

STANDARD FOR SMOKE ALARMS

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STANDARD FOR SMOKE ALARMS

PREFACE

This is the Third Edition of the Standard for Smoke Alarms, CAN/ULC-S531.

This Edition of the Standard has been formally approved by the ULC Standards Committee on Fire Alarm and Life Safety Equipment and Systems.

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.

Annexes A through F, identified as Informative, are for information purposes only.

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 Third Edition National Standard of Canada is based on, and now supersedes, the Second Edition.

Attention is drawn to the possibility that some of the elements of this Canadian standard may be the subject of patent rights. ULC Standards shall not be held responsible for identifying any or all such patent rights.

Requests for interpretation of this Standard should be sent to ULC Standards. The requests should be worded in such a manner as to permit a “yes” or “no” answer based on the literal text of the requirement concerned.

The initiation of the review of this Standard will commence within 5 years of the date of publication, unless the Standard is identified as fitting within a stabilized category, whereby the review will commence within the appropriate time frame set out by ULC Standards.

This Standard is intended to be used for conformity assessment.

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INTRODUCTION

1 Scope

1.1 These requirements cover electrically operated single and multiple station smoke alarms intended for open area protection in indoor locations, in accordance:

- a) Installation of Smoke Alarms, CAN/ULC-S553;
- b) National Building Code of Canada; and
- c) National Fire Code of Canada.

1.2 A single station smoke alarm (e.g. ionization-type, photoelectric-type, smoke alarm with supplementary heat detection type, combination smoke type, multi-criteria type), as defined by these requirements, is a self-contained fire alarm device that consists of an assembly of electrical components including a smoke sensor / chamber, alarm sounding appliance, and provision for connection to a power supply source, either by splice leads, terminals, a cord and plug arrangement or containing integral batteries to detect one or more products of combustion. The products of combustion may consist of visible as well as invisible smoke particles, gases, heat, radiant energy, and water vapor. Additional functionality such as, a supplemental heat detector, terminals for connection to a remote audible signaling appliance (device) or accessory, and an integral transmitter to energize a remote audible signaling appliance (device) is permitted to be incorporated as part of the smoke alarm assembly.

1.3 Smoke alarms not intended for interconnection are defined as single-station type.

1.4 Multiple station units are single station smoke alarms that are:

- a) interconnected so that actuation of one results in alarm sounding by all interconnected smoke alarms , or
- b) smoke alarms that are connected to remote heat detectors or heat alarms (thermostats).

1.5 These requirements, where applicable, also cover all remote accessories that are to be connected.

1.6 This standard does not cover the following:

- a) Smoke detectors of the non-self-contained type that are intended for connection to a household or industrial system control unit. These are included in ULC-S529, Smoke Detectors for Fire Alarm Systems.
- b) Mechanically operated single and multiple station fire alarm devices that are specified in ULC-ORD-C539, Single and Multiple Station Heat Alarms.
- c) Heat detectors [except for the requirements in the Fire Test smoke alarm with heat detection (Heat Detector), Section 64] incorporated as part of a single station smoke alarm assembly whose requirements are covered in the CAN/ULC-S530, Heat Actuated Fire Detectors for Fire Alarm Systems and/or when part of a multi-criteria smoke alarm.
- d) An accessory that is provided with a means to transmit alarm signals to a constantly attended, remote monitoring location. Any accessory capable of transmitting these types of signals is covered by the requirements in CAN/ULC-S545, Residential Fire Warning System Control Units.

- e) A gas and vapor detector or sensor incorporated as a part of a smoke alarm assembly, and covered by CSA 6.19-01 (R2006), Standard for Carbon Monoxide Alarming Devices, except when part of a multi-criteria smoke alarm.

2 General

2.1 Assembly

2.1.1 A smoke alarm 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 smoke alarm shall comply with the requirements for that component, except that such requirements may be modified if appropriate for the particular application.

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

2.2 Components

2.2.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Annex D, Standards for Components, 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 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 The documents shown below are referenced in the text of this Standard. Unless otherwise stated elsewhere in this Standard such reference shall be considered to indicate the edition and/or revisions of the document available at the date on which the Committee approved this ULC Standard.

Documents Published by the American Society for Testing and Materials (ASTM)
100 Barr Harbour Drive, PO Box C700, West Conshohocken, PA 19428-2959 U.S.A.
Telephone: (610) 832-9585
www.astm.org

- ASTM B117-11, Standard for Salt Spray (Fog) Testing
 - ASTM MNL12, Manual on the Use of Thermocouples in Temperature Measurement – Edition 4, 1993.01.01
-

Documents Published by CSA Group

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- CAN/CSA C22.2 No. 0.17-02, Evaluation of Properties of Polymeric Materials
 - CAN/CSA 6.19-01 (R2006), Standard for Residential Carbon Monoxide Alarming Devices
 - CSA C22.1-12, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations
 - CSA C22.2 No. 17-00 (R2013), Standard for Evaluation of Properties of Polymeric Materials
 - CSA C22.2 No. 65-13, Standard for Wire Connectors
 - CSA C22.2 No. 153-09, Standard for Electrical Quick-Connect Terminals
 - CSA C22.2 No. 158-10, Standard for Terminal Blocks
 - C22.2 No. 77-95 (R2009), Standard for Motors with Inherent Overheating Protection
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Documents Published by the Department of Defense (DoD)

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- MIL-HDBK-217F(2) – February 28, 1995 Reliability Prediction of Electronic Equipment
 - MIL-STD-750E – January 3, 2012 Test Methods for Semiconductor Devices
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- ANSI/IEEE C62.41, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
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- CAN/ULC-S530-91, Heat Actuated Fire Detectors for Fire Alarm Systems
- CAN/ULC-S540-13, Residential Fire and Life Safety Warning Systems: Installation, Inspection, Testing and Maintenance
- CANULC-S552-02, Inspection, Testing and Maintenance of Smoke Alarms
- CAN/ULC-S553-02, Installation of Smoke Alarms
- ULC-S529-09, Smoke Detectors for Fire Alarm Systems
- ULC-ORD-C539-14, Single and Multiple Station Heat Alarms

3 Glossary

For the purpose of this standard the following definitions apply.

3.1 COMBINATION SMOKE ALARM – A smoke alarm 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.

3.2 COMPONENT, LIMITED-LIFE – A component which is likely to fail during the anticipated service life of a smoke alarm and be periodically replaced and the failure of which 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.

3.3 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 h as determined for a "Ground Fixed" (GF) environment by MIL-HDBK 217, or equivalent (see Annex D, Reliability Prediction and Criteria for Acceptance).

3.4 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.

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

3.6 END-OF-LIFE-SIGNAL – An audible signal, differing from the alarm signal, intended to indicate that the device has reached the end of its useful life and should be replaced. It is permitted for the audible component of the signal to be of the same format as a trouble signal, provided a visual indicator is employed to differentiate between the end-of-life and other trouble conditions.

3.7 GAS SENSITIVITY – Relative degree of response of gas sensor(s) that are used within the multi-criteria smoke alarm as defined by the manufacturer and verified by the tests required in this Standard.

3.8 HEAT ALARM, SINGLE STATION – A self-contained fire alarm system comprising of a heat alarm, an alarm sounding device, and a stored energy source (wound spring) incorporated in one integral package.

3.9 HEAT DETECTOR – A device that detects an abnormal high temperature or rate of temperature rise.

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 alarm.

3.11 MULTI-CRITERIA SMOKE ALARM – An alarm 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 alarm signal is warranted. Aside from this smoke alarm signal, the smoke alarm 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 83, Sensitivity Calibration Tests.

3.13 PRODUCTION SMOKE SENSITIVITY – A smoke sensitivity range established by the tests in this Standard within the limits outlined in Table 6, Visible Smoke Obscuration Limits (gray smoke/aerosol), and Table 7, Measuring Ionization Chamber (MIC) Measurement, for single criteria smoke alarms. For multi-criteria smoke alarms, smoke sensitivity limits may be provided by the manufacturer.

3.14 RISK OF ELECTRIC SHOCK – A risk of electric shock is determined to exist at any part, when:

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

3.15 RISK OF FIRE – A risk of fire is determined to exist at any point in a circuit where:

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

3.16 SMOKE ALARM SIGNAL – An audible signal intended to indicate an emergency fire condition.

3.17 SMOKE ALARM ACTIVATION – An audible signal that lasts at least 5 s.

3.18 SMOKE ALARM SENSITIVITY – Relative degree of response of the smoke alarm as a whole.

3.19 SMOKE ALARM WITH SUPPLEMENTARY HEAT DETECTION – A smoke alarm that responds to excessive concentrations of smoke or heat in compliance with Clause 13.6, Supplementary Heat Sensor, and Section 65, Fire Test – Smoke Alarm With Supplementary Heat Detection. The sensor output signals are individually evaluated but not combined to determine when an alarm signal is warranted.

3.20 SMOKE SENSITIVITY – Relative degree of response of a smoke sensor in a smoke alarm as measured in % / m obscuration (% / ft obscuration). A high sensitivity denotes response to a lower concentration of smoke than a low sensitivity, under identical smoke build-up conditions.

3.21 SMOKE SENSOR / CHAMBER – Components of a smoke alarm that sense particulate.

3.22 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 this 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.

3.23 TRANSCEIVER – A device capable of transmitting and receiving wireless signals.

3.24 TROUBLE SIGNAL – A visible or audible signal intended to indicate a fault or trouble condition.

3.25 VOLTAGE CLASSIFICATION– Unless otherwise indicated, all voltage and current values specified in this standard are rms:

- a) Extra-Low-Voltage Circuit – A circuit that has an ac voltage of not more than 30 V alternating current (ac) (42.4 V peak) and maximum power of 100 V•A, such as supplied by a Class 2 transformer; or a circuit of not more than 30 V direct current (dc) supplied by a primary battery; or a circuit supplied by a combination of a transformer and fixed impedance, that as a unit, complies with all the performance requirements of a Class 2 transformer. A circuit that is derived from a supply circuit of more than 30 V by connecting resistance or impedance, or both, in series with the supply circuit to limit the voltage and current, is not identified as an extra-low-voltage circuit.
- b) Hazardous-Voltage Circuit – A circuit having characteristics in excess of those of an extra-low-voltage circuit.

3.26 WATERTIGHT – A product that is constructed to prevent water from entering the enclosure under any condition other than submersion.

4 Smoke Alarm Reliability Prediction

4.1 Smoke alarms shall be constructed to a maximum failure rate of 4.0 failures per million h as calculated by a full part stress analysis prediction as described in Section 2.0 5 through Section 23 of MIL-HDBK 217F or 3.5 failures per million h as calculated by a simplified parts count reliability prediction as described in Appendix A of MIL-HDBK 217F, or equivalent. See Annex C, Reliability Prediction and Criteria for Acceptance. 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), or
- 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, battery contacts and functional light source (LED or IRLED) that is supervised for light degradation as well as additional failures as specified within this standard and/or as identified by the manufacturer.

4.3 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.

4.4 A reliable light emitting diode (LED) of a single station smoke alarm employing a photocell-light assembly shall have a predicted failure rate of not greater than 2.5 failures per million h.

4.5 An application specific integrated circuit (ASIC) employed in a smoke alarm shall have a predicted failure rate of not greater than 2.5 failures per million h. The failure rate is to be determined through evaluation of data in a 3000 h burn-in test, or equivalent.

4.6 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 217H or equivalent demonstrating a predicted failure rate of not more than 2.5 failures per million h operation (see 4.5) or
- b) Supervision of the predicted failure modes other than for loss of electrical continuity.
- 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.

4.7 Documentation of the failure modes resulting from aging for the sensor 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 37. All predicted failure modes shall result in a trouble signal.

4.8 Integral transceiver and related components used for non-supervised, wireless interconnected alarms are required to be included in the reliability prediction.

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 smoke alarm. For this purpose, a printed edition is not required. The information is to be included in a homeowner's manual. See Section 91, Marking, General; and Section 92, Instructions, General.

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 smoke alarm.

6 Automatic Drift Compensation For Smoke Sensing

6.1 Where automatic drift compensation of smoke sensitivity is provided and initiated within the smoke alarm, the alarm shall initiate a visual and/or audible trouble condition when drift compensation is no longer capable of making additional adjustments to the smoke sensitivity of the smoke alarm. 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 alarms with adjustable smoke sensitivity settings, after automatic drift compensation has occurred, the smoke sensitivity of the smoke alarm shall be within 1.6 %/m (0.5 % / Ft) obscuration of the initial smoke sensitivity when tested as described in Clauses 38.5.1 – 38.5.4.

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

6.4 The compensation shall not adversely affect the operation of the smoke alarm. The magnitude of each compensation step shall not change the clean-air reference value by more than 5 % of the shift necessary to initiate an alarm signal. The summation of compensation steps over a twenty-four 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 smoke alarm as specified in Clause 6.2.

7 Non-Fire Alarm Feature

7.1 A non-fire alarm feature, such as a carbon monoxide detector, shall be used in common with a single or multiple station smoke alarm or both, or an accessory only when it does not degrade or interfere with operation of the smoke alarm or accessory and complies with all the requirements of this standard. See Clauses 4.3 and 34.1.9.

8 Smoke Sensitivity Indicating Means (Optional)

8.1 This requirement applies to end product installation smoke alarms that are provided with a means for measuring or indicating the nominal sensitivity or a sensitivity range, as described in Clause 8.2. 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.

8.2 The measuring or indicating instrument may include the use of jacks or terminals for the connection of a meter, visual indicators (such as a change in frequency of a pulsing light visible with the smoke alarm installed), operation of a mechanical device (such as described in Clause 8.3), or any arrangement determined to be equivalent. An instrument used for measuring smoke sensitivity of a smoke alarm shall be provided with the following information and features:

- a) The instrument shall have the capability to determine if the smoke alarm 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 alarm that it is capable of testing. A chart is not required for a numerical readout in units of % obscuration per ft.
- b) Instructions for the instrument 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.

8.3 The test feature of such an alarm shall verify that the smoke sensitivity alarm is within its marked range. Unless it is employed on a alarm 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.

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

8.5 An alarm 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.

9 Maintenance (Field Cleaning)

9.1 If a smoke alarm is capable of being cleaned it shall be done so without:

- a) degradation of performance, when tested in accordance with Subsection 79.2, VA Capacity; and
- b) disturbance of field wiring.

10 Alarm Silencing Feature

10.1 Each smoke alarm shall be provided with an automatically resettable alarm silencing feature.

10.2 The alarm silence feature shall have either a fixed or a variable time setting that desensitizes the alarm. Alarm silencing shall not disable the smoke alarm. Sensitivity shall not be reduced to more than 12.5 %/m (4 %/ft) of obscuration (0.0177 OD/ft) or 37.5 pA MIC reading for ionization alarms. Following the silenced period, the alarm shall restore automatically to its intended operation. Silencing of one smoke alarm of a multiple station system shall not prevent an alarm operation from the other smoke alarms in the system. Each smoke alarm shall produce a distinctive audible or visible trouble signal while in the silence mode.

10.3 The maximum allowable alarm silence shall not exceed 10 min.

10.4 When a variable adjustment is provided on an alarm to vary the silenced period, the adjustment means shall be provided with a mechanical stop or the equivalent, so that the maximum alarm silence limit is not exceeded.

10.5 Smoke alarms powered by a non-replaceable battery shall be provided with a temporary alarm silencing means.

11 Battery Removal Indicator

11.1 Removal of a battery from a battery-operated (or ac with battery back-up) smoke alarm shall result in a readily apparent and prominent visual indication. The visual indication shall consist of one of the following:

- a) A warning flag that is exposed with the battery removed and the cover closed;
- b) A hinged cover that is resistant to being closed with the battery removed; or
- c) A swing-out or pull-out battery compartment that is resistant to being closed unless it has a battery in place;
- d) An audible or audible and tactile trouble signal on an AC powered smoke alarm with battery back-up);
- e) An arrangement to render the unit resistant to reinstallation; or
- f) A local audible, local audible and tactile, or local visual indication at the control panel.

11.2 Deactivation of the battery of a smoke alarm that uses a non-replaceable battery with a 10-year minimum battery life shall result in a readily apparent and prominent visual indication. The visual indication shall consist of one of the following:

- a) A warning flag that is exposed with the battery removed and the cover closed;
- b) A hinged cover that is resistant to being closed with the battery removed;
- c) A swing-out or pull-out battery compartment that is resistant to being closed unless it has a battery in place;
- d) An audible or audible and tactile trouble signal on an ac powered smoke alarm with battery back-up;
- e) An arrangement to render the unit resistant to reinstallation or
- f) A local audible, local audible and tactile, or local visual indication at the control panel.

11.3 When a warning flag, or equivalent, is employed to comply with the requirement of Clauses 11.1 or 11.3, it shall be marked as required in Clause 91.6.

12 Smoke Sensitivity Test Feature

12.1 A smoke alarm shall incorporate means for manual test of its operability and sensitivity by mechanically or electrically simulating a preset level of smoke in the sensing chamber. The test means shall be externally accessible when the unit is installed as intended and shall test the operability of the entire unit with the exception of the trouble indicating part of the circuit, which may be excluded. See Subsection 38.7, Smoke Sensitivity Test Feature.

CONSTRUCTION

ASSEMBLY

13 General

13.1 Remote accessories

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

13.2 Smoke sensitivity adjustment (Single Criteria)

13.2.1 When a field smoke sensitivity adjustment is provided, it shall be accessible with the alarm installed as intended, marked to indicate the direction of smoke sensitivity (high or low), and shall employ a mechanical stop at both extremes. The smoke sensitivity shall be within the production sensitivity limits indicated in Clause 38.1.1. Removal of a snap-on cover to gain access to the smoke sensitivity control is permissible only when no high-voltage parts are able to be contacted by the user.

13.3 Radioactive materials

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

13.3.2 Documentation verifying compliance with regulating agency requirements is required for listing the smoke alarm.

13.4 Supplementary signaling feature

13.4.1 A supplementary signaling feature, such as a transmitter for remote signaling, included integral with a single or multiple station smoke alarm, is to be compatible with the device(s) with which it is intended to be employed, and the remote signaling device(s) shall be intended for fire alarm application.

13.5 Insect guards

13.5.1 A smoke sensor shall be provided with a screen or equivalent protection (louvers, slots, holes) as a deterrent for entry of insects into the detecting chamber. The maximum opening size shall not exceed 1.27 mm (0.05 in).

13.5.2 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 are to be made at different locations by an optical micrometer; five measurements are to be made in each direction (not on diagonal).

13.6 Supplementary heat sensor

13.6.1 When a heat sensor is provided integral with a non multi-criteria smoke alarm, the temperature rating of the heat sensor shall not be less than 57° C (135°F). The heat sensor shall be either connected in the smoke alarm circuit or intended for connection to a separate circuit.

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

13.6.3 A fixed-temperature heat alarm shall operate within the temperature tolerance range according to its rating as specified in the operating temperature test.

14 Servicing and Maintenance Protection

14.1 General

14.1.1 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.

14.1.2 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.

14.1.3 In determining compliance with Clause 14.1.2 only uninsulated live parts in circuits above 30 Vrms shall be considered.

14.1.4 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 accident hazard from adjacent hazardous moving parts.

14.1.5 Other arrangements of location of components and/or guarding shall be also acceptable where electrical components are accessible for service as indicated by Clause 14.1.1.

14.1.6 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 suitable insulation; and
- d) Insulated wire.

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

14.2 Sharp edges

14.2.1 An edge, or corner of an enclosure, opening, frame, guard, knob, handle, or other similar projection of a smoke alarm shall be smooth and rounded, so as not to result in a cut-type injury when contacted during use or user maintenance.

15 Enclosure

15.1 General

15.1.1 The enclosure of a smoke alarm shall be constructed to resist the abuses encountered in service. The degree of resistance to abuse inherent in the smoke alarm 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.

15.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two shall be evaluated in determining compliance with the requirement specified in Clause 15.1.1.

15.1.3 All electrical parts of a smoke alarm, including a separate power supply, except for plug-in blades, shall be enclosed to provide protection against contact with uninsulated live parts. A separate enclosure for field wiring terminals that will be enclosed by a back box is not required.

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

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

15.1.6 To comply with Clauses 15.1.5 and 15.1.6, one of the following methods, or a method determined to be equivalent, shall be used:

- a) An elastomeric rubber or neoprene gasket, or the equivalent, interposed between the rear of the alarm and the mounting surface to seal the rear openings and preclude the escape of air from around the edge of the alarm or
- b) Instructions in the installation manual provided to describe the location and method(s) of applying a sealing compound that has been found appropriate for the intended use.

15.1.7 Representative smoke alarms shall be subjected to the Smoke Entry (Stack Effect) Test, Section 41.

15.1.8 The enclosure of a smoke alarm 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 smoke alarm. The mounting means shall be accessible without disassembling any operating part of the smoke alarm. The removal of a completely assembled panel, cover, or equivalent, to mount the smoke alarm is not identified as disassembly of an operating part.

15.1.9 If the smoke alarm is intended for permanent connection, the enclosure shall either have provision for the connection of metal-clad cable, conduit, or non-metallic sheathed cable or have provision for mounting on an outlet box.

15.2 Cast metal enclosures

15.2.1 The thickness of cast metal used for an enclosure shall be as indicated in Table 1, Cast metal enclosures. 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.

15.2.2 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.

15.2.3 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.

15.3 Sheet Metal Enclosures

15.3.1 The thickness of sheet metal employed for the enclosure of a smoke alarm shall not be less than that indicated in Table 2, Sheet metal enclosures, 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.

15.3.2 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).

15.3.3 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.

15.3.4 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 Subsection 21.1, Mounting of Components.

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

15.3.6 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 32.

15.4 Nonmetallic Enclosures

15.4.1 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 Sheet metal enclosures, Table 2, or Thickness of glass covers, Table 3. See also the Tests on Polymeric Materials, Section 72.

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

15.4.3 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 successful completion of the Flame Test – 127 mm (5 in), Subsection 72.4;
- 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:

- i) V-2 or;
- ii) HB and successful completion of the Flame Test – 19 mm (3/4-in), Subsection 72.3; and
- c) Enclosures containing circuits powered by sources with energy limited to 15 watts – minimum flammability rating of HB.

Flammability ratings are defined in CAN/CSA-C22.2 No. 0.17-00, Evaluation of Properties of Polymeric Materials.

15.5 Ventilating Openings

15.5.1 Ventilating openings in an enclosure, including holes, louvres, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening will permit passage of a rod having a 13 mm for circuits 30 V rms (42.4 V peak) or less. An enclosure for fuses or other overload protective device and provided with ventilating openings shall afford adequate protection against the emission of flame or molten metal. Openings provided to permit cleaning or openings which may be used to clean internal parts shall be arranged to prevent damage to functional internal components during such cleaning operations. For units equipped with a cover, the requirements of this Clause apply with the cover open for circuits greater than 30 V rms (42.4 V peak).

15.5.2 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.

15.5.3 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).

15.5.4 The wires forming a screen employed as a smoke chamber cover shall be not less than 0.032mm² (22 AWG) for steel and not less than 0.025 mm² (20 AWG) for aluminum.

15.6 Covers

15.6.1 An enclosure cover, other than the type usually employed over the sensing chamber, shall be hinged, sliding, pivoted, or similarly attached when:

- a) It provides ready access to fuses or any other overcurrent protective device, the intended protective functioning of which requires renewal or

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

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

EXCEPTION: This requirement does not apply to a photoelectric type smoke alarms where the lamp is intended to be periodically replaced, or to the battery replacement aspect of an alarm employing a battery as the main or standby supply.

15.6.2 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.

15.6.3 When a smoke alarm cover is not intended to be removed for cleaning, maintenance, or both, and the smoke alarm 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 Clause 91.1(s) for marking.

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

15.6.4 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" «MISE EN GARDE» and the following or equivalent marking is indicated on the cover of a smoke alarm employing hazardous-voltage circuits: "Circuit Fuse(s) Inside – Disconnect Power Prior To Servicing." «Circuit fusible (s) Inside – Débranchez l'alimentation pour effectuer une réparation»

15.6.5 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.

15.7 Glass Panels

15.7.1 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, Thickness of glass covers.

15.7.2 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.

15.7.3 A lens, light filter, or similar part of a smoke alarm 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 Performance Sections 33, General – 81, Smoke Alarms for Use On Recreational Boats.

16 Corrosion Protection

16.1 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.

16.2 The requirement of Clause 16.1 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 smoke alarm.

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

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

16.5 Hinges and other attachments shall be resistant to corrosion.

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

17 Field Wiring Connections

17.1 Permanent Connection

17.1.1 A single station or multiple station smoke alarm intended for permanent connection shall be provided with wiring terminals or leads for the connection of conductors of at least the size corresponding to the rating of the unit in accordance with CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations.

17.2 Field Wiring Compartment

17.2.1 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.

17.2.2 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.

17.3 Field Wiring Terminals (General)

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

- a) Clauses 17.3.2 – 17.3.5;
- b) CSA C22.2 No. 153, Standard for Electrical Quick-Connect;
- c) CSA C22.2 No. 65, Standard for Wire Connectors; or

- d) CSA C22.2 No. 158, Standard for 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.

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

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

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

17.3.4 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 1.3 mm (0.050 in) thick when used with a 4.2 mm (No. 8) diameter or larger screw, and not less than 0.76 mm (0.030 in) thick when used with a 3.5 mm (No. 6) diameter or smaller screw.

17.3.5 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.

17.4 Special Field-Wiring Terminals (Qualified Application)

17.4.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in 17.4.2 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 (a) and (b) and are limited to the same restrictions.

17.4.2 Any of the terminal configurations listed in Clause 17.4.1 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 0.13 mm² (26 AWG) for a jacketed, multi-conductor cable or 0.82 mm² (18 AWG) 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 Subsection 73.3, Strain Relief (Special Field-Wiring Terminals).

17.5 Field Wiring Leads

17.5.1 Power supply 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 0.82 mm² (18 AWG); 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.

17.5.2 Extra-low voltage leads provided for field connection signaling circuits, such as employed for multiple station interconnection or for connection to remote signaling devices, shall not be smaller than 1.3 mm² (16 AWG), for a single conductor, 0.65 mm² (19 AWG) for two or more conductors, and 0.32 mm² (22 AWG) for four or more conductors of a multi-conductor cable. The conductor shall be solid, bunch tinned stranded, or stranded copper. Stranded copper wire, consisting of not more than seven strands, shall be used only for 0.82 mm² (18 AWG) and larger conductors.

17.6 Grounding Terminals and Leads

17.6.1 Except as permitted by Clause 17.6.9, an equipment-grounding terminal or lead shall be provided in a smoke alarm intended for connection to other than a 30 V rms or less energy limited source of supply (see Subsection 31.1, Primary Power Supply) by means of other than metal enclosed wiring system.

17.6.2 The grounding means shall be reliably connected to all exposed dead metal parts which are liable to become energized and all dead metal parts within the enclosure which are exposed to contact during servicing and maintenance.

17.6.3 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.

17.6.4 A field wiring terminal intended for connection of an equipment grounding conductor shall be plainly identified, such as being marked "G", "GR", "Ground", "Grounding", or the equivalent, or by a suitable marking on a wiring diagram provided on the smoke alarm. The field wiring terminal shall be so located that it is unlikely to be removed during normal servicing of the smoke alarm.

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

17.6.6 A field wiring lead provided for connection of an identified supply conductor shall be finished to show a white or natural gray colour and shall be readily distinguishable from other leads and no other leads, other than identified supply conductors, shall be so identified.

17.6.7 A terminal or lead identified for the connection of the identified 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.

17.6.8 The grounding means for a cord-connected smoke alarm shall consist of a separate ground lead integral with the supply cord and terminating in the grounding pin of a parallel blade attachment-plug.

17.6.9 An equipment grounding terminal or lead is not required for a smoke alarm provided with an overall non-metallic enclosure and cover and which is not intended to be internally serviced or a smoke alarm provided with an overall non-metallic enclosure and cover and does not employ internal dead-metal parts which may be energized under a fault condition and which can be contacted during servicing.

17.7 Power Supply Cord

17.7.1 A cord-connected single station smoke alarm accessory shall be provided with not less than 1.83 m (6 ft) nor more than 6.10 m (20 ft) of flexible cord and a two or three prong attachment plug of the type and rating for connection to the supply circuit.

17.7.2 The flexible cord shall be of minimum 0.82 mm² (18 AWG). It shall be rated for use at the voltage and ampacity rating of the smoke alarm. Acceptable cord types are POT-64, SPT-3, SV, SVT, SJ, SJT, or equivalent, and in accordance with C22.1, Part I, Canadian Electrical Code, Safety Standard for Electrical Installations.

17.7.3 Means shall be provided to prevent the flexible cord from being pushed into the enclosure through the cord-entry hole if such displacement can subject the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is rated, reduce spacings below the minimum acceptable values, or result in damage in internal components.

17.7.4 Where a flexible cord passes through an opening in a wall, barrier, or enclosing case, the edges of the hole shall be smooth and rounded, without burrs, fins, or sharp edges which may damage the cord jacket. The cord as connected to the smoke alarm shall comply with Strain Relief Test, Section 73.

18 Remote Power Supply

18.1 For an alarm that is intended to be connected to a separate remote power supply such as a transformer, the supply cord is not required to be factory wired to the alarm, or to the transformer terminals or leads, when the installation instructions provided with the unit are explicit regarding the method of connection. The minimum size conductors between the alarm and remote power supply shall not be less than 0.82 mm² (18 AWG) and shall not be longer than 6.1 m (20 ft). The interconnecting wiring is to be provided with the alarm and the transformer by the manufacturer.

18.2 Where longer runs of interconnecting wiring are used in an installation, such as in a multiple station configuration, or where several alarms are supplied by a common power supply, the wiring is not required to be provided by the manufacturer. In addition, the resistance of the interconnecting wiring shall be a maximum of 10 ohms, unless otherwise specified by the manufacturer.

19 Internal Wiring

19.1 General

19.1.1 The internal wiring of a smoke alarm 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.

19.1.2 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.

19.1.3 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).

19.1.4 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 Subsection 19.4, Barriers.

19.1.5 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.

19.2 Wireways

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

19.3 Splices

19.3.1 All splices and connections shall be mechanically secured and bonded electrically. Tack soldering of components 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.

19.3.2 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.

19.3.3 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.

19.4 Barriers

19.4.1 A metal barrier shall have a thickness at least equal to that required by Table 2, Sheet metal enclosures, 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).

19.5 Strain Relief

19.5.1 A strain relief means shall be provided for the field leads and all internally connected wires or cords that are subject to movement in conjunction with the installation, operation, or servicing of a smoke alarm 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 73.

20 Bonding for Grounding

20.1 An exposed non-current-carrying metal part of a smoke alarm 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 smoke alarm equipped with auxiliary function contacts rated at more than 30 Vrms.

20.2 Except as indicated in Clause 20.3, 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 service person in servicing or operating the equipment.

20.3 Metal parts as described below are not required to comply with the requirement specified in Clause 20.2:

- a) Adhesive attached metal foil markings, screws, and handles, that are located on the outside of the smoke alarm 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.

20.4 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.

20.5 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 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.

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

COMPONENTS

21 General

21.1 Mounting of Components

21.1.1 All parts of a smoke alarm 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 means for mounting the switch makes so that the operation of the switch shall not loosen it.
- c) The spacings are not reduced below the minimum required values when the switch rotates.
- d) The operation of the switch is by mechanical means rather than by the direct contact by persons.

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

21.1.2 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.

21.1.3 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 may 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.

21.2 Operating Components

21.2.1 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.

21.2.2 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.

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

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

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

21.3 Current-Carrying Parts

21.3.1 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.

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

22 Bushings

22.1 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.

22.2 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.

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

22.4 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 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.

22.5 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.

22.6 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.

23 Electrical Insulating Material

23.1 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.

23.2 Polymeric materials shall be used for the sole support of uninsulated live parts only when determined to be equivalent to the materials indicated in Clause 23.1.

23.3 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.

23.4 The thickness of a flat sheet of insulating material, such as phenolic composition employed for panel mounting of parts, shall not be less than the applicable value indicated in Table 4, Thickness of flat sheets of insulating material.

23.5 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, Thickness of flat sheets of insulating material.

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

23.6 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).

24 Lampholders and Lamps

24.1 A smoke alarm intended to be connected to a utility supply, either directly or via a separate power supply as described in Clause 24.2 shall be provided with a steady "power-on" lamp to indicate energization of the unit.

24.2 When a smoke alarm has more than one indicator lamp, lamp colors shall be:

- 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.

24.3 At least one spare lamp shall be provided in a smoke alarm that employs photocell illuminating lamps that burn out during the service life of a smoke alarm.

24.4 A lampholder and lamp shall be rated for the circuit in which they are employed.

24.5 A lampholder in a hazardous-voltage circuit shall be wired so that the screw shell is connected to an identified neutral (grounded circuit) conductor.

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

25 Photocell Illuminating Lamps and Light Emitting Diodes (LEDs)

25.1 General

25.1.1 A LED used as a light source of a smoke alarm employing a photocell light assembly shall comply with electrical supervision requirements specified in Clauses 37.3.1 – 37.3.5, and the reliability prediction specified in 4.4.

25.1.2 To be determined reliable, an LED shall comply with 4.4 and with the requirements specified in 37.3.3 and 37.3.4. In addition, the operating conditions of the LED in the smoke alarm circuit, as well as the LED and smoke alarm manufacturer's Quality Assurance (QA) Programs, shall be evaluated as to the level of reliability they provide as described in 25.2.

25.1.3 A reliable LED that complies with the requirement specified in 25.1.2 shall additionally comply with the requirements specified in the Reduction in Light Output Test, Section 43, and the electrical supervision requirements described in 37.3.2 – 37.3.5.

25.2 Quality Assurance Program

25.2.1 Light emitting diode (LED) manufacturer

25.2.1.1 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 LED.

25.2.2 Smoke alarm manufacturer

25.2.2.1 The smoke alarm 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.

25.2.2.2 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 smoke alarm manufacturer need only conduct 100% inspection for light output.

26 Protective Devices

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

27 Printed Wiring Boards

27.1 The components of a printed wiring board shall be attached securely and the spacings between circuits shall comply with the spacing requirements of Section 32, Spacings for rigidly clamped assemblies (see Table 16). 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.

28 Switches

28.1 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.

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

28.3 An alarm silencing switch or equivalent means shall be provided if its off-normal position results in an audible smoke alarm trouble signal, or if following alarm silencing the unit automatically returns to normal condition after a timed interval as specified in Section 10, Alarm Silencing Feature.

29 Transformers and Coils

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

29.2 A transformer shall meet the requirements of C22.2 No. 66-1988 (R2001), Specialty Transformers.

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.

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

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

30 Dropping Resistors

30.1 A carbon composition resistor shall not be used as a dropping resistor in the hazardous-voltage circuit of a smoke alarm.

31 Power Supplies

31.1 Primary Power Supply

31.1.1 The primary power supply of a smoke alarm shall be either a utility supply (commercial light and power source) or an integral battery or batteries. Connection to the utility supply (commercial light and power source), when used, shall be in the form of permanent wiring to terminals or leads in a separate wiring compartment having provision for the connection of conduit, metal-clad or nonmetallic sheathed cable, by means of a power-supply cord and attachment-plug, or by means of a separate power supply.

31.1.2 When a separate power supply is provided, it shall have limited output energy consisting of an open circuit voltage not in excess of 30 V rms, 42.4 V peak or direct current (dc), and its output capacity shall be limited to a maximum of 100 VA. The energy may be limited by an energy limiting device having an output rating of 100 VA or less or by a transformer plus additional circuitry having characteristics equivalent to those of a 100 VA transformer.

31.2 Secondary Power Supply

31.2.1 A secondary power supply, such as a battery, shall be provided and have the capacity to supply the maximum intended power to the smoke alarm for no less than 7 days in the standby condition and thereafter be able to operate the smoke alarm for an alarm signal for at least 4 min continuously. This capacity shall be measured using a fully charged battery or other applicable rechargeable energy storage media, or a fresh non-rechargeable battery, as appropriate. Refer to Subsection 37.5, Battery Powered (primary or secondary) Smoke Alarms. Smoke Alarms consisting of battery primary power shall not be subject to this requirement.

31.2.2 If a battery or set of batteries is employed as the main source of power of a smoke alarm, it shall meet the requirements of the Battery Tests, Subsection 77.3.

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

31.2.4 When a non-rechargeable or rechargeable type battery is used as a secondary power supply, the marking on the unit shall include specified periodic battery replacement instructions.

31.2.5 The discharge condition of a non-rechargeable or rechargeable type battery shall be monitored where a trouble indication, as described in 37.5.3 is obtained. The monitoring shall take place whether the alarm is operating on the primary supply or on the standby supply.

32 Spacings

32.1 Spacings shall be maintained between uninsulated live parts and dead metal parts and between uninsulated live parts of opposite polarity. The spacings shall not be less than those indicated in Table 16.

32.2 The spacings between an uninsulated live part and:

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

shall not be less than that indicated in Table 16.

32.3 The "Through Air" and "Over Surface" spacings of Table 16 measured at an individual component part shall be judged on the basis of the V•A 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.

32.4 The spacing requirements specified in Table 16 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 smoke alarm. Such spacings are judged on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete device, including clearances to dead metal or enclosures, shall be as indicated in Table 16.

32.5 The "To Walls of Enclosure" spacings of Table 18 are not to be applied to an individual enclosure of a component part within an outer enclosure.

32.6 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.

32.7 Spacings on printed-wiring boards which are less than those indicated in Table 16 shall comply with the minimum spacings of Table 16 or shall be provided with a coating in compliance with Conformal Coatings on Printed-Wiring Boards, Section 78.

PERFORMANCE

33 General

33.1 Test units

33.1.1 Smoke alarms and power supply units that are fully representative of production units shall be used for the tests specified in Sections 33 – 81, unless otherwise specified. The sensitivity setting or range of sensitivities provided on the units for test will define the production smoke sensitivity (single and multi-criteria smoke alarms) and gas sensitivity (multi-criteria smoke alarms).

33.1.2 The devices employed for testing shall be those specified by the wiring diagram of the smoke alarm. When substitute devices are used, they shall produce functions and load conditions equivalent to those obtained with the smoke alarm in service, including devices intended to be used with the smoke alarm. Smoke alarms intended to be energized by a separate power supply, as described in 31.1.2, shall be tested as a combination and the applicable requirements of the test also applied to the power supply unit. See Subsection 79, Power Supply Tests.

33.2 Performance of Single Sensor Components of Multi-Criteria Smoke Alarms

33.2.1 The performance of single sensor components of a multi-criteria smoke alarm need not comply with the standards specific for those single phenomena smoke alarms.

33.2.2 The performance of the multi-criteria smoke alarm shall meet the requirements of this standard except for the smoke sensitivity limits specified in Tables 6 and 7. Manufacturers shall provide samples that reflect, and information that identifies the combined and discrete maximum and minimum sensitivities of each constituent sensor.

33.3 Test Voltages

33.3.1 Unless otherwise specified, the test voltage for each test shall be as specified in Table 17, Test voltages and at rated frequency.

33.4 Test Samples and Data

33.4.1 The following samples and data are required; the data required in (d) and (e) does not have to be in final printed form:

- a) At least 28 assembled smoke alarms, 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 % from any other unit in each setting, and shall establish the maximum and minimum sensitivities to be employed in production. Combination/multi-criteria smoke alarms shall be provided with means for monitoring each principle of operation during the Sensitivity Test, Section 38. 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 smoke alarm.
- c) Five additional samples of smoke alarms that operate on the photoelectric principle provided with means to reduce the light output as described in 43.2.
- d) The monitoring instrument, or reference to a readily available instrument, intended to monitor the sensitivity of each sensor in the multi-criteria smoke alarm.
- e) Installation and Operating Instructions, see Section 5 and Instructions, General, Section 92.
- f) Where applicable, samples of conformal coated printed-wiring boards, as specified in Conformal Coatings on Printed-Wiring Boards, Section 78;
- g) Power supplies, if the smoke alarms are intended to be employed with specific power supply.

33.4.2 For smoke alarms employing a battery as the main operating supply, 24 additional battery operated smoke alarms for long term battery tests or equivalent test circuit set ups with appropriate measuring facilities to monitor the battery voltage, standby current, and alarm current shall be provided. See the Battery Tests, Section 77.3.

33.4.3 Four battery test setups shall be provided for subjection to each of four environmental conditions. Each set up shall be representative of six smoke alarms and shall include test terminals and switches, limiting resistors, the alarm horn, and batteries. The value of resistors shall represent the normal standby current which is obtained from a complete smoke alarm.

33.4.4 The batteries shall be connected in the test circuit with the same terminal arrangement employed in the smoke alarm. Provision for connection of the actual sounding appliance used in the unit for the periodic and weekly testing shall also be made. See Battery Test, Section 77.3.

33.5 Component Reliability Data

33.5.1 Data on smoke alarm 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 military specification is referenced, a copy of the specification is to be provided for review.

33.5.2 The data required by 33.5.1 shall include the following or equivalent information:

- a) Component Fault Analysis. Effect of failure, open and short, of capacitors and limited-life components on operation of a smoke alarm.
- b) Maximum supplier's ratings for each component as well as the actual maximum operating values (voltage and current) in the smoke alarms.
- c) A description of component screening and burn-in test data for solid-state devices (including, but not limited to, relays, semiconductor, integrated circuit) that operate at greater than the limits described in note d of Table 9.
- d) General description of the smoke alarm 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 smoke alarm employing a reliable LED as the photocell illuminating light source, the data shall be as specified in Section 25, Photocell Illuminating Lamps and Light Emitting Diodes (LEDs).
- g) General calibration procedure of test instruments employed by the manufacturer in the calibration of a smoke alarm.
- h) Amount of derating of components under normal standby and alarm conditions.
- i) Component failure rate data at rated values and derated values.

33.6 Accessories

33.6.1 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 34;
- b) Circuit Measurement Test, Section 49;
- c) Overvoltage and Undervoltage Tests, Section 50;
- d) Temperature Test, Section 51;

- e) Jarring Test, Section 54;
- f) Variable Ambient Temperature Tests, Section 55;
- g) Humidity Test, Section 56;
- h) Transient Tests, Section 59;
- i) Overload Test, Section 62;
- j) Endurance Test, Section 63;
- k) Leakage Current Test, Section 66;
- l) Dielectric Voltage-Withstand Test, Section 70;
- l) Tests of Polymeric Materials, Section 72;
- m) Drop Test, Section 75 (portable appliance only); and
- n) Audibility Test, Section 76.

33.6.2 Optional accessories used to assist persons with disabilities by enhancing the low frequency or signaling a tactile appliance shall include a source of secondary power equal to that of the smoke and heat alarms that the unit is compatible with.

33.6.3 Detached accessories utilizing a low frequency sound or actuating tactile appliances for Single and Multiple Units shall provide a low frequency sound or visual indication in the event of the following:

- a) Loss of primary power,
- b) Low energy of the secondary power source, or
- c) The accessory unit cannot perform its intended function of enhancing the Smoke or Heat alarms primary low frequency audible sound or operate the tactile appliance.

33.7 Smoke Alarm Guards

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

- a) Normal Operation Test, Section 34;
- b) Sensitivity Test, Section 38;
- c) Velocity-Sensitivity Test, Section 40;
- d) Reduction in Light Output Test, Section 43;
- e) Fire Tests, Section 46;
- f) Smoldering Smoke Test, Section 47; and
- g) Audibility Test, Section 76.