

Subject 268

February 29, 2008

SUMMARY OF TOPICS

The following changes in requirements are being proposed:

1. Proposed Sixth Edition of UL 268, Smoke Detectors for Fire Alarm Signaling Systems, and Proposed Third Edition of ULC-S529, Smoke Detectors for Fire Alarm Systems, as a Single Binational Standard

STP BALLOTS DUE: APRIL 29, 2008

COMMENTS DUE: APRIL 29, 2008

1. Proposed Sixth Edition of UL 268, Smoke Detectors for Fire Alarm Signaling Systems, and Proposed Third Edition of ULC-S529, Smoke Detectors for Fire Alarm Systems, as a Single Binational Standard

RATIONALE

The accompanying proposed new edition standard is the product of a team of about ten smoke detector experts from Canada and the United States working part time over a period of several years. The team's goal: to merge the System Smoke Detector Standard from Canada (ULC-S529) and the United States (UL 268) into a single binational standard that will be used for both countries.

Although these two standards have mostly identical requirements, there are some that are very similar, but not identical. There are also requirements that are unique to one country or the other.

The benefits realized by creating a binational standard are:

- a) A single standard for Canada and the United States where minor, negligible differences in requirements are eliminated through harmonization.
- b) Users will need to acquire and be familiar with just one standard for both countries.
- c) Testing labs will be able to accept each other's test data with more confidence knowing that minor differences in requirements have been harmonized. This will strengthen confidence in the results of accreditation audits.
- d) Similar, but different language for identical requirements are harmonized, resulting in eliminating the need to interpret different wording.
- e) Except for country-specific requirements, users need only work with a unified binational standard.
- f) Public proposals to revise or enhance the binational standard will get broader review, since it will be examined by experts in both countries.

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g) Revisions to the standard will have the same effective date in both countries, resulting in tighter and more efficient coordination between the laboratories and manufacturers to complete file reviews and subsequent testing for new requirements.

h) Future proposals to harmonize existing country-specific requirements will be reviewed by the binational community resulting in a more coordinated effort of review, comment and debate prior to voting.

Guidelines used by the team, known at the Technical Harmonization Committee or THC, to develop the binational standard are:

- 1) Where technical requirements and language are identical, use text from either standard.
- 2) Where technical requirements are identical but language is different, use the text that is better written. Make editorial changes for improved readability and/or description of the requirement.
- 3) Where technical requirements are not identical, but are nearly identical, choose the requirement that is most stringent.
- 4) Where technical requirements appear in only one of the standards, examine the value of the requirement to the binational standard. If it is deemed an important or valuable requirement, then it is adopted for the binational standard. In this case, a smoke detector may need to be re-examined or re-tested to maintain listing in the country that adopts the new requirement.
- 5) Where a technical requirement appears in only one of the standards, and the requirement does not apply for the other country, the requirement is retained in the binational standard, but is denoted as country-specific.

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Typical Air Duct Detector Test Facility

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PROPOSED BINATIONAL STANDARD FOR SINGLE AND MULTIPLE STATION SMOKE DETECTORS FOR FIRE ALARM SIGNALING SYSTEMS, UL 268/ULC-S529

INTRODUCTION

1 Scope

1.1 This Standard sets forth requirements for smoke detectors rated at 300 V or less and mechanical guards to be employed in ordinary indoor locations in accordance with the following:

IN THE UNITED STATES

- a) National Fire Alarm Code, NFPA 72.

IN CANADA

- b) Standard for the Installation of Fire Alarm Systems, CAN/ULC-S524;
- c) National Building Code of Canada; and
- d) National Fire Code of Canada.

1.2 A smoke detector (e.g. ionization-type, photoelectric-type and the like) as covered by this Standard consists of an assembly of electrical components arranged to detect one or more products of combustion. The products of combustion may consist of gases, water vapor, and visible as well as invisible smoke particles. The detector includes provision for the connection to a source of power, signaling, and optional remote control circuits. Additional functionality, such as a heat detector, or audible signaling appliance/device, or both, is not prohibited from being incorporated as part of the smoke detector assembly.

1.3 This standard covers the following types of detectors:

- a) Detectors intended for open area protection and for connection to a compatible power supply or control unit for operation as part of a fire alarm system.
- b) Detectors intended solely for control of releasing devices such as electromagnetic door holders, fire dampers or smoke dampers.
- c) Detectors intended for both applications described in (a) and (b) above, and
- d) IN CANADA, duct detectors.

1.4 This standard does not cover the following:

IN THE UNITED STATES (a — f)

- a) Control units to which the detectors are intended to be connected that are covered by the Standard for Control Units for Fire-Protective Signaling Systems, UL 864;
- b) Self-contained single and multiple station smoke alarms, not intended for connection to a system control unit, that are covered by the Standard for Single and Multiple Station Smoke Alarms, UL 217;

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- c) A heat detector incorporated as a part of a smoke detector assembly, and covered by the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521; except for the requirements of the Fire Test (Heat Detector);
- d) Fire tests for smoke detectors integral with combination door closers and holders that are covered by the Standard for Door Closers-Holders, With or Without Integral Smoke Detectors, UL 228;
- e) Commercial-residential detectors not intended for connection to a system control unit that are covered by the Standard for Smoke Detector Monitors and Accessories for Individual Living Units of Multifamily Residences and Hotel/Motel Rooms, UL 1730;
- f) Detectors for monitoring the smoke density within flues or stacks;

IN CANADA (g – k)

- g) Control units to which the detectors are intended to be connected that are covered by the Standard for Control Units for Fire Alarm Systems, ULC-S527;
- h) Self-contained single and multiple station smoke alarms, not intended for connection to a system control unit, that are covered by the Standard For Smoke-Alarms, CAN/ULC-S531;
- i) A heat detector incorporated as a part of a smoke detector assembly, and covered by the Standard For Heat Actuated Fire Detectors for Fire Alarm Systems, CAN/ULC-S530;
- j) Fire tests for smoke detectors integral with combination door closers and holders that are covered by the ULC/ORD C-228, Door Closers and Holders; and
- k) Detectors for monitoring the smoke density within flues or stacks

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

2 General

2.1 Assembly

2.1.1 A detector shall be so constructed that it will be reliable and sufficiently durable for its intended installation and use.

2.1.2 A component of a detector shall comply with the requirements for that component, except that such requirements may be modified if appropriate for the particular application.

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2.2 Components

2.2.1 Except as indicated in 2.2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Annex E for a list of standards covering components used in the products covered by this standard.

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

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this statement or
- b) Is superseded by a requirement in this standard.

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

2.2.4 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.

2.3 Units of measurement

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

2.4 Reference publications

2.4.1 Where reference is made to other publications, such reference shall be considered to refer to the latest edition and all amendments published to that edition up to the time when this Standard was approved.

UL Standards

UL 228,
Door Closers and Holders

UL 864,
Control Units for Fire-Protective Signaling Systems

UL 521,
Heat Detectors for Fire Protective Signaling Systems

UL 2111,
Overheating Protection for Motors

UL 94,
Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 217,
Single and Multiple Station Smoke Alarms

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UL 1730,
Smoke Detector Monitors and Accessories for Individual Living Units of Multifamily Residences and Hotel/Motel Rooms

UL 268A,
Smoke Detectors for Duct Application

ULC Standards

CAN/ULC-S524,
Installation of Fire Alarm Systems

CAN/ULC-S530,
Heat Actuated Fire Detectors for Fire Alarm Systems

CAN/ULC-S536,
Inspection and Testing of Fire Alarm Systems

CAN/ULC-S531,
Smoke Alarms

ULC-S537,
Verification of Fire Alarm Systems

ULC-S527,
Control Units for Fire Alarm Systems

ULC/ORD-S228,
Door Closers and Holders

CSA Standards

C22.1-02,
Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations

C22.2 No. 1-98,
Audio, video, and Similar Electronic Equipment

C22.2 No. 77-95,
Motors with Inherent Overheating Protections

Other Standards

ANSI/NFPA No. 72,
National Fire Alarm Code

MIL-HDBK-217F(2) – February 2, 1995,
Reliability Prediction of Electronic Equipment

ISA-MC96.1-1982,
Temperature Measurement Thermocouples

National Research Council of Canada, National Building Code of Canada 2005

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National Research Council of Canada, National Fire Code of Canada, 2005

Department of Justice, Canada, Nuclear Safety and Control Act (1997, c.9)

3 Glossary

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

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

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

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

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

3.6 COMBINATION SMOKE DETECTOR – A smoke detector that employs more than one smoke detecting principle in one unit. To qualify as a combination smoke detector it is required that each principle either predominate or contribute in response to at least one of the Fire Tests, section 38, or the Smoldering Smoke Test, section 39.

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

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

3.9 PRODUCTION SENSITIVITY – A smoke sensitivity range equal to or less than the limits of the range in Table 30.1 and defines the limits necessary to achieve compliance with all tests in this Standard.

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

- a) The potential between the part and earth ground or any other accessible part is more than 42.4 volts peak and
- b) The continuous current flow through a 1500 ohm resistor connected across the potential exceeds 0.5 milliampere.

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

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- a) The open circuit voltage is more than 42.4 volts peak and the energy available to the circuit under any condition of load including short circuit, results in a current of 8 amperes or more after 1 minute of operation or
- b) A power of more than 15 watts shall only be delivered in an external resistor connected between the two points.

3.12 SENSITIVITY – Relative degree of response of a detector measured in %/foot obscuration (dB/meter obscuration). A high sensitivity denotes response to a lower concentration of smoke than a low sensitivity, under identical smoke build-up conditions.

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

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

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

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

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

In the United States

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

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

4 Detector reliability prediction

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

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4.2 Any component whose failure results in a trouble signal shall not be included in the failure rate calculation.

4.3 A reliable light emitting diode (LED) of a smoke detector employing a photocell-light assembly shall have a predicted failure rate of not greater than 2.5 failures per million hours. See 18.1 and 18.2.

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

5 Installation and operating instructions

5.1 A copy of the installation and operating instructions and related schematic wiring diagrams and installation drawings shall be used as a reference in the examination and test of the detector. For this purpose, a printed edition is not required. It is not prohibited that the information be included in a manual or technical bulletin.

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

CONSTRUCTION

Assembly

6 General

6.1 Remote accessories

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

6.2 Sensitivity indicating means

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

6.2.2 In lieu of 6.2.1, each detector shall be provided with a means for 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 test feature control is permissible, only when no hazardous-voltage parts are exposed or are able to be contacted by the user.

6.2.3 Measuring or indicating means include the use of jacks or terminals for connection of a meter, visual indicators (such as a change in frequency of a pulsing light visible with the detector installed), operation of a mechanical device (such as described in 6.2.4), or any arrangement determined to be equivalent. An instrument used for measuring sensitivity of a detector shall be provided with the following information and features:

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- a) The instrument shall have a measurement capability to determine if the smoke detector is within its production sensitivity range. If the instrument contains a numerical readout, a chart shall be provided with the instrument to indicate the acceptable production sensitivity range of each model of smoke detector that it is capable of testing. A numerical readout in units of percent obscuration per foot requires no chart for conversion.
- b) Instructions shall clearly state the operating temperature range of the instrument.
- c) If a warm-up period is required, the instrument shall clearly state this period.
- d) The instrument shall include the description of the method used to confirm the calibration of the instrument and the period at which re-calibration is required.
- e) The instrument shall have provision to identify its date of last calibration.
- f) The instrument shall have a method of identifying to the user that it is not calibrated, if low batteries, dirty filters, or the like, affect the instrument.

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

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

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

6.3 Radioactive materials

6.3.1 The manufacture, importation, distribution, marking, and disposal of smoke detectors containing radioactive material are subject to the safety requirements of local and federal agencies responsible for the control of these materials.

6.3.2 Documentation verifying compliance with regulating agency requirements is required for listing the detector.

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6.4 Insect guards

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

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

6.5 Supplementary heat detector

6.5.1 When a heat detector is provided integrally with a smoke detector, the requirements are as in 6.5.2 and 6.5.3.

6.5.2 The temperature rating of the heat detector shall not be less than 57°C (135°F).

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

6.6 Alarm verification feature

6.6.1 To reduce the effect of electrical and migratory smoke transients, it is not prohibited that a smoke detector have provision for alarm verification. The alarm verification time shall be 10 to 30 seconds. See 39.2 and 73.1 r).

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

6.6.2 When an alarm verification feature is employed in a detector, a bypass arrangement, readily accessible after installation, shall be provided and shall be resettable after field testing is completed. It is appropriate to include the bypass as part of the sensitivity indicating means described in 6.2.1 – 6.2.5.

Exception: The bypass is not required when the detector complies with the Fire Tests, Section 38, and the Smoldering Smoke Test, Section 39.

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6.7 Maintenance (cleanability)

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

7 Compatibility information

7.1 General

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

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

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

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

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

7.2 Method of evaluation

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

- a) The Dynamic Load Immunity Test, and
- b) The Two-Wire Smoke Detector Compatibility Tests.

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

In the United States, the above tests are specified in the Standard for Control Units for Fire-Protective Signaling Systems, UL 864.

In Canada, the above tests are specified in Control Units for Fire Alarm Systems, ULC-S527.

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7.3 Changes affecting compatibility

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

8 Servicing and Maintenance Protection

8.1 General

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

8.1.2 Manual switching devices may be located or oriented with respect to uninsulated live parts or hazardous moving parts so that manipulation of the mechanism can be accomplished in the normal direction of access if uninsulated live parts or hazardous moving parts are not located in front (in the direction of access) of the mechanism, or not located within 150 mm of any side or behind the mechanism, unless guarded.

8.1.3 In determining compliance with Clause 4.16.2 only uninsulated live parts in circuits above 30 Vrms shall be considered.

8.1.4 An electrical control component, which may require examination, adjustment, servicing, or maintenance while energized (excluding voltage measurements except for jacks or terminals specifically intended for that purpose), shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for electrical service functions without subjecting persons to the likelihood of shock hazard from adjacent uninsulated live parts or to accidental hazard from adjacent hazardous moving parts.

8.1.5 Other arrangements of location of components and/or guarding shall be also acceptable where electrical components are accessible for service as indicated by Clause 4.16.4.

8.1.6 The following are not identified as uninsulated live parts:

- a) Coils of controllers, relays, and solenoids, and transformer windings, when the coils and windings are provided with appropriate insulating overwraps;
- b) Enclosed motor windings;
- c) Terminals and splices with insulation determined to be appropriate; and insulated wire; and
- d) Insulated wire.

8.1.7 An assembled part intended to be removed during installation shall be protected against damage from normal handling.

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9 Enclosure

9.1 General

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

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

9.1.3 All electrical parts of a detector shall be enclosed to reduce the risk of contact with un-insulated live parts. A separate enclosure for field-wiring terminals that are to be enclosed by a back box is not required. An electrical part of a sampling chamber may be exposed if contact with such part does not result in a hazard or affect the operation of the detector or system supervision.

9.1.4 There shall be no rear openings in a smoke detector through which debris or air currents can pass that would affect detector response.

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

9.1.6 Representative detectors shall be subjected to the Smoke Entry (Stack Effect) Test, Section 33.

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

9.1.8 An enclosure shall have provision for the connection of metal-clad cable, non-metallic sheathed cable, or conduit. A detector intended for permanent connection only to a wiring system other than metal-clad cable or conduit shall be marked to indicate the system or systems for which it is suitable. The marking shall be so located that it will be visible when power-supply connections to the detector are made, or may appear on the installation wiring diagram.

Note: An enclosure without provision for such connection may be acceptable if the unit is intended for mounting on an outlet box.

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9.2 Cast metal enclosures

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

Table 9.1
Cast metal enclosures

Use or dimensions of area involved	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	mm	(inch)	mm	(inch)
Area of 155 cm ² (24 square inches) or less and having no dimension greater than 152 mm (6 inches)	1.6	(1/16 ^a)	3.2	(1/8)
Area greater than 155 cm ² (24 square inches) or having any dimension greater than 152 mm (6 inches)	2.4	(3/32)	3.2	(1/8)
At a threaded conduit hole	6.4	(1/4)	6.4	(1/4)
At an unthreaded conduit hole	3.2	(1/8)	3.2	(1/8)
^a The area limitation for metal 1.6 mm (1/16 inch) thick is obtained by the provision of reinforcing ribs subdividing a larger area.				

9.2.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than 3.5 nor more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing can be properly attached.

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

9.3 Sheet metal enclosures

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

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

In Canada – At any point where conduit or metal clad cable is to be attached, sheet metal shall be of such thickness or shall be so formed or reinforced that it will have a stiffness at least equivalent to that of an uncoated, flat, sheet steel having a minimum thickness of 1.6 mm (1/16 inch).

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Table 9.2
Sheet metal enclosures

In the United States											
Maximum dimensions of enclosure				Minimum thickness of sheet metal							
Length or width, mm (inches)		Area, cm ² (inches) ²		Steel, zinc-coated,			Steel, uncoated,			Brass or aluminum,	
				mm	(inch)	GSG	mm	(inch)	GSG	mm	(inch) AWG
305	(12)	581	(90)	0.86	(0.034)	20	0.81	(0.032)	20	1.14	(0.045) 16
610	(24)	2322	(360)	1.14	(0.045)	18	1.07	(0.042)	18	1.47	(0.058) 14
1219	(48)	7742	(1200)	1.42	(0.056)	16	1.35	(0.053)	16	1.91	(0.075) 12
1524	(60)	9678	(1500)	1.78	(0.070)	14	1.70	(0.067)	14	2.41	(0.095) 10
1524	(Over 60)	9678	(Over 1500)	2.46	(0.097)	12	2.36	(0.093)	12	3.10	(0.122) 8
In Canada											
Maximum enclosure dimensions				Minimum thickness of sheet metal							
Length or width (mm)		Area of any surface (cm ²)		Steel Zinc-coated (mm)		Aluminum Uncoated (mm)		Aluminum (mm)		Brass (mm)	
305		580		1.0		1.0		1.2		1.2	
610		2320		1.2		1.2		1.6		1.6	
1220		7740		1.6		1.6		2.0		2.5	
1524		9670		2.0		2.0		2.5		2.5	
Over 1524		Over 9670		2.8		2.8		3.5		3.5	

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

9.3.4 A closure for a hole larger than 35 mm (1-3/8 inch) diameter shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted. See 14.1, Mounting of Components.

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

9.3.6 A knockout shall be provided with a surrounding surface for seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout used during installation does not result in spacings between uninsulated live parts and the bushing of less than those indicated in Spacings, Section 26.

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9.4 Nonmetallic enclosures

9.4.1 An enclosure or parts of an enclosure of nonmetallic material shall be formed so that operating parts are protected against damage. The mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 9.2. See also the Tests on Polymeric Materials, 60.

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

9.4.3 Polymeric material used for an enclosure shall comply with the following requirements:

- a) Enclosures containing parts including a risk of fire – minimum flammability rating of V-0 and successful completion of the Flame Test (5 inch), Section 60.4;
- b) Enclosures containing power limited and Class 3 circuits with a voltage not exceeding 30 volts AC, 42.4 volts-peak, or 60 volts DC – minimum flammability rating of HB and successful completion of the Flame Test (3/4 inch), Section 60.3; and
- c) Enclosures containing circuits powered by sources with energy limited to 15 watts – minimum flammability rating of HB.

9.5 Ventilating openings

9.5.1 Ventilating openings in an enclosure for hazardous-voltage circuits, including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening permits passage of a rod having a diameter of 13 mm (33/64 inch). An enclosure for a fuse(s) or other overload protective device and provided with ventilating openings shall not permit the emission of flame or molten metal. Openings provided which permit cleaning of internal parts shall not permit damage to functional internal components during such cleaning operations.

9.5.2 Perforated sheet metal and sheet metal employed for expanded metal mesh shall be not less than 1.0 mm (0.042 inch) in average thickness, 1.2 mm (0.046 inch) when zinc coated.

9.5.3 When the indentation of the guard enclosure does not alter the clearance between uninsulated live parts and grounded metal so as to reduce spacings below the minimum values required, it is appropriate for 0.5 mm (0.021 inch) expanded metal mesh or perforated sheet metal, 0.6 mm (0.024 inch) when zinc coated, to be employed under the following conditions:

- a) The exposed mesh on any one side or surface of the device so protected has an area of not more than 465 cm² (72² inches) and has no dimension greater than 300 mm (12 inches); and
- b) The width of an opening so protected is not greater than 90 mm (3.5 inches).

9.5.4 The wires forming a screen protecting current-carrying parts shall be not smaller than 16 AWG and the screen openings shall be not greater than 3 cm² (0.465 in²) in area.

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9.5.5 The wires forming a screen employed as a smoke chamber cover shall be not less than 22 AWG for steel and not less than 20 AWG for aluminum.

9.6 Covers

9.6.1 An enclosure cover of a detector shall be hinged, sliding, pivoted, or similarly attached when:

- a) It provides ready access to fuses or any other overcurrent protective device, the intended protective functioning of which requires renewal or
- b) It is required to periodically open the cover in connection with the intended operation of the detector.

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

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

9.6.3 When a detector cover is not intended to be removed for cleaning, maintenance, or both, and the detector is intended to be returned to the factory for servicing, the cover shall be secured so that it cannot be readily removed. Exposed screw slots or nuts, other than a tamper proof type, shall be sealed or covered. See 73.1(r) for marking.

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

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

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

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9.7 Glass panels

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

Table 9.3
Thickness of glass covers

Maximum size of opening				Minimum thickness,	
Length or width,		Area,		mm	(inch)
mm	(inches)	cm ²	(inches ²)		
102	(4)	103	(16)	1.6	(1/16)
305	(12)	929	(144)	3.2	(1/8)
Over 305	(Over 12)	Over 929	(Over 144)	see footnote a	see footnote a
^a 3.2 mm (1/8 inch) or more, based upon the size, shape, and mounting of the glass panel. A glass panel for an opening having an area greater than 929 cm ² (144 square inches), or having any dimension greater than 305 mm (12 inches), shall be supported by a continuous groove not less than 4.8 mm (3/16 inch) deep along all four edges of the panel.					

9.7.2 A transparent material other than glass employed as a cover over an opening in an enclosure shall have mechanical strength equivalent to that of glass, shall not become a fire hazard or distort, and shall not become less transparent at the temperature to which it may be subjected under normal or abnormal service conditions.

9.7.3 A lens, light filter, or similar part of a smoke detector shall be constructed of a material the transparency of which is not impaired by the conditions to which it is exposed in service as represented by the performance tests described in 28 – 67.

10 Corrosion protection

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

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

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

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

10.4 Iron and steel parts, except bearings, and the like, where such protection is impracticable, shall be suitably protected against corrosion by enamelling, galvanizing, sherardizing, plating, or other equivalent means.

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

10.6 Hinges and other attachments shall be resistant to corrosion.

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

11 Field wiring connections

11.1 General

11.1.1 A detector shall be provided with wiring terminals or leads for the connection of conductors corresponding to the electrical rating of the detector and sized in accordance with:

In the United States: National Electrical Code, ANSI/NFPA 70

In Canada: CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations.

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

11.2 Field wiring compartment

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

11.2.2 Protection 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.

11.2.3 The location of an outlet box or compartment in which field wiring connections are to be made shall be such that these connections may be inspected after the detector is installed as intended. The removal of not more than two mounting screws, or equivalent arrangement, to view the field wiring connections, is considered to comply with this requirement.

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11.3 Field wiring terminals and leads

11.3.1 Terminal parts to which field connections are to be made shall ensure good connections under hard usage. The parts to which wiring connections are made shall consist of binding head screws with terminal plates having upturned lugs or the equivalent to hold the wires in position. Other terminal connections may be provided if found to be equivalent. A separate lead or terminal shall be provided for each installation wire.

11.3.2 If a wire binding screw is employed at a field wiring terminal, the size of the screw shall be not less than: 10 if for use with a copper conductor larger than 14 AWG; 8 if for use with a copper conductor of 14 AWG; or 6 if for use with a copper conductor smaller than 24 AWG.

11.3.3 Except as noted in 11.3.4, a terminal plate tapped for a wire binding screw shall be of metal not less than 1.27 mm (0.05 inch) in thickness for a No. 8 or larger screw, and not less than 0.76 mm (0.030 inch) in thickness for a No. 6 screw, and shall have not less than two full threads in the metal.

11.3.4 A terminal plate may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Other constructions may be employed only when they are identified as providing equivalent security.

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

11.4 Field wiring leads

11.4.1 Leads provided for field connections shall not be less than 152 mm (6 inches) long; shall be provided with strain relief; shall not be smaller than 18 AWG (0.82 mm²); and the insulation, when of rubber or thermoplastic, shall not be less than 0.8 mm (1/32 inch) thick. Wire shall be of stranded copper.

11.5 Grounding terminals and leads

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

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

- a) An extra-low voltage detector;
- b) A hazardous-voltage detector provided with an overall nonmetallic enclosure and cover and that is not intended to be internally serviced; or
- c) A hazardous-voltage detector provided with an overall nonmetallic enclosure and cover, and:
 - 1) That does not employ internal dead-metal parts which are energized under a fault condition and be contacted during servicing, or
 - 2) Having internal dead metal parts that are insulated; or
- d) A hazardous-voltage detector provided with an overall nonmetallic enclosure and cover that includes internal dead metal parts which are contacted during servicing, and employs a 2-pole disconnect switch which de-energizes both legs of the supply circuit upon removal of the cover.

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

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

11.6 Grounded supply terminals and leads

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

11.6.2 A field wiring lead provided for connection of the grounded supply conductor 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.

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

11.7 Isolated (nongrounded) detectors

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

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

11.7.3 In Canada, the arrangement described in 11.7.1 is not permitted.

12 Internal Wiring

12.1 General

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

- a) Insulation rated for the potential involved,
- b) Insulation rated for the temperatures to which they are subjected, and

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c) The current-carrying capacity for the service.

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

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

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

12.1.4 Internal wiring of circuits which operate at different potentials shall be reliably separated by barriers or shall be segregated, unless the conductors of the circuits of lower voltage are provided with insulation equivalent to that required for the highest voltage involved. Segregation of insulated conductors may be accomplished by clamping, routing, or an equivalent means, which ensures permanent separation. See 12.4, Barriers.

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

12.2 Wireways

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

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12.3 Splices

12.3.1 All splices and connections shall be mechanically secured and bonded electrically. Tack soldering is permitted where the construction precludes mechanical security only when 5 samples resist a pull-force of 8.9 N (2 lbs) applied for 3 seconds and the connection is subjected to 100 percent inspection and testing with the same pull force by the manufacturer.

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

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

12.4 Barriers

12.4.1 A metal barrier shall have a thickness at least equal to that required by Table 9.2 as determined by the size of the barrier. A barrier of insulating material shall not be less than 0.71 mm (0.028 inch) thick and shall be thicker when it is possible for deformation which defeats its purpose to be easily accomplished. Any clearance between the edge of a barrier and a compartment wall shall not be more than 1.6 mm (1/16 inch).

12.5 Strain relief

12.5.1 A strain relief means shall be provided for the field supply leads and all internally connected wires or cords that are subject to movement in conjunction with the installation, operation, or servicing of a detector to reduce the risk of any mechanical stress being transmitted to internal connections and terminals. Inward movement of the cord or leads provided with a ring-type cord grip shall not damage internal connections or components, or result in a reduction of the electrical spacings required. See the Strain Relief Test, Section 61.

13 Bonding for Grounding

13.1 An exposed non-current-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 power-supply connections. This requirement also applies to a detector equipped with auxiliary function contacts rated at more than 30 Vrms.

13.2 Except as indicated in 13.3, uninsulated metal parts of electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors, and other electrical components shall be bonded for grounding when it is possible that they be contacted by the user or by a serviceman in servicing or operating the equipment.

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

- a) Adhesive attached metal foil markings, screws, and handles, that are located on the outside of the detector enclosure and isolated from electrical components or wiring by grounded metal parts so that they shall not become energized.
- b) Isolated metal parts, such as small assembly screws, that are separated from wiring and uninsulated live parts.

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

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

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

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

Note 1: A bolted or screwed connection that incorporates a star washer under the screw head is considered acceptable for penetrating nonconductive coatings.

Note 2: Where the bonding means depend upon screw threads, two or more screws or two full threads of a single screw engaging metal are considered acceptable. Metal-to-metal hinge-bearing members for doors or covers may be considered as a means for bonding the door or cover for grounding providing that a multiple bearing, pin-type hinge is employed.

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

COMPONENTS

14 General

14.1 Mounting of components

14.1.1 All parts of a detector shall be securely mounted in position and prevented from loosening or turning if such motion may adversely affect the normal performance of the unit, or may affect the fire and accident hazard incident to the operation of the detector.

Exception No. 1: It is not required that a switch be prevented from turning when all four of the following conditions are met:

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

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

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

14.1.3 Uninsulated live parts, for example, field wiring terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they shall not turn or shift in position when such motion results in reduction of spacings below the minimum values required. This is to be accomplished by two screws or rivets, by square shoulders or mortises, by a dowel pin, lug, or offset, by a connecting strap or clip fitted into an adjacent part, or by any method determined to be equivalent.

14.2 Operating components

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

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

14.2.3 Moving parts shall have sufficient play at bearing surfaces to prevent binding.

14.2.4 Manually operated parts shall have sufficient strength to withstand the stresses to which they will be subjected in operation.

14.2.5 An electromagnetic device shall be reliable and ensure positive electrical and mechanical performance under all conditions of normal operation.

14.3 Current-carrying parts

14.3.1 A current-carrying part shall have adequate mechanical strength and current-carrying capacity for the service, and shall be a metal such as silver, copper or copper alloy, or other material, which will provide equivalent performance.

14.3.2 Bearings, hinges, and the like shall not be acceptable for carrying current between interrelated fixed and moving parts.

15 Bushings

15.1 When a lead or wire harness passes through an opening in a wall, barrier, or enclosing case, there shall be a metal or insulating type bushing, or the equivalent, that shall be substantial, secured in place, and have a smooth, rounded surface to provide support for the wire.

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15.2 When the opening is in a phenolic composition or other nonconducting material or in metal of thickness greater than 1.07 mm (0.042 inch) at the opening, a smooth surface having rounded edges is identified as the equivalent of a bushing.

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

15.4 Fiber shall be employed only where:

- a) It is not be subjected to a temperature higher than 90°C (194°F) under normal operating conditions;
- b) The bushing is not less than 1.6 mm (1/16 inch) thick, with a minus tolerance of 0.4 mm (1/64 inch) for manufacturing variations; and
- c) It does not deteriorate in normal ambient humidity conditions.

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

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

16 Electrical Insulating Material

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

Table 16.1
Thickness of flat sheets of insulating material

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

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

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

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

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

16.5 A terminal block mounted on a metal surface which is capable of being grounded shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base to reduce the risk of the parts and the ends of replaceable terminal screws from reducing spacings below the minimum thickness specified in Table 16.1.

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

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

17 Lampholders and Lamps

17.1 Lampholders and lamps shall be rated for the circuit in which they are employed when the detector is operated under any condition of normal service.

17.2 A lampholder shall be installed so that uninsulated live parts other than a screw shell will not be exposed to contact by persons removing or replacing lamps in normal service.

17.3 A lampholder employing a metal shell, such as a screw shell, used in a circuit rated at 30 vrms or greater shall be wired so that the metal shell is connected to an identified (grounded circuit) conductor.

17.4 When more than one lampholder employing a metal shell is provided, the metal shells of all such lampholders shall be connected to the same grounded circuit conductor.

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

17.6 When a detector has more than one lamp, lamp colors are required as follows:

- a) A "power-on" lamp, white or green,
- b) An alarm indicating lamp, red and
- c) A trouble lamp, amber or yellow.

Other colors for the "power-on" lamp shall be used only when the lamp is marked to identify the function.

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

17.8 A means shall be provided to indicate a latched-in alarm condition. The indication shall be red and shall be distinctive from the normal state. If flashing is used, the flash rate shall be no less than 12 flashes per minute in the alarm condition.

18 Photocell Illuminating Lamps and LEDs

18.1 General

18.1.1 A limited life component such as an incandescent lamp, or a light emitting diode (LED) that is used as a light source of a smoke detector photocell light assembly, shall comply with the requirements specified in the Electrical Supervision Test, Section 29.

18.1.2 To be determined reliable, an LED shall comply with 4.3 and shall comply with the requirements specified in 29.3.3 and 29.3.4. In addition, the operating conditions of the LED in the detector circuit, as well as the LED and detector manufacturer's Quality Assurance (QA) Programs, are to be evaluated as to the level of reliability they provide as described in 18.2.

18.1.3 A reliable LED that complies with the requirement specified in 18.1.2 shall additionally comply with the requirements specified in the Reduction in Light Output Test, Section 35, and the electrical supervision requirements described in 29.3.2 – 29.3.5.

18.2 Quality assurance program

18.2.1 LED manufacturer

18.2.1.1 Verification shall be provided by the LED manufacturer to indicate compliance with the following minimum quality assurance program:

- a) Lot sample testing of optical efficiency, anode bond, and chip peel tests are performed on diode chips;
- b) 100% production tests of light output, forward conduction, leakage, and reverse breakdown are performed on the finished product.

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18.2.2 Smoke detector manufacturer

18.2.2.1 The smoke detector manufacturer shall conduct the following minimum quality assurance programme on the LED lamps:

a) All incoming LEDs, in a de-energized condition, are to be subjected to one of the following stress conditions:

1) Ten cycles of temperature variation from minus 40°C to 85°C (minus 40°F to 185°F) with 30 min at each extreme and 5 min between extremes. Each cycle consists of starting at minus 40°C, going to 85°C, and returning to minus 40°C;

2) Exposure for 48 h at the LED Manufacturer's maximum recommended storage temperature;

b) Following the stress conditioning, 100% inspection tests shall be conducted on the following parameters:

1) Light output;

2) Maximum forward voltage drop at specified forward current;

3) Maximum reverse leakage current at specified reverse voltage.

18.2.2.2 The temperature cycling burn-in and component screening may be conducted by the LED manufacturer if each shipment is accompanied by a certificate of compliance verifying its conduction on that shipment. In this case the detector manufacturer need only conduct 100% inspection for light output.

19 Motors

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

19.2 A fan motor shall be protected by thermal or overcurrent protective devices or shall be of the impedance-protected type. See the Locked Rotor Test, Section 57. A thermal or overcurrent protective device shall not open the circuit during the Temperature Test, Section 43.

19.3 A motor employing thermal protection which complies with CSA C22.2 No. 77, Motors with Inherent Overheating Protection, or the Standard for Overheating Protection For Motors, UL 2111, is considered to comply with the requirement of 19.2.

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

20 Protective Devices

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

21 Printed Wiring Boards

21.1 The components of a printed wiring board shall be attached securely and the spacings between circuits shall comply with the spacing requirements of Section 26 for rigidly clamped assemblies (see Table 26.1). The board shall be mounted so that deflection of the board during servicing shall not result

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in damage to the board or in a reduction of electrical spacings below those required in this standard. Printed wiring boards shall comply with the printed-wiring board standard referenced in the country specific appendices.

22 Switches

22.1 A switch provided as part of a unit shall have a current and voltage rating not less than that of the circuit which it controls when the device is operated under any condition of normal service.

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

22.3 When a nonself-restoring switch is employed, a related audible trouble signal is to be obtained from the control unit to which the detector is connected, with the switch in the "off-normal" position.

23 Transformers and Coils

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

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

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

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

24 Dropping Resistors

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

25 Batteries (United States Only)

25.1 General

25.1.1 When a battery or set of batteries is employed as the main source of power for a smoke detector, it shall comply with the requirements of the Battery Tests, Section 66.

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

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

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

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

25.2 Battery connections

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

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

25.2.3 Each lead of a clip-lead assembly employed as a part of a battery operated detector shall not be smaller than 26 AWG (0.21 mm²) stranded wire, and the insulation shall not be less than 0.4 mm (1/64 inch) thick.

26 Spacings

26.1 Spacings shall be maintained between uninsulated live parts and dead metal parts and between uninsulated live parts of opposite polarity. The spacings shall not be less than those indicated in Table 26.1.

26.2 The spacings between an uninsulated live part and:

- a) A wall or cover of a metal enclosure,
- b) A fitting for conduit or metal-clad cable, and
- c) Any dead-metal part

shall not be less than that indicated in Table 26.1.

26.3 The "Through Air" and "Over Surface" spacings of Table 26.1 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.

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26.4 The spacing requirements specified in Table 26.1 do not apply to the inherent spacings inside motors, except at wiring terminals, nor to inherent spacings for a component provided as part of the detector. Such spacings are judged on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete device, including clearances to dead metal or enclosures, shall be as indicated in Table 26.1.

26.5 The "To Walls of Enclosure" spacings of Table 26.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

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

Table 26.1
Minimum spacings

Point of application	Voltage range ^f	Minimum spacings ^{a,b}			
		Through air,		Over surface,	
		mm	(inch)	mm	(inch)
To walls of enclosure					
Cast metal enclosures	0 – 300	6.4	(1/4)	6.4	(1/4)
Sheet metal enclosures	0 – 300	12.7	(1/2)	12.7	(1/2)
Installation wiring terminals					
With barriers	0 – 30	3.2	(1/8)	4.8	(3/16)
	31 – 150	3.2	(1/8)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)
Without barriers	0 – 30	4.8	(3/16)	4.8	(3/16)
	31 – 150	6.4	(1/4)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)
Rigidly clamped assemblies ^c					
100 volt-amperes maximum ^{d,e}	0 – 30	0.8	(1/32)	0.8	(1/32)
Over 100 volt-amperes ^e	0 – 30	1.2	(3/64)	1.2	(3/64)
	31 – 150	1.6	(1/16)	1.6	(1/16)
	151 – 300	2.4	(3/32)	2.4	(3/32)
Other parts	0 – 30	1.6	(1/16)	3.2	(1/8)
	31 – 150	3.2	(1/8)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)

^a An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or similar material employed where spacings are otherwise insufficient shall not be less than 0.71 mm (0.028 inch) thick. When a liner or barrier is used which is less than 0.71 mm (0.028 inch), and not less than 0.33 mm (0.013 inch) thick, it shall be used in conjunction with an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it is not affected adversely by arcing. When insulating material having a thickness of less than that specified is used, it shall be found to be appropriate for the particular application.

^b Measurements are to be made with solid wire of an ampacity that is intended for the applied load connected to each terminal. In no case is the wire to be smaller than 16 AWG (1.3 mm²) in the USA, or 18 AWG in Canada.

^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 0.4 mm (1/64 inch), are appropriate for the connection of integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 0.8 mm (1/32 inch).

^e When spacings between traces on a printed wiring board are less than the minimum specified the boards shall be covered with a conformal coating, and the combination shall be evaluated to the requirements in Conformal Coatings of Printed Wiring Boards, Section 67. In Canada refer to Table 26.2 for minimum spacing requirements.

^f RMS volts for sinusoidal waveform. The equivalent peak voltage should be used for non-sinusoidal waveforms.

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Table 26.2 (In Canada Only)
Minimum over surface spacings on printed wiring boards (see Table 26.1, footnote e)

Voltage (V) ^a	Energy Available (VA)	Spacing (mm)	Coating program
0 – 30	100 VA max.	0.2	I (see 67.1)
0 – 30	Over 100 VA	0.4	I (see 67.1)
31 – 300	Over 100 VA	0.8	II (see 67.2)
Note: The minimum spacings are required between live parts of opposite polarity. Spacings between live parts and dead metal shall comply with Table 26.1.			
^a RMS volts for sinusoidal waveform. The equivalent peak voltage should be used for non- sinusoidal waveforms.			

PERFORMANCE

27 General

27.1 Test units

27.1.1 Detectors that are fully representative of production units are to be used for the tests specified in Sections 28 – 67, unless otherwise specified. The sensitivity setting or range of sensitivities provided on the units for test will define the production sensitivity.

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

27.2 Test voltages

27.2.1 Unless otherwise specified, the test voltage for each test shall be as specified in Table 27.1 and at rated frequency.

Table 27.1
Test voltages

Nameplate voltage rating ^a	Test voltage ^b
110 to 120	120
220 to 240	240
Other	Marked nameplate rating
^a The voltage rating shall be applied at the voltage waveform(s) specified in the markings. See 73.1(e).	
^b Detectors rated at frequencies other than 60 hertz are to be tested at their rated nameplate voltage and frequency.	

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27.3 Test samples and data

27.3.1 The following samples and data are required; the data required in (g) and (h) does not have to be in final printed form:

- a) At least 28 assembled spot type detectors, 12 preset (as close as intended production calibration permits) to the nominal maximum production sensitivity (most sensitive setting), and 16 preset (as close as intended production calibration permits) to the nominal minimum anticipated production sensitivity (least sensitive setting). Four of the 12 units preset to the maximum sensitivity and four of the 16 preset to the minimum sensitivity shall be calibrated so that the sensitivity of any individual unit does not vary more than 25 percent from any other unit in each setting, and shall establish the maximum and minimum sensitivities to be employed in production. Combination smoke detectors are to be provided with means for monitoring each principle of operation during the Sensitivity Test, Section 30. Fewer samples are permitted to be submitted for partial investigations based on a limited test program when agreed to by the testing agency.
 - b) One additional unassembled spot type detector.
 - c) Six photocell and light assemblies of a projected beam type detector.
 - d) Three control units, or three power supplies, or both, when the detectors are intended to be employed only with a specific unit or power supply.
 - e) Five additional samples of detectors that operate on the photoelectric principle, provided with means to reduce the light output as described in 35.2.
 - f) The monitoring instrument, or reference to a readily available instrument, intended to monitor the sensitivity of the detector.
 - g) Installation wiring diagram, operating and maintenance instructions.
- In the United States:
- h) Copy of the Technical Bulletin. See Technical Bulletin, Section 77.
- In Canada:
- i) The following information also applies where applicable, samples of conformal coated printed circuit wiring boards, as required by Sections 26 and 67.

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27.4 Component reliability data

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

27.4.2 The data required by 27.4.1 shall include the following or equivalent information:

- a) Component Fault Analysis. Effect of failure, open and short, of capacitors and limited-life components on operation of a detector.
- b) Maximum supplier's ratings for each component as well as the actual maximum operating values (voltage and current) in the detectors.
- c) A description of component screening and burn-in test data for solid-state devices or integrated circuits that operate at greater than the limits described in note b of Table 43.1.
- d) General description of the detector manufacturer's quality assurance (QA) program. This data shall include incoming inspection and screening, in-process quality assurance, burn-in data, and testing. This applies to complete and partial assemblies as well as individual components.
- e) A general description of the circuit operation under standby, alarm, and trouble conditions.
- f) For a detector employing a reliable LED as the photocell illuminating light source the data specified in the Overload Tests, Section 53.
- g) General calibration procedure of test instruments employed by the manufacturer in the calibration of a detector.
- h) Amount of derating of components under normal standby and alarm conditions.
- i) Component failure rate data at rated values and derated values.

27.5 Remote accessories

27.5.1 Unless specifically indicated otherwise, the applicable performance requirements of this standard shall also apply to any remote accessories with which it is to be employed.

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27.6 Detector guards (United States only)

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

- a) Normal Operation Test (Section 28);
- b) Sensitivity Test (Section 30);
- c) Velocity-Sensitivity Test (Section 32);
- d) Reduction in Light Output Test (Section 35);
- e) Fire Tests (Section 38);
- f) Smoldering Smoke Test (Section 39); and
- g) Audibility Test (Section 64).

28 Normal Operation Test

28.1 General

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

28.1.2 The test voltage is to be in accordance with 27.2.1 and the detector is to be in the standby condition and prepared for its intended signaling operation when it is connected to related devices and circuits.

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

28.1.4 When a heat detector is provided integral with a smoke detector, actuation of the heat detector shall result in the same type of alarm signal as when actuated by smoke as is required by for a smoke detector in 28.1.3.

28.1.5 Neither principle of operation of a combination smoke detector shall be rendered inoperative by any of the Performance Tests (Sections 28 – 67) of this standard. A circuit analysis is to be made, supplemented by electrical measurement when required, to determine that both principles of operation contribute to detector operation.

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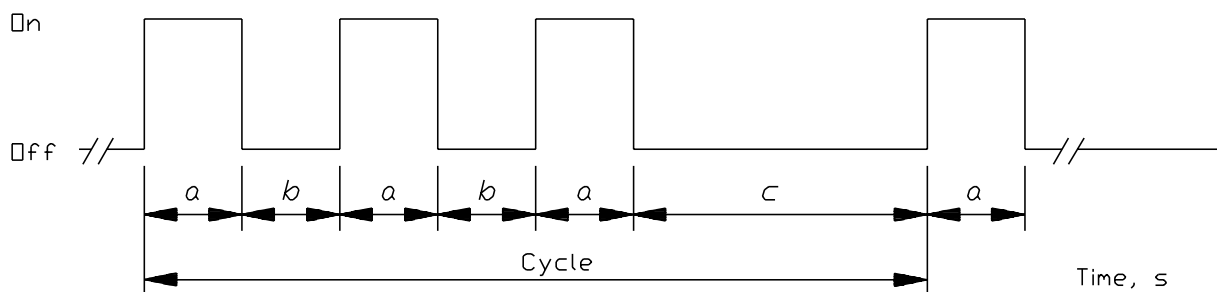
28.1.6 When an audible alarm signaling appliance is provided integral with a smoke detector, the alarm shall be energized by any one of the following conditions:

- a) Operation of the test means,
- b) The smoke detector is activated by the introduction of smoke, or
- c) Reception of an alarm signal from the connected control unit.

28.2 Standardized alarm signal (United States only)

28.2.1 A detector that produces an audible signal which is intended to initiate immediate evacuation from the protected area, shall produce the signal in the form of the "three pulse" temporal pattern shown in Figure 28.1. Each ON phase shall last 0.5 second ± 10 percent followed by an OFF phase of 0.5 second ± 10 percent. After the third of these ON phases, there shall be an OFF phase that lasts 1.5 seconds ± 10 percent. Where the intended action is not immediate evacuation, the audible signal shall produce an alert signal distinctive from the "three pulse" temporal system.

Figure 28.1
Standardized alarm signal temporal pattern
(United States only)



Key

- Phase a signal is "on" for $0.5 \text{ s} \pm 10 \%$
- Phase b signal is "off" for $0.5 \text{ s} \pm 10 \%$
- Phase c signal is "off" for $1.5 \text{ s} \pm 10 \%$ ($c = a + 2b$)
- Total cycle lasts for: $4 \text{ s} \pm 10 \%$

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28.3 Sensitivity shift criteria

28.3.1 During or immediately after performance tests, the sensitivity of the detectors shall not vary more than 0.014 optical density per meter (± 1 percent per foot) obscuration from the value recorded prior to the test. In no circumstance shall the sensitivity of a detector shift outside the sensitivity limits as specified in 30.1.1.

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29 Electrical Supervision Test

29.1 General

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

- a) Single open or single ground fault of the connecting field wiring,
- b) Failure of a non-reliable component. See 3.7,
- c) De-energization of the detector power supply circuit, and
- d) Removal of a separable detector head from its base, unless the head is secured to the base after installation by a means that requires a special tool to release.

29.1.2 The requirements in 29.1.1 do not apply to the following:

- a) Circuits of detectors intended only for releasing device service only if it results in release.
- b) Circuits for trouble-indicating devices.
- c) The neutral of a 3-, 4-, or 5-wire alternating current or direct current light-and-power-supply circuit.
- d) A circuit for a supplementary signal annunciator, signal-sounding appliance, motor controller, or similar appliance, only when a break, short circuit, or ground fault in no way affects the normal operation of the detector other than to result in the omission of the supplementary feature.
- e) A supplementary source of power used as an auxiliary means for maintaining normal operation of a detector when the main supply source is interrupted.
- f) The leads of a trickle-charged battery.

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

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

29.1.5 The operation of any manual switching part of a detector from its "normal" position while the detector is in the standby condition shall be indicated by a trouble signal when the "off-normal" position of the switch interferes with the operation of the detector.

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

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

- a) The detector,
- b) The control unit, or
- c) The power supply to which the detector is connected.

Such faults shall not result in an alarm signal.

29.1.8 Failure of a non-reliable component, which may prevent normal operation, shall be indicated by a trouble signal at the control unit, or a reliable component shall be employed.

29.2 Component Failure

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

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

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

29.2.4 In determining that a detector complies with the requirement with respect to failure of a limited life component, the fault condition, open or short, is to be applied, in turn, with the detector connected to a source of supply in accordance with the requirements in 27.2.1. See also the Abnormal Operation Test, Section 56.

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29.3 Photocell illuminating lamps and LEDs

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

29.3.2 In detectors employing a limited life LED light source, the source shall be monitored for an open, short, or, except as exempted in 29.3.3, 50 percent or greater light degradation, by means of a trouble signal. Failure of the light source shall not result in an alarm signal. See 3.2.

29.3.3 A trouble signal for greater than 50 percent light degradation of a limited life LED is not required when light degradation data is supplied by the LED manufacturer to show that, for the conditions under which it is to be operated, the LED does not reach 50 percent light output at the maximum failure rate prediction described in Section 4, Detector Reliability Prediction.

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

29.3.5 An LED employed as the light source of a photoelectric type detector is not required to be electrically supervised by means of a trouble signal if it is considered to be reliable.

29.4 Battery powered units (United States only)

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

29.4.2 To determine compliance with 29.4.1, three samples are to be equipped with batteries that have been depleted to the trouble signal level. The samples are then to be placed in alarm for 4 minutes. Following the 4 minutes of alarm, the trouble signal shall persist for at least seven consecutive days. It is possible to deplete a fresh battery by applying a 1 percent or smaller loading factor based on the ampere hour rating of the battery. For example, to deplete a 1000 milliampere-hour rated battery, allow a 10 milliampere (1 percent load) or less drain, continuously, until the battery voltage reaches the predetermined test level.

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

29.4.4 To determine compliance with 29.4.3, two samples of a detector that locks in on an alarm mode are to be equipped with batteries that have been depleted and stabilized at a level just above the trouble signal level. The samples are then to be placed in alarm and the battery voltage monitored. The samples shall automatically transfer to a trouble mode when the battery trouble voltage is reached. The trouble signal shall persist for seven consecutive days. When the battery voltage recovers to a point where the trouble signal is no longer emitted, the units are to be placed into alarm again until the trouble signal is reinstituted.

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

29.5 Chamber monitoring

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

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

30 Sensitivity Test

30.1 General

30.1.1 A spot type smoke detector, when calibrated to each end of its production window, shall operate within the limits specified in Table 30.1 when subjected to a smoldering smoke or aerosol buildup condition using the test equipment described in 30.2.1 – 30.4.1 and when subjected to a range of air velocities. The smoke generating method used for this test can be smoldering cotton lamp wick or aerosol generator. Interchangeability between the two methods is acceptable (e.g., conformity assessment testing utilizing a different method than the manufacturer) and shall be so documented in product reports and procedures created to document compliance to this standard. When the detector employs a variable field adjustable sensitivity setting, test measurements are to be made at maximum and minimum detector settings as specified in Table 30.2. The sensitivity measurement is to be made with the detector located in the air stream in the least and most favorable horizontal positions for smoke entry as determined in the Directionality Test, Section 31. When a detector employs alarm verification (see 73.1 (t)), the sensitivity measurements are to be made with and without the alarm verification bypass applied. When a detector evaluated for a special application employs sensitivities outside of the range specified in Table 30.1, it shall have been evaluated using the sensitivities use in the conditions covered by the detector's Technical Bulletin (see Technical Bulletin, Section 77).

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Table 30.1
Visible smoke obscuration limits (gray smoke)

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

Note: Refer to Annex C for the calculation of obscuration and optical density

Table 30.2
Measuring Ionization Chamber (MIC) measurement

United States	Canada
93 pA (maximum) – 37.5 pA (minimum)	Smoke Density* (Relative Measuring Ionization Chamber Units ^a): 0.625 (maximum) – 0.12 (minimum)

*NOTE: Smoke Density X is derived as follows:

$$X = \log_{10} I_0 - \log_{10} I$$

Where:

I_0 is the quiescent chamber current in clean air in pA, and
 I is the reduced chamber current when smoke is present in pA.

^a See Annex A, Clause A4

Refer to Annex C for the calculation of obscuration and optical density

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

- a) Equal to 0.3 m (2 percent per foot) of length of its light beam for lengths of 6.7 m (22 feet) or less,
- b) Not more than 36 percent total obscuration of its light beam for lengths of 6.7 to 13.4 m (22 to 44 feet), and
- c) Equal to 0.3 m (1 percent per foot) of its light beam for lengths of more than 13.4 m (44 feet).

30.1.3 The sensitivity tests are to be conducted as follows:

- a) Spot Type Detector – By means of the test chamber. See Annexes A and B; and
- b) Projected Beam Type Detector – By means of transparencies calibrated in the test chamber.

30.1.4 When the manufacturer's required production control, inspection and test procedures (see 69 and 73) include testing in accordance with the Sensitivity test, then all product conformity testing shall use the same smoke generating method (e.g. aerosol or cotton wick) as specified in the manufacturer's procedures for the Sensitivity test and all related gray smoke/aerosol testing.

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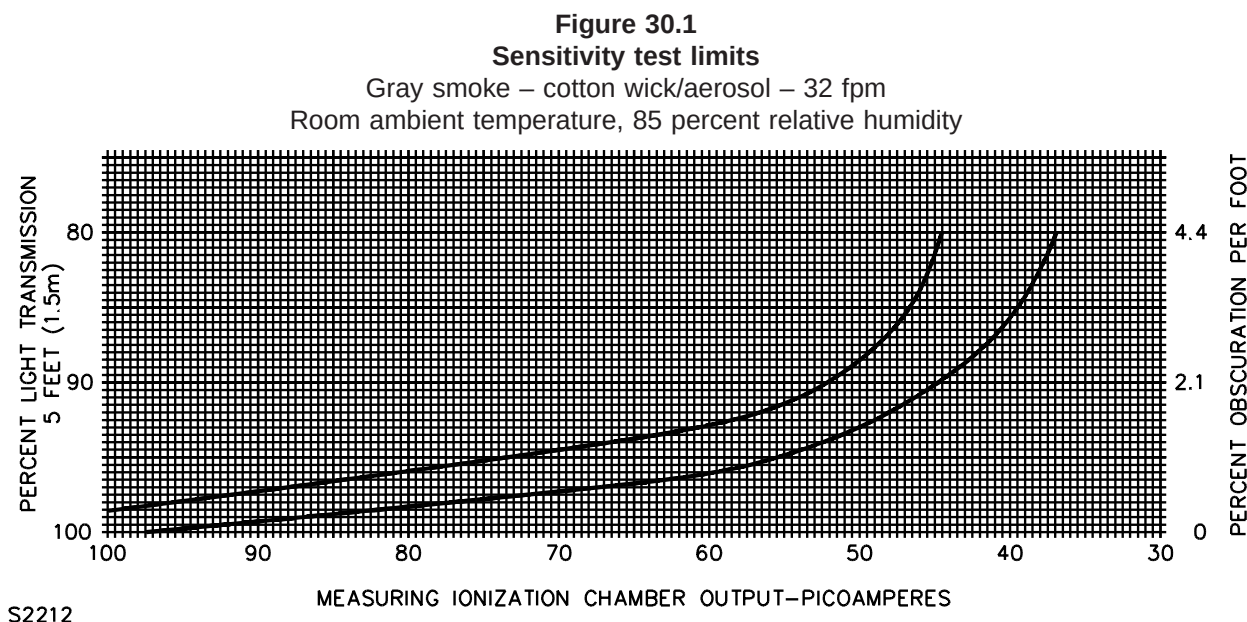
30.2 Combustibles

30.2.1 In the United States: A cotton lamp wick, nominally 3.2 mm (1/8 inch) in diameter, a minimum of 127 mm (5 inches) long and secured by a thin wire inserted through one end, is to be employed as the source of smoke. Prior to use, the wick is to be conditioned at least 72 hours at 45°C (113°F) and 10 percent or less relative humidity. It is then to be stored in a desiccator at room temperature and 10 percent or less relative humidity. The wick end is to be cut square and smoldering initiated by momentarily placing the wick end over a horizontally mounted resistive heater element energized to a dull red color. Upon ignition, it is possible for momentary flaming to occur for 1 second, after which the flame is to be extinguished. The wick is then permitted to smolder a minimum of 30 seconds before being placed in the chamber. The smoldering rate of the wick is to be such that the relationship between the MIC output and the percent light transmission remains within the curves illustrated in Figure 30.1. The visible smoke buildup rate is to be maintained within the limits illustrated in Figure 30.2 outside the test compartment and the smoke permitted to enter through an inverted funnel-pipe arrangement.

30.2.2 In Canada: Smoldering cotton lamp wick, or equivalent, producing a gray smoke having an equivalent particle size distribution shall be used as the actuating medium. The rate of smoke build-up shall be uniform and within the limits as specified in Figure 30.3 and Figure 30.4.

30.3 Aerosol generation equipment (alternate method)

30.3.1 The equipment used shall generate the buildup rates specified in Figures 30.1 and 30.2.



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