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(Revision 2016)**

**STANDARD FOR SMOKE DETECTORS FOR FIRE ALARM
SYSTEMS**

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Seventh Edition

Standard for Smoke Detectors for Fire Alarm Systems

January 11, 2016



ANSI/UL 268-2016

Approved by



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Preface

This is the common UL and ULC Standard for Smoke Detectors. It is the fourth edition of CAN/ULC-S529 and the seventh edition of ANSI/UL 268.

This Joint Standard was prepared by Underwriters Laboratories Inc., ULC Standards, and the NEMA Technical Harmonization Committee on Smoke Alarms and Smoke Detectors. The standard was formally approved by the UL Standards Technical Panel on Smoke Detectors and Alarms; and the ULC Technical Committee on Fire Alarm and Life Safety Equipment and Systems. The efforts and support of the NEMA Technical Harmonization Committee, the UL Standards Technical Panel, and the ULC Technical Committee are gratefully acknowledged.

Only metric SI units of measurement are used in this Standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

This standard has been approved as a National Standard of Canada by the Standards Council of Canada.

This standard has been approved by the American National Standards Institute as an American National Standard.

Annexes A, B, E, F and H are identified as informative and are for informational purposes only. Annexes C & D are identified as normative and forms a mandatory part of this Standard. Annex I is identified as normative for the United States only.

Note: *Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.*

Level of Harmonization

This Standard is published as an equivalent standard for UL and ULC Standards. An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical deviations are allowed for codes and governmental regulations and those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental, climatic, geographical, technological or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is to be word for word except for editorial changes.

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The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

INTRODUCTION

1 Scope

1.1 This Standard sets forth requirements for smoke detectors and accessories, including mechanical guards to be employed in ordinary indoor locations in accordance with the following:

In the United States:

- a) National Fire Alarm and Signaling 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, smoke detector with supplementary heat detection type, combination smoke type, multi-criteria type) as covered by this Standard consists of an assembly of electrical components arranged to detect one or more products of combustion. At a minimum the detector shall contain a smoke (particulate) sensor. The products of combustion may consist of visible as well as invisible smoke particles, gases, heat, radiant energy, and water vapor.. 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, heat sensor, or audible signaling appliance/device, is permitted to be 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 – g):

- 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;

- 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) and/or when part of a multi-criteria smoke detector;
- d) A gas and vapor detector or sensor incorporated as a part of a smoke detector assembly, and covered by the Standard for Gas and Vapor Detectors and Sensors, UL 2075, except when part of a multi-criteria smoke detector;
- e) 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;
- f) 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;
- g) Detectors for monitoring the smoke density within flues or stacks;

In Canada (h – m):

- h) Control units that are covered by the Standard for Control Units for Fire Alarm Systems, CAN/ULC-S527;
- i) Self-contained single and multiple station smoke alarms that are covered by the Standard For Smoke Alarms, CAN/ULC-S531;
- j) 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 and/or when part of a multi-criteria smoke detector;
- k) Fire tests for smoke detectors integral with combination door closers and holders that are covered by the Standard for Door Closers and Holders, ULC/ORD-C228;
- l) Detectors for monitoring the smoke density within flues or stacks; and
- m) A residential CO alarming device incorporated as a part of a smoke detector assembly, and covered by the CAN/CSA 6.19, Standards for Residential CO Alarming Devices, except when part of a multi-criteria smoke detector.

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 for the particular application.

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 generally 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 The metric unit shall be designated as the official unit for purposes of this standard. Where values of measurement are specified in both SI and English units, either unit is used. In cases of dispute, the metric unit shall be used.

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. All undated references shall be interpreted as referring to the latest edition of that document.

UL Standards

UL 94

Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 217

Single and Multiple Station Smoke Alarms

UL 228

Door Closers and Holders

UL 268A

Smoke Detectors for Duct Application

UL 521

Heat Detectors for Fire Protective Signaling Systems

UL 864

Control Units for Fire-Protective Signaling Systems

UL 1730

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

UL 2111

Overheating Protection for Motors

ULC Standards

ULC/ORD-C228,

Door Closers and Holders

CAN/ULC-S524,

Installation of Fire Alarm Systems

CAN/ULC-S527,

Control Units for Fire Alarm Systems

CAN/ULC-S530,

Heat Actuated Fire Detectors for Fire Alarm Systems

CAN/ULC-S531,

Smoke-Alarms

CAN/ULC-S536,

Inspection and Testing of Fire Alarm Systems

CAN/ULC-S537,
Verification of Fire Alarm Systems

CSA Standards

C22.1-12,
Canadian Electrical Code, Part I, Safety Standard for Electrical Installations

CAN/CSA-C22.2 No. 0.17-00,
Evaluation of Properties of Polymeric Materials

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

Other Standards

ANSI/NFPA No. 72,
National Fire Alarm and Signaling Code

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

National Research Council of Canada, National Building Code of Canada 2010

National Research Council of Canada, National Fire Code of Canada, 2010

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 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.

3.4 COMBINATION SMOKE DETECTOR – A smoke detector that employs more than one smoke detecting principle in one unit. The sensor output signals are individually evaluated but not combined to determine when an alarm signal is warranted.

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

3.6 RELIABLE COMPONENT – 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).

3.7 CONFORMAL COATING – A protective covering applied on a printed-wiring board capable of conforming to the configuration of objects coated, used to increase the dielectric voltage-withstand capability between conductors and/or to protect against environmental conditions. Conformal coatings may be used on printed wiring boards where electrical spacing's are insufficient between uninsulated live parts of opposite polarity or between such parts and accessible dead-metal parts.

3.8 DRIFT COMPENSATION – A feature of a smoke detector that monitors and automatically adjusts the detector's smoke sensitivity, example: to the gradual build-up of contaminants in the sensing chamber or degradation of the sensor components.

3.9 END-OF-LIFE SIGNAL – A trouble signal at the control panel or remote display and/or indication on the detector, identifying the specific trouble condition intended to annunciate the device or a component has reached the end of its useful life and should be replaced.

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

3.11 MULTI-CRITERIA SMOKE DETECTOR – A detector comprised of a smoke sensor plus one or more additional sensors such as heat, radiant energy, fire gases, or smoke that operates on different principles. Each sensor in the set is separately monitored for the presence or absence of physical stimuli. The individual signal from each sensor is mathematically evaluated together with the signals from the other sensor(s) to determine when a smoke detector alarm signal is warranted. Aside from this smoke detector alarm signal, the detector may generate other independent alarm signals, such as, but not limited to, a CO alarm, heat alarm, or a flame alarm for which each alarm type complies with the applicable standard.

3.12 PRODUCTION GAS SENSITIVITY – A gas sensitivity range equal to or less than the sensitivity limits determined by the applicable tests required in this Standard. This range is used to verify sensitivity calibration in Section 80.

3.13 PRODUCTION SMOKE SENSITIVITY – A smoke sensitivity range established by the tests in this standard within the limits outlined in Tables 9 and 10 for single criteria smoke detectors. For multi-criteria smoke detectors, smoke sensitivity limits may be provided by the manufacturer. A smoke sensitivity range established by the tests in this Standard within the limits outlined in Table 9, Visible Smoke Obscuration Limits (gray smoke) and Table 10, Measuring Ionization Chamber (MIC) Measurement for single criteria smoke detectors. For multi-criteria smoke detectors, smoke sensitivity limits may be provided by the manufacturer.

3.14 SPECIFIED LIFETIME – For purposes of this standard, "specified lifetime" will be referred to as "lifetime." A continuous period of time specified by the manufacturer, during which the alarm meets the requirements of the standard. The manufacturer will specify the start date of the period as either the date of manufacturer or the fully assembled unit in its final enclosure, or the date the unit is placed into service.

3.15 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 V peak; and
- b) The continuous current flow through a 1500 Ω resistor connected across the potential exceeds 0.5 mA.

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

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

3.17 SMOKE SENSITIVITY – Relative degree of response of a smoke sensor in a smoke detector as measured in percent per meter obscuration (percent per foot obscuration). A high sensitivity denotes response to a lower concentration of smoke than a low sensitivity, under identical smoke build-up conditions.

3.18 SMOKE DETECTOR SENSITIVITY – Relative degree of response of the smoke detector as a whole.

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

3.20 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.

3.21 SMOKE DETECTOR – SPOT TYPE – A single criteria 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.

3.22 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 permissible to provide additional terminals or leads for annunciation or control of supplementary functions.

3.23 SMOKE DETECTOR WITH SUPPLEMENTARY HEAT DETECTION – A smoke detector that responds to excessive concentrations of smoke or heat in compliance with Section 7.5, Supplementary heat sensor and Section 61, Fire Test – Smoke Detector with supplementary heat detection but are not fully compliant with UL 521 and ULC-S530. The sensor output signals are individually evaluated but not combined to determine when an alarm signal is warranted.

3.24 SMOKE SENSOR – Components of a smoke detector that sense particulate.

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

3.26 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 V alternating current (AC) [42.4 V peak or direct-current (DC)], and supplied from a circuit whose power is limited to a maximum of 100 V-A.

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

4 Detector reliability prediction

4.1 Detectors shall be constructed to a maximum failure rate of 4.0 failures per million hours as calculated by a full part stress analysis prediction as described in Section 2.0 of MIL-HDBK 217 or 3.5 failures per million hours as calculated by a simplified parts count reliability prediction as described in Section 3.0 of MIL-HDBK 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 permissible that it be used in lieu of the projected data for the purpose of determining reliability.

4.2 Any component whose failure:

- a) Results in energization of an audible trouble signal, or
- b) Results in energization of a separate visual indication (orange or yellow),
- c) Results in de-energization of a power-on light, or:
- d) Does not affect the normal operation or
- e) Is evaluated by specific performance tests included in this standard,

is not required to be included in the failure rate calculation. Examples include but are not limited to the audible signal appliance, non-compulsory thermostat, test switch, and battery contacts.

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 Section 30 and 19.2.

4.4 An application specific integrated circuit (ASIC) 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 h burn-in test, or equivalent.

4.5 A gas sensor or a gas sensing component supervision system of an alarming device shall be provided with the following:

- a) Reliability data developed using the Military Standardization Handbook, MIL-HDBK 217 or equivalent demonstrating a predicted failure rate of not more than 2.5 failures per million hours operation (see 4.4); or
- b) Supervision of the predicted failure modes other than for loss of electrical continuity; or
- c) If the sensor is automatically and periodically tested for its performance response to the target gas (acceptable proxy gas), and results in a trouble signal when the sensor drifts out of specification, then the sensor can be excluded from the reliability calculation.

4.6 Documentation of the failure modes resulting from aging for the gas sensor in a multi-criteria alarm or the sensing components and identification of failure modes addressed by the supervision system shall be provided. The manufacturer shall submit a test method to render the sensor unresponsive to the test concentrations as specified by the manufacturer if the documentation submitted for the sensor or the sensing components indicates drift in the less sensitive direction. This method shall be used when conducting the Electrical Supervision Test, Section 30. All predicted failure modes shall result in a trouble signal.

4.7 An integral or remote accessory is not required to be included in the reliability prediction except for those components whose failure affects the normal operation of the alarm.

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 permissible 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.

6 Automatic drift compensation for smoke sensing

6.1 Where automatic drift compensation of smoke sensitivity is provided and initiated within the detector, the detector shall initiate a visual trouble condition when drift compensation is no longer capable of making additional adjustments to the smoke sensitivity of the detector. The trouble signal(s) created when reaching the drift compensation limit shall differ from the low battery signal but may be identical or similar to trouble signals for other supervised conditions. The trouble signal shall be activated when the limit of compensation is reached.

6.2 For detectors with adjustable smoke sensitivity settings after automatic drift compensation has occurred, the smoke sensitivity of the detector shall be within 0.5 %/Ft obscuration of the initial smoke sensitivity when tested as described in 32.1 – 32.4.

6.3 For detectors without adjustable smoke sensitivity settings, after automatic drift compensation has occurred, the smoke sensitivity of the detector shall remain within the manufacturer's identified range.

6.4 The compensation shall not adversely affect the operation of the detector. The summation of compensation steps over a 24 h period shall not change the clean-air reference value by more than 50 % of the shift necessary to indicate an alarm signal and shall not impact the smoke sensitivity of the detector as specified in 6.2. Maximum compensation rate of the clean air reference value shall not exceed 5% every 2.4 h.

CONSTRUCTION

Assembly

7 General

7.1 Remote accessories

7.1.1 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.

7.2 Smoke sensitivity indicating means

7.2.1 Each detector shall be provided with a means for measuring or indicating the nominal smoke sensitivity or smoke sensitivity range of the smoke detector, as described in 7.2.3 after it has been installed as intended. Removal of a snap-on cover to gain access to the smoke sensitivity control is permissible, only when no hazardous-voltage parts are exposed or are able to be contacted by the user.

7.2.2 In lieu of 7.2.1, each detector shall be provided with a means for a smoke sensitivity test feature, as described in 7.2.3 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.

7.2.3 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 7.2.4), or any arrangement determined to be equivalent. An instrument used for measuring smoke sensitivity of a detector shall be provided with the following information and features:

- a) The instrument shall have a measurement capability to determine if the smoke detector is within its production smoke sensitivity range. If the instrument contains a numerical readout, a chart shall be provided with the instrument to indicate the acceptable production smoke 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.

7.2.4 The test feature is to verify that the smoke sensitivity of the detector is within its marked range. Unless it is employed on a detector that has other means of measuring its smoke 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.

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

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

7.3 Radioactive materials

7.3.1 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.

7.3.2 Documentation verifying compliance with regulating agency requirements is required.

7.4 Insect guards

7.4.1 A smoke sensor 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 in).

7.4.2 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 in) diameter rod. For nonrigid openings, such as a screen, ten measurements shall be made at different locations by an optical micrometer; five measurements shall be made in each direction (not on diagonal).

7.5 Supplementary heat sensor

7.5.1 When a heat sensor is provided integrally with a smoke detector, the requirements are as in 7.5.2 – 7.5.4, unless the heat sensor is solely used as one of the sensors in a multi-criteria smoke detector.

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

7.5.3 The temperature rating of a heat sensor 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.

7.5.4 A fixed-temperature heat detector shall operate within the temperature tolerance range according to its rating as specified in the operating temperature test of the following standards:

- a) In the United States, the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521; or
- b) In Canada, the Standard for Heat Actuated Fire Detectors for Fire Alarm Systems, CAN/ULC-S530.

7.6 Maintenance (Field Cleaning)

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

- a) Degradation of performance , when tested in accordance with Section 71, Field Service Tests; and
- b) Disturbance of field wiring.

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

8 Compatibility information

8.1 General

8.1.1 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.

8.1.2 It is permissible 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.

8.1.3 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.

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

8.1.5 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.

8.2 Method of evaluation

8.2.1 In accordance with 8.1.1 – 8.1.5, 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 Two-Wire Smoke Detector Compatibility Tests shall be conducted, in accordance with the country specific standards.

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

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

8.3 Changes affecting compatibility

8.3.1 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.

9 Servicing and maintenance protection

9.1 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.

9.2 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.

9.3 In determining compliance with 9.2 only uninsulated live parts in circuits above 30 Vrms shall be considered.

9.4 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.

9.5 Other arrangements of location of components and/or guarding shall be also acceptable where electrical components are accessible for service as indicated by 9.4.

9.6 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 appropriate to the application; and
- d) Insulated wire.

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

10 Enclosure

10.1 General

10.1.1 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.

10.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two shall be evaluated in determining compliance with the requirement specified in 10.1.1.

10.1.3 All electrical parts of a detector shall be enclosed to reduce the risk of contact with uninsulated live parts. A separate enclosure for field-wiring terminals that are intended 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.

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

10.1.5 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.

10.1.6 Representative detectors shall be subjected to the Smoke Entry (Stack Effect) Test, Section 35.

10.1.7 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.

10.1.8 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.

10.2 Cast metal enclosures

10.2.1 The thickness of cast metal used for an enclosure shall be as indicated in Table 1. Cast metal having a thickness 0.8 mm (1/32 in) less than that indicated in Table 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.

10.2.2 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.

10.2.3 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.

10.3 Sheet metal enclosures

10.3.1 The thickness of sheet metal employed for the enclosure of a detector shall not be less than that indicated in Table 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.

10.3.2 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 in) when of uncoated steel, not less than 0.86 mm (0.034 in) when of galvanized steel, and not less than 1.14 mm (0.045 in) 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 in).

10.3.3 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 in) or 0.81 mm (0.032 in) nonferrous metal for a hole having a 34.9 mm (1-3/8 in) diameter maximum dimension.

10.3.4 A closure for a hole larger than 35 mm (1-3/8 in) 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 15.1, Mounting of Components.

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

10.3.6 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 27.

10.4 Nonmetallic enclosures

10.4.1 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 2. See also the Tests on Polymeric Materials, Section 66.

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

10.4.3 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 5VA or V-0 and compliance with the 127-mm (5-in) Flame Test, Section 66.4.
- b) Enclosures containing power limited circuits with a voltage not exceeding 30 V AC, 42.4 V-peak, or 60 V DC - minimum flammability rating of V-2 or HB and successful completion of the 19 mm (3/4 in) Flame Test, Section 66.3; and
- c) Enclosures containing circuits powered by sources with energy limited to 15 W - minimum flammability rating of HB.

Flammability ratings are defined: in the United States in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; and in Canada in CAN/CSA-C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials.

10.5 Ventilating openings

10.5.1 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 in). 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.

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

10.5.3 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 permissible for 0.5 mm (0.021 in) expanded metal mesh or perforated sheet metal, 0.6 mm (0.024 in) 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 (72 in²) and has no dimension greater than 300 mm (12 in); and
- b) The width of an opening so protected is not greater than 90 mm (3.5 in).

10.5.4 The wires forming a screen protecting current-carrying parts shall be not smaller than 16 AWG (1.3 mm²) and the screen openings shall be not greater than 3 cm² (0.465 in²) in area.

10.5.5 The wires forming a screen employed as a smoke chamber cover shall be not less than 22 AWG (0.3 mm²) for steel and not less than 20 AWG (0.5 mm²) for aluminum.

10.6 Covers

10.6.1 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.

10.6.2 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.

10.6.3 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 81.1(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.

10.6.4 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."

Note: In Canada, there are two official languages, French and English. Attention is drawn to the fact that some Canadian authorities may require markings to be in both official languages. Annex G lists acceptable French translations of the markings specified in this standard.

10.6.5 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.

10.7 Glass panels

10.7.1 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 3.

10.7.2 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.

10.7.3 A lens, light filter, or similar part of a smoke detector shall be constructed of a material the transparency of which is not impaired by the conditions to which it is exposed in service as represented by the performance tests described in Sections 29 – 72.

11 Corrosion protection

11.1 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.

11.2 The requirement of 11.1 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.

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

11.4 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.

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

11.6 Hinges and other attachments shall be resistant to corrosion.

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

12 Field wiring connections

12.1 General

12.1.1 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:

- a) In the United States: National Electrical Code, ANSI/NFPA 70
- b) 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 permissible that a common terminal be used in lieu of duplicate terminals when it is intended to prevent the looping of an unbroken wire around or under a terminal screw in a manner that permits the looped wire to remain unbroken during installation, thereby precluding monitoring in the event the wire becomes dislodged from under the terminal. A notched clamping plate under a single securing screw, where separate conductors are intended to be inserted in each notch, is an equivalent arrangement. When duplicate terminals or leads are used and there is no provision to prevent looping an unbroken wire around or under one terminal, the marking in 83.1.2(c) shall be provided.

12.2 Field wiring compartment

12.2.1 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.

12.2.2 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.

12.2.3 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.

12.3 Field wiring terminals (general)

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

a) 12.3.2 – 12.3.5;

United States Use Only:

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

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

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

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

Canada Use Only:

f) CSA C22.2 No. 153, Quick-Connect;

g) CSA C22.2 No. 65, Standard for Wire Connectors;

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

i) CSA C22.2 No. 158, Terminal Blocks, rated for field-wiring (FW) Code 2 applications and also suitable for the voltage, current, wire range, and wire type of the intended application.

12.3.2 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 10 AWG (5.3 mm²) and larger wires. When the connectors or lugs are secured to a plate, the plate thickness shall not be less than 0.050 in (1.3 mm) thick. Securing screws of plated steel have been determined to meet the requirements.

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

Exception: A No. 6 (3.5 mm) diameter screw is appropriate for use for the connection of a 14 AWG (2.1 mm²) and a No. 4 (2.8 mm) diameter screw is appropriate for use for the connection of a 19 AWG (0.65 mm²) or smaller conductor.

12.3.4 Terminal plates tapped for wire-binding screws shall:

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

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

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

12.4 Special field-wiring terminals (qualified application)

12.4.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in 12.4.2 are met:

- a) Quick-Connect Terminals – Nonferrous, quick-connect (push-type) terminals consisting of male posts permanently secured to the device and provided with compatible, female connectors for connection to field wiring. These require a special tool for crimping of field wires. Mating terminals shall be shipped with the control unit with instructions for their installation;
- b) Push-In Terminals – Nonferrous (screwless), push-in terminals of the type used on some switches and receptacles. Solid conductors are pushed into slots containing spring-type contacts. The leads are removable by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals are not to be used with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used; and
- c) Other Terminals – Other terminal connections are not prohibited when determined to be equivalent to item a and b and are limited to the same restrictions.

12.4.2 Any of the terminal configurations listed in 12.4.1 are appropriate for connection of field wiring provided all of the following indicated conditions are met.

- a) When a special tool is required for connection, it shall be provided and its use indicated on the installation wiring diagram by name of the manufacturer and the model number or equivalent.
- b) The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size to be used shall not be less than 26 AWG (0.13 mm²) for a jacketed, multi-conductor cable or 18 AWG (0.82 mm²) for a single conductor wire.
- c) The wire size to be used shall be rated for the current-carrying capacity of the circuit application.
- d) The special field-wiring terminal assembly shall comply with the strain relief test as outlined in 67.2.

12.5 Field wiring leads

12.5.1 Leads provided for field connections shall not be less than 152 mm (6 in) 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 in) thick. Wire shall be of stranded copper.

12.6 Grounding terminals and leads

12.6.1 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.

12.6.2 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:
 - i) That does not employ internal dead-metal parts which are energized under a fault condition and be contacted during servicing, or
 - ii) 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.

12.6.3 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 14.

12.6.4 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," «Terre, Mise à la terre» 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 be removed during servicing of the detector.

Note: In Canada, there are two official languages, French and English. Attention is drawn to the fact that some Canadian authorities may require markings to be in both official languages. Annex G lists acceptable French translations of the markings specified in this standard.

12.7 Grounded supply terminals and leads

12.7.1 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.

12.7.2 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.

12.7.3 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 over-current (not thermal) protective device.

12.8 Isolated (nongrounded) detectors

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

12.8.2 The arrangement described in 12.8.1 is permitted only on a detector intended for connection to a low-voltage circuit. In addition, the word "CAUTION" «MISE EN GARDE» and the following or equivalent marking is to be displayed in letters at least 3.2 mm (1/8 in) 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." «INSTALLER ENCEINTE ISOLE DE LA TERRE SELON LES INSTRUCTIONS ET MATERIELS DU CONSTRUCTEUR PREVUE. TERRE POURRAIT ENTRAINER UNE FAUSSE ALARME».

13 Internal wiring

13.1 General

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

- a) Insulation rated for the potential involved,
- b) Insulation rated for the temperatures to which they are subjected, and
- c) The current-carrying capacity for the service.

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

13.1.2 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.

13.1.3 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 permissible 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 in) diameter or less shall not be less than 0.43 mm (0.017 in). 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 in).

13.1.4 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 13.4, Barriers.

13.1.5 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.

13.2 Wireways

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

13.3 Splices

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

13.3.2 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.

13.3.3 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.

13.4 Barriers

13.4.1 A metal barrier shall have a thickness at least equal to that required by Table 2 as determined by the size of the barrier. A barrier of insulating material shall not be less than 0.71 mm (0.028 in) 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 in).

13.5 Strain relief

13.5.1 A strain relief means shall be provided for the field supply leads, battery 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 67.

14 Bonding for grounding

14.1 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.

14.2 Except as indicated in 14.3, 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.

14.3 Metal parts as described below are not required to comply with the requirement specified in 14.2:

- a) Adhesive attached metal foil markings, screws, and handles, that are located on the outside of the detector enclosure and isolated from electrical components or wiring by grounded metal parts so that they shall not become energized.
- b) Isolated metal parts, such as small assembly screws, that are separated from wiring and uninsulated live parts.
- c) Panels and covers which do not enclose uninsulated live parts, when wiring is positively separated from the panel or cover so that it shall not become energized.
- d) Panels and covers which are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 0.8 mm (1/32 in) thick and secured in place.

14.4 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.

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

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

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

Components

15 General

15.1 Mounting of components

15.1.1 All parts of a detector shall be securely mounted in position and prevented from loosening or turning.

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

- a) The switch is 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 switch mounting means is constructed so that it is not loosened by the switch operation.*
- c) The spacings are not reduced below the minimum required values when the switch rotates.*
- d) The operation of the switch is by mechanical means rather than by the direct contact by persons.*

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

15.1.2 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 permissible.

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

15.2 Operating components

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

15.2.2 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 permissible.

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

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

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

15.3 Current-carrying parts

15.3.1 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.

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

16 Bushings

16.1 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.

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

16.3 Ceramic materials and some molded compositions are permissible for insulating bushings, separate bushings of wood and of hot-molded shellac are prohibited.

16.4 Fiber shall be employed only where:

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

16.5 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.

16.6 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 in) thick and completely fills the space between the grommet and the metal in which it is mounted.

17 Electrical insulating material

17.1 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.

17.2 Polymeric materials shall be used for the sole support of uninsulated live parts only when determined to be equivalent to the materials indicated in 17.1.

17.3 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.

17.4 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 4.

17.5 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 4.

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

17.6 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 in).

18 Lampholders and lamps

18.1 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.

18.2 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.

18.3 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.

18.4 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.

18.5 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.

18.6 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.

When the "power-on" lamp is of a different color it shall be marked to identify the function.

18.7 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 be permitted.

18.8 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.

19 Photocell illuminating lamps and light emitting diodes (LEDs) – Quality assurance program

19.1 Light emitting diode (LED)

19.1.1 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.

19.2 Smoke detector manufacturer

19.2.1 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, shall 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.

19.2.2 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.

20 Motors

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

20.2 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 63. A thermal or overcurrent protective device shall not open the circuit during the Temperature Test, Section 47.

20.3 A motor employing thermal protection is considered to comply with the requirement of 20.2. when evaluated to the following standards:

- a) In Canada, CSA C22.2 No. 77, Motors with Inherent Overheating Protection,
- b) In the United States, the Standard for Overheating Protection For Motors, UL 2111.

20.4 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.

21 Protective devices

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

22 Printed wiring boards

22.1 The components of a printed wiring board shall be attached securely and the spacings between circuits shall comply with the spacing requirements of Section 27 for rigidly clamped assemblies [see Table 5 (United States or Table 6 (Canada)]. The board shall be mounted so that deflection of the board during servicing shall not result in damage to the board or in a reduction of electrical spacings below those required in this standard. Printed wiring boards shall comply with the printed-wiring board standard referenced in the country specific annexes.

23 Switches

23.1 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.

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

23.3 When a nonself-restoring switch is in the "off-normal" position, a trouble signal is to be communicated to the control unit.

24 Transformers and coils

24.1 A transformer shall meet the requirements of the following:

- a) In Canada, C22.2 No. 66-1988 (R2001) Specialty Transformers
- b) In the United States, Transformers, Specialty, UL 506

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 12.6.1 and 12.6.2.

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

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

25 Dropping resistors

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

26 Batteries

26.1 General

26.1.1 When a battery or set of batteries is employed as the main source of power for a smoke detector, it shall comply with the requirements of the Battery Tests, Section 72.

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

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

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

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

26.2 Battery connections

26.2.1 A lead or terminal assembly connection to a battery shall be provided with strain relief and shall be identified with the proper polarity (plus or minus signs) unless the intended connection is determined by the terminal configuration. It is permissible for polarity to be indicated on the unit adjacent to the battery terminals or leads.

26.2.2 Connections to battery terminals shall be either by a lead terminating in a positive snap-action type of clip, or a fixed butt-type connection that applies a minimum of 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.

26.2.3 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 in) thick.

27 Spacings

27.1 Spacings shall be maintained between uninsulated live parts and dead metal parts and between uninsulated live parts of opposite polarity. The spacings shall not be less than those indicated in Table 5 for the United States and Table 6 for Canada.

27.2 The spacings between an uninsulated live part and:

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

shall not be less than that indicated in Table 5 (United States Only) or Table 6 (Canada Only).

27.3 The "Through Air" and "Over Surface" spacings of Table 5 (United States Only) or Table 6 (Canada Only) measured at an individual component part shall be judged on the basis of the volt-amperes used and controlled by the individual component. However, the spacing from one component to another, and from any component to the enclosure or to other uninsulated dead metal parts, excluding the component mounting surface, shall be judged on the basis of the maximum voltage and total volt-ampere ratings of all components in the enclosure.

27.4 The spacing requirements specified in Table 5 (United States Only) or Table 6 (Canada Only) 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 5.

27.5 The "To Walls of Enclosure" spacings of Table 5 (United States Only) or Table 6 (Canada Only) are not to be applied to an individual enclosure of a component part within an outer enclosure.

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

PERFORMANCE

28 General

28.1 Test units

28.1.1 Detectors that are fully representative of production units shall be used for the tests specified in Sections 29 – 73, unless otherwise specified. The sensitivity setting or range of sensitivities of the detectors provided for test will define the production smoke sensitivity (single and multi-criteria detectors) and production gas sensitivity, for multi-criteria detectors.

28.1.2 The devices employed for testing shall 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.

28.2 Accessories

28.2.1 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. For example, but not limited to:

- a) Normal Operation Test, Section 29;
- b) Circuit Measurement Test, Section 45;
- c) Temperature Test, Section 47;
- d) Overload Test, Section 58;
- e) Endurance Test, Section 59;
- f) Variable Ambient Temperature Test, Section 51 and Humidity Test, Section 52;
- g) Transient Tests, Section 55;
- h) Dielectric Voltage-Withstand Test, Section 64;
- i) Overvoltage and Undervoltage Tests, Section 46;
- j) Jarring Test, Section 50;
- k) Audibility Test, Section 70;
- l) Tests on Polymeric Materials, Section 66;