating-air oven.

49.3.5 The test samples are to be mounted as intended in service in the test chamber. The test flame is to be applied at an angle of 20 degrees from the vertical to any portion of the interior of the enclosure evaluated ignitable by proximity to live or arcing parts, coils, wiring, and similar items.

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

49.4 Conduit connections

49.4.1 General

49.4.1.1 A polymeric enclosure intended for connection to a rigid conduit system shall comply with the requirements in 49.4.2.1 – 49.4.4.2 without pulling apart, or cracking and breaking. The tests are to be

conducted after the enclosure has been subjected to either of the temperature conditions described in 49.2.1.

Exception: The test in 49.2.1 does not apply to an enclosure that is not provided with a preassembled hub and that has instructions stating that the hub is to be connected to the conduit before being connected to the enclosure.

49.4.2 Pullout

49.4.2.1 The enclosure is to be suspended by a length of rigid conduit installed in one wall of the enclosure and a direct pull of 200 pounds is to be applied for 5 minutes to a length of conduit installed in the opposite wall of the enclosure.

49.4.3 Torque

49.4.3.1 The enclosure is to be mounted as intended in service. A torque of 800 pound-inches (90.3 N·m) for 3/4 inch (20.9 mm ID) and smaller conduit trade sizes, 1000 pound-inches (112.9 N·m) for 1-, 1-1/4, and 1-1/2 inch trade sizes (26.6, 34.2, and 40.9 mm ID), and 1600 pound-inches (180.6 N·m) for 2 inch (62.5 mm ID) and larger trade sizes is to be applied to a length of installed conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit.

49.4.4 Bending

49.4.4.1 A length of conduit, no less than 1 foot long, is to be installed:

a) In the center of the largest unreinforced surface or

b) In a hub or opening provided as part of the enclosure.

The enclosure is to be mounted as intended in service, and also positioned so that the installed conduit extends in a horizontal plane. The weight required to produce the required bending moment when suspended from the end of the conduit is to be determined from the equation:

$$W = \frac{M - 0.5CL}{L}$$

in which:

W is the weight, in pounds, to be suspended at the end of the conduit (1 pound = 0.453 kilograms);

M is the bending moment required in pound-inches (1 lbf·in = 0.1129 N·m);

C is the weight of the conduit in pounds; and

L is the length of conduit, in inches, from the wall of the enclosure to the point at which the weight is suspended (1 inch = 25.4 mm).

49.4.4.2 The bending moment for the test described in 49.4.4.1 shall as be specified in Table 49.1. When the enclosure surface is able to be installed in either a vertical or horizontal plane, the vertical bending moment value shall be used.

Table 49.1
Bending moment

Normal mounting plane of enclosure surface	Conduit size, inches	Bending moment, pound-inches	
		Metallic conduit	Nonmetallic conduit
Horizontal	all	300	300
Vertical	1/2 – 3/4	300	300
	1 – up	600	300
NOTE – It is appropriate to terminate the test prior to attaining the values specified when the deflection of the conduit exceeds 10 inches (254 mm) for a 10 foot (3 m) length of conduit.			

50 Tests of Elastomeric and Foam Materials

50.1 General

50.1.1 Elastomeric or foam materials employed as functional parts of an air duct smoke detector, such as gaskets, seals, and stoppers shall comply with the requirements of the tests in 50.2.1 and 50.2.2.

50.2 Accelerated aging

50.2.1 There shall not be excessive cracking, discoloration, shrinking, swelling, melting, warping, or damage of elastomeric or foam materials used as gaskets, seals, and similar materials, when representative samples of the material are aged as indicated in 50.2.2.

50.2.2 At least three representative samples of each material are to be aged in an air circulating oven maintained at 100 ±2°C (212 ±3.6°F) for 70 hours. Following the aging period, the samples are to be viewed while in the oven for distortion, removed, cooled to room temperature, and then reexamined. Prior to the final reexamination, each specimen is to be hand flexed or otherwise manipulated to induce cracking, softening, and similar results. Following the flexing, aged samples are to be compared to unaged samples for signs of shrinkage, distortion, and similar results, that affect the integrity of the seal intended to be provided by the material.

51 Strain Relief Test

51.1 Each lead used for field connections, or an internal lead or cord subject to movement or handling during installation and servicing, 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.

51.2 A strain relief test on a cord or leads that depend upon a thermoplastic enclosure or part to prevent removal of the cord or lead, is to be conducted following exposure to either temperature conditioning test described in 49.2.1. The test is to be performed after the sample has been placed in room temperature for at least 3 hours.

51.3 Special field-wiring terminals

51.3.1 To determine suitability as a field-wiring connection in compliance with 9.8.1 and 9.8.2, representative samples shall comply with all of the tests specified in 51.3.2 and 51.3.3.

51.3.2 A terminal connection shall withstand the application of a straight pull of 22.2 N (5 lb), applied for 1 minute to the wire in the direction which would most likely result in pullout, without separating from the terminal.

51.3.3 Six samples of the terminal are to be connected to the wire sizes with which they are intended to be used, in accordance with the manufacturer's published instructions. When a special tool is required to assemble the connection, it is to be used. Each sample is to be subjected to a gradually increasing pull on the wire until the test pull of 22.2 N (5 lb) is reached and maintained at 22.2 N (5 lb) for 1 minute.

52 Radioactive Material Measurement Test

52.1 The total activity of the radioactive source(s) of a sensing chamber used in an air duct smoke detector shall not exceed the maximum content specified by the marking on the detector.

52.2 The measurement is to be made on at least five samples of the detector in the as-received condition, using instrumentation and techniques as specified in Appendix B.

53 Sensitivity Tests of Smoke Sensing Chamber(s)

53.1 The sensitivity of the sensing head or projected beam assembly, employed as a component of an air duct smoke detector, shall comply with the following sections of the Standard for Smoke Detectors for Fire Alarm Systems, UL 268:

a) Performance Tests:

1) Sensitivity

2) Directionality (where applicable)

3) Lamp Interchangeability (Photoelectric)

4) Reduction in Light Output (Photoelectric)

5) Stability

6) Overvoltage and Undervoltage

7) Vibration

8) Jarring

9) Variable Ambient Temperature

10) Humidity

11) Corrosion

12) Transient

13) Static Discharge

14) Dust

15) Endurance

16) Polarity Reversal

17) Accelerated Aging (Long-Term Stability Test – not required)

18) Temperature Test (Polymeric Materials)

19) Field Service Tests

b) Manufacturing and Production Tests:

1) Sensitivity Calibration

2) Smoke

3) Photocell Illuminating Lamp.

MARKING

54 General

54.1 An air duct smoke detector shall be marked with the following information in a contrasting color, finish, or equivalent, unless it is specifically indicated that the marking appears on the installation wiring diagram. Unless the letter height is specified in these requirements, 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.

c) Electrical ratings that appear on the installation wiring diagram, 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) Steady state supervisory current and maximum surge current upon energization (surge current applies only to a 2-wire detector).

3) Maximum alarm current.

4) Maximum permissible current that is able to be handled by detector (applies only to a 2-wire detector.

5) Frequency.

d) Intended mounting position of the detector, when the detector is intended to be mounted in a definite position. (It is not prohibited that this appear on the installation wiring diagram.)

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

f) Maximum rating of a fuse in each fuseholder (marking shall be located adjacent to the fuseholder).

g) Reference to an installation wiring diagram, when the diagram not attached to the detector, by drawing number and issue number or date. See 55.1.

h) A reference to the Technical Bulletin. (It is not prohibited that this appear on the installation wiring diagram.)

i) Reference to a specific model number or description of the instrument(s) to be used for checking the sensitivity of the detector.

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

k) The following or equivalent notice: "Do Not Paint" on the outer surface of the enclosure for a detector head that is not intended to be enclosed in a housing and not intended to be painted during intended use. The letters shall be not less than 1/8 inch (3.2 mm) high and shall be located so as to be visible after the detector is mounted in its intended manner.

l) For a detector that employs a radioactive material, the following information, in letters at least 3/64 inch (1.2 mm) high, shall be indicated directly on the exterior of the detector head or exterior of the duct assembly:

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.

m) The wiring system or systems for which the detector is intended, when intended for permanent connection only to a wiring system other than metal-clad cable or conduit. It is appropriate for the marking to appear on the installation wiring or located so that it is visible when power-supply connections to the detector are made.

n) Range of duct air velocities for which the detector is intended.

o) Reference to a specific model number or description of the instrument(s) and method of measurement to be used for checking the air flow or pressure differential in the detector sensor area.

54.2 Information required to appear directly on the detector shall be readily visible after installation. The removal or opening of an enclosure cover, or an equivalent arrangement to view the marking, is considered readily visible.

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

54.4 Additional marking requirements are specified in 5.5.2, 9.5.5, and 9.7.2.

54.5 The following marking information is to appear on each separable detector sensing head or marked adjacent to where the head is installed:

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

b) Model number and date of manufacture, or equivalent. This information is not prohibited from being in code.

c) Sensitivity setting for a sensing head having a fixed factory setting. When a head is intended to be adjusted in the field, the range of sensitivity shall be indicated. The sensitivity shall be indicated as an obscuration level or an instrument reading. A sensitivity indication other than an instrument reading shall be employed only when it provides an equivalent indication of the sensitivity of the head.

d) For a separable detector head containing a radioactive material, the information described in 54.1(l), unless it appears on the duct assembly.

54.6 A mounting base or duct assembly, used with one or more separable detector heads, shall be marked with the following or equivalent marking: "FOR USE WITH MODELS ____(+) ____ DETECTOR HEADS."

(+) – Insert applicable model numbers.

54.7 The air flow measurement, pressure differential, or equivalent measurement or range obtained during the fire tests described in 36.5.1.1 shall be marked on the detector for all velocities and tube lengths with which the detector is to be employed.

55 Installation Instructions – Wiring Diagram

55.1 An installation wiring diagram shall be provided with each detector illustrating the field connections to be made. The drawing shall be attached to the detector or, when separate, its drawing number and issue number or date, shall be referenced in the marking attached to the detector. It is permitted for the installation information (including the wiring diagram) to be provided via electronic means. If the information is provided via the internet, a bar code or URL that leads to the information, shall be marked on the product.

55.2 The diagram shall show a pictorial view of the installation terminals or leads to which field connections are to be made as they appear when viewed during an installation, and the minimum internal dimensions of a backbox, when not provided with the detector, shall be specified. The terminal numbers on the detector shall correspond with the numbers on the drawing. A drawing not attached to the detector is to be marked with the manufacturer's or private labeler's name or identifying symbol, drawing number, and issue date.

55.3 The following marking information shall appear on each detector or the installation wiring diagram (part of the manufacturer's published instructions), for the applicable circuits to which field connections are made.

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

Exception: This marking is not required when reference is made for connection to a specific control unit, or equivalent.

b) Initiating Device Circuit – 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 illustrated, for a total of three detectors. An equivalent arrangement is not prohibited.

c) Supplementary Circuits – Voltage, current or watts, and frequency.

d) For a two-wire detector intended to receive its power from the initiating device circuit of a control unit, reference to at least one specific control unit(s) by name of manufacturer and model number. "Stuffers" with model numbers of added control units are not prohibited.

e) A marking adjacent to terminals intended to be connected to an initiating device alarm circuit of a fire alarm control unit: the word "CAUTION"– and the following or equivalent text, "FOR SYSTEM MONITORING – FOR TERMINALS _____ AND _____, DO NOT USE LOOPED WIRE UNDER TERMINALS. BREAK WIRE RUN TO PROVIDE MONITORING OF CONNECTIONS." The letter height for the text shall be a minimum of 1/8 inch (3.2 mm) for the word "CAUTION" and a minimum of 3/64 inch (1.2 mm) for the remainder of the text. The blanks shall contain the applicable terminal identification.

f) The following designation: THIS DETECTOR IS NOT INTENDED AS A SUBSTITUTE FOR OPEN AREA PROTECTION. The letter height for the text shall be a minimum of 1/8 inch.

56 Technical Bulletin

56.1 A Technical Bulletin available for each installation shall be provided by the manufacturer and shall be used as a reference by the installer. The Bulletin shall include reference to the Standard for Automatic Fire Detectors, NFPA 72, and the Standard for Installation of Air Conditioning and Ventilating Systems, NFPA 90A, for the installation of detectors. The bulletin shall include guidelines in accordance with NFPA 72 and NFPA 90A on detector installation, maintenance, servicing tests, and similar topics, under various environmental conditions and physical configurations.

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

56.3 Detailed information shall be provided regarding the use of the sensitivity level or test means shall be 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.

d) Guidelines on instrument use for an engineering survey, installation, and maintenance.

56.4 Detailed information shall also be provided regarding:

a) The proper installation of sampling tubes, when employed;

b) Correct use of air flow monitoring equipment provided with the detector; and

c) The range of duct air velocities for which the detector is intended.

56.5 Reference to the Technical Bulletin number and date shall appear 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.

56.6 The Technical Bulletin shall not include information, other than specified in 56.1, such as manufacturer's claims for the operation of the detector that have not been substantiated by the performance tests included in this standard, or that are not covered in the Standard for Automatic Fire Detectors, NFPA 72, or other applicable NFPA Standards.

57 Packaging Marking

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

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

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

c) The following or equivalent statement:

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