UL 217

STANDARD FOR SAFETY

Smoke Alarms

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UL Standard for Safety for Smoke Alarms, UL 217

Ninth Edition, Dated January 2, 2020

SUMMARY OF TOPICS

This new edition of ANSI/UL 217, includes the following:

- ***Sensitivity Test Clarifications***
- ***Supervised Battery Clarifications***
- ***Mechanical Push Test for Push-Type Features***
- ***Combination of Requirements for Recreational Vehicles and Boats***
- ***New Firmware Requirements***
- ***Updated Polyurethane Foam and Cooking Nuisance Requirements (including new Go/No Go Flaming PU Test)***
- ***Trouble Signal for Detached Low Frequency or Tactile Accessories***
- ***Revisions for High Voltage Printed Wiring Boards***
- ***Additional Stability Tests for Multi-Criteria Smoke Detectors Employing CO Gas Sensors***
- ***Nuisance Sensor Requirements***
- ***Velocity Revisions***
- ***Manufacturer's Published Instructions***
- ***Smoke Alarm Activation***
- ***Strain Relief/Field Wiring Clarifications***
- ***Fire Test Clarifications***
- ***Paintbrush Marking***
- ***Updated Go/No-Go Field Test (for the smoke sensor)***
- ***Addendum – Minimum Screening Programs in Table C3.1***
- ***Removal of Lamp Interchangeability Requirements***

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated June 28, 2019.

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UL 217

Standard for Smoke Alarms

Prior to the seventh edition, the previous editions were entitled Standard for Single and Multiple Station Smoke Alarms.

First Edition – January, 1976
Second Edition – October, 1978
Third Edition – October, 1985
Fourth Edition – May, 1993
Fifth Edition – February, 1997
Sixth Edition – August, 2006
Seventh Edition – June, 2015
Eighth Edition – October, 2015

Ninth Edition

January 2, 2020

This ANSI/UL Standard for Safety consists of the Ninth Edition.

The most recent designation of ANSI/UL 217 as an American National Standard (ANSI) occurred on January 2, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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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 and portable smoke alarms used as "travel" alarms in accordance with:

a) National Fire Alarm and Signaling Code, NFPA 72;

b) Standard for Recreational Vehicles, NFPA 501C, for smoke alarms intended for use in recreational vehicles;

c) For smoke alarms intended for use in recreational boats:

1) Fire Protection Standard for Pleasure and Commercial Motor Craft, NFPA 302,

2) AC and DC Electrical Systems on Boats, ABYC E-11, and

3) The applicable regulations of the United States Coast Guard.

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.

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 the Standard for Smoke Detectors for Fire Protective Signaling Systems, UL 268;

b) Mechanically operated single and multiple station fire alarm devices that are specified in the Standard for Single and Multiple Station Heat Alarms, UL 539;

c) Heat detectors – except for the requirements in the Fire Test – Smoke Alarm with Supplementary Heat Detection, Section 72, incorporated as part of a single station smoke alarm assembly whose requirements are covered in the Standard for Heat Detectors for Fire Alarm Signaling Systems, UL 521 or and/or when part of a multi-criteria smoke alarm.

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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 the Standard for Household Fire-Warning System Units, UL 985 or;

e) A gas and vapor detector or sensor incorporated as a part of a smoke alarm assembly and covered by the Standard for Single and Multiple Station Carbon Monoxide Alarms, UL 2034, or except when part of a multi-criteria smoke alarm.

2 Assembly

2.1 A smoke alarm shall be so constructed that it will be reliable and sufficiently durable for its intended installation and use.

2.2 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.

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

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Annex D for a list of standards covering components used in the products covered by this standard.

3.2 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.

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

3.4 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.

4 Units of Measurement

4.1 Values in parentheses are explanatory or approximate information.

5 Referenced Publications

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

UL Standards

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*
UL 521, *Heat Detectors for Fire Protective Signaling Systems*
UL 985, *Household Fire Warning System Units*

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

NFPA

ANSI/NFPA 70, *National Electrical Code*
ANSI/NFPA 72, *National Fire Alarm and Signaling Code*
NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft*

ASTM International

ASTM B117-16, *Standard for Salt Spray (Fog) Testing*
ASTM MNL12, *Manual on the Use of Thermocouples in Temperature Measurement – Edition 4, 1993.01.01*

ISO

ISO 8201, *Acoustics – Audible Emergency Evacuation Signal*
ISO/FDIS 8201, *Acoustics – Audible and other emergency evacuation signals*

Department of Defense

MIL-HDBK-217F(2) – February 28, 1995, *Reliability Prediction of Electronic Equipment*
MIL-STD-750E(2) – November 30, 2016 *Test Methods for Semiconductor Devices*
MIL-STD-883K(2) – February 22, 2017 *Test Methods Standard Microcircuits*

Acoustical Society of America

ANSI/ASA S3.41, *Audible Emergency Evacuation Signal*

IEEE

ANSI/IEEE C62.41, *IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits*

American Boat and Yacht Council

ABYC-E_11, *AC and DC Electrical Systems on Boats*

Federal Communications Commission

FCC 47 CFR Part 15.247

6 Glossary

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

6.2 BROILING – The fresh-frozen hamburger cooking process used to cook the fresh-frozen hamburger in the oven of an electric range.

6.3 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.

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6.4 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.

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

6.6 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.

6.7 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).

6.8 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.

6.9 FIRMWARE – For the purpose of this Standard, software programs residing permanently on a microprocessor or in a nonvolatile memory chip within smoke alarm and accessory devices.

6.10 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.

6.11 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.

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

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

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

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6.15 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.

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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.

6.16 NUISANCE SENSOR – A component on a smoke alarm that is solely used to identify nuisance (non-fire) conditions.

6.17 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 91, Sensitivity Calibration Tests.

6.18 PRODUCTION SMOKE SENSITIVITY – The smoke sensitivity range produced during manufacture, established by the tests in this Standard within the limit outlined in Table 37.1, Most sensitive visible smoke obscuration limits (gray smoke), and Table 37.2, Measuring ionization chamber (MIC) measurement, for single criteria smoke alarms. For multi-criteria smoke alarms, smoke sensitivity limits may be provided by the manufacturer.

6.19 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 milliampere.

6.20 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 amperes or more after 1 minute of operation, or

b) A power of more than 15 watts is deliverable into an external resistor connected between the two points.

6.21 SMOKE ALARM ACTIVATION – An audible signal that lasts at least two complete cycles of the temporal pattern.

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

6.23 SMOKE ALARM AUDIBLE SIGNAL – The Audible Emergency Evacuation Signal as defined in ANSI/ASA S3.41, Audible Emergency Evacuation Signal, ISO 8201, Acoustics – Audible Emergency Evacuation Signal, or ISO/FDIS 8201, Acoustics – Audible and other emergency evacuation signals.

6.24 SMOKE ALARM WITH SUPPLEMENTARY HEAT DETECTION – A smoke alarm that responds to excessive concentrations of smoke or heat in compliance with 17.6, Supplementary heat sensor, and Section 72, Fire Test – Smoke Alarm with Supplementary Heat Detection, but are not fully compliant to the Standard for Single and Multiple Station Heat Alarms, UL 539. The sensor output signals are individually evaluated but not combined to determine when an alarm signal is warranted.

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

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

6.27 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.

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

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

6.30 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-volts alternating current (AC) (42.4 volts peak) and maximum power of 100 volt-amperes, such as supplied by a Class 2 transformer; or a circuit of not more than 30-volts 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 volts 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.

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

7 Smoke Alarm Reliability Prediction

7.1 Smoke alarms 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 Military Standardization Handbook, MIL-HDBK 217F 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 217F, or equivalent. See Annex C, Instructions for Determining a Reliability Prediction of Electronic Components and Microelectric Circuits. 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.

7.2 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

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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.

7.3 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.

7.4 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 hours.

7.5 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 hours. The failure rate is to be determined through evaluation of data in a 3000 hour burn-in test, or equivalent.

7.6 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 217F or equivalent demonstrating a predicted failure rate of not more than 2.5 failures per million hours operation (see 7.5); or

b) Supervision of the predicted failure modes other than for loss of electrical continuity; and

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.

7.7 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 41. All predicted failure modes shall result in a trouble signal.

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

8 Manufacturer's Published Instructions

8.1 A copy of the manufacturer's published instructions, which includes installation and operating instructions, related schematic wiring diagrams, and installation drawings shall be used as a reference in the examination and test of the smoke alarm. For this purpose, a printed edition is not required. The information is to be included in a homeowner's manual. See MARKING, Section 99, General; Section 100, Packaging Marking; and INSTRUCTIONS, Section 101, General.

8.2 The manufacturer's published instructions 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.

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9 Automatic Drift Compensation for Smoke Sensing

9.1 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.

9.2 For alarms with adjustable smoke sensitivity settings, after automatic drift compensation has occurred, the smoke sensitivity of the smoke alarm shall be within 1.65 percent/m (0.5 percent/ft) obscuration of the initial smoke sensitivity when tested as described in 42.5.1 – 42.5.4 (Test method).

9.3 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.

9.4 The compensation shall not adversely affect the operation of the smoke alarm. The summation of compensation steps over a twenty-four hour period shall not change the clean-air reference value by more than 50 percent of the shift necessary to indicate an alarm signal and shall not impact the smoke sensitivity of the smoke alarm as specified in 9.2. Maximum compensation rate of the clean air reference value shall not exceed 5 percent every 2.4 hours.

10 Non-fire Feature

10.1 A non-fire feature, such as carbon monoxide detection, shall be used in common with a single or multiple station smoke alarm or both, or an accessory only when a non-fire feature does not degrade or interfere with operation of the smoke alarm or accessory and complies with all the applicable requirements of this standard. See smoke alarm reliability in 7.3 (Smoke Alarm Reliability Prediction) and 38.1.9 (Normal Operation Test).

11 Smoke Sensitivity Indicating Means (Optional)

11.1 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 11.2. 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.

11.2 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 11.3), 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 percent obscuration per m (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.

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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.

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

11.4 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.

11.5 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.

12 Maintenance (Field Cleaning)

12.1 If recommended by the manufacturer, the smoke alarm shall be cleaned without:

a) Degradation of performance when tested in accordance with 86.2, Maintenance (cleaning); and

b) Disturbance of field wiring.

13 Alarm Silencing Feature

13.1 Each smoke alarm shall be provided with an automatically resettable alarm silencing means that has a fixed or variable time setting which desensitizes the alarm for a maximum of 10 minutes. Alarm silencing shall not disable the smoke alarm. Sensitivity shall not be reduced to a level that is less than the manufacturer's minimum sensitivity setting. Each alarm shall produce a distinctive audible or visible trouble signal while in the silence mode. Following the silenced period, the alarm shall restore automatically to its intended operation. Silencing of one alarm of a multiple station system shall not prevent an alarm operation from the other alarms in the system. See Section 40, Alarm Silenced Test.

13.2 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 10-minute limitation is not exceeded.

13.3 When single station smoke alarms are configured in a multiple station connection (interconnection of two or more smoke alarms), the smoke alarm that initiates an alarm signal shall be designed to be silenced through a manual operation by physically depressing the alarm silence feature on the initiating alarm.

13.4 As an optional feature, the manufacturer is permitted to include an additional wireless communication remote silencing feature. If included and tested for compliance with the requirements outlined in 13.7, the wireless communication remote silence feature may be activated through a remote device and shall be capable of providing additional instructions for the user to confirm his physical proximity to the initiating smoke alarm. Manufacturers that include a wireless communication remote silencing feature shall include language on their remote device for the user to confirm his physical proximity to the initiating smoke alarm, and that the user verified the presence or absence of smoke/fire at the initiating alarm(s) before silencing the alarm signal using the remote device.

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13.5 A multiple-station interconnected smoke alarm that produces an alarm signal (wired, wireless, relay, audible and/or visual) shall be permitted to be silenced by either of the following:

a) By activating the alarm silence feature on any multiple station interconnected smoke alarm, provided the smoke alarm that initiated the alarm signal remains in alarm; or

b) By physically depressing the alarm silence feature on the initiating smoke alarm(s), as noted in 13.3; or

c) By activating the wireless communication remote silencing feature using a remote device.

Exception: In the event that the initiating alarm(s) cannot be silenced per the requirements in 13.1, it is permitted that the smoke alarms providing an alarm signal resulting from the multiple-station interconnect, excluding the initiating alarm(s), be silenced but not exceed the limits defined in 13.1.

13.6 Upon activation of an alarm signal from a smoke alarm in the multiple-station circuit, or reactivation of the alarm signal from the originating smoke alarm, all alarms in the multiple-station interconnect shall re-initiate their alarm signal.

13.7 Smoke alarms with a wireless RF communication remote device and employing a remote alarm silence feature shall be tested in accordance with one of the following requirements:

a) The remote transmission radio of the smoke alarm shall comply with FCC 47 CFR Part 15.249 for the frequency band used and the field strength limits:

1) Frequency range

i) 2.4 GHz (2.4 GHz – 2.4835 GHz)

ii) 900 MHz (902 – 928 MHz)

iii) 5.8 GHz (5725 – 5875 MHz)

2) Field strength

i) 94 dBuV/m @ 3m

or

b) The remote transmission radio of the smoke alarm shall comply with FCC 47 CFR Part 15.247 for the frequency band used and the field strength limits:

1) Frequency range

i) 2.4 GHz (2.4 GHz – 2.4835 GHz)

ii) 900 MHz (902 – 928 MHz)

iii) 5.8 GHz (5725 – 5875 MHz)

2) Field strength

i) 30 dBm (1 W) (using antennas with directional gains < 6 dBi)

or

c) The manufacturer shall provide a defined test procedure, test frequency and field strength in compliance with FCC regulations that demonstrate the open field (line of sight) transmission range of the smoke alarm does not exceed 300 m (984 ft).

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13.8 Where a visible signal device or component is used as an optional feature, the alarm silence feature may be permitted to deactivate the visible signal device or component.

14 Smoke Sensitivity Test Feature

14.1 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 42.7, Smoke sensitivity test feature.

14.2 Where a visible signaling device or component is used for the smoke sensitivity test feature it shall also activate the visible signaling device or component.

15 Batteries

15.1 General

15.1.1 When a battery or set of batteries is used as the main source of power of a single or multiple station smoke alarm, it shall comply with the requirements of the Battery tests, 86.3.

15.1.2 Batteries included as part of an alarm shall be so located and mounted that terminals of cells are prevented from coming in contact with uninsulated live parts, terminals or adjacent cells, or metal parts of the enclosure as a result of shifting.

15.1.3 A battery compartment intended for use with rechargeable batteries which emit gases during charging shall be provided with vent holes.

15.1.4 Ready access shall be available to the battery compartment to facilitate battery replacement, without damage to the alarm components or disassembly of any part of the alarm, except for a cover or the equivalent. When the battery is capable of powering the alarm for a minimum of 10 years, the battery shall not be user replaceable.

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

15.1.6 A smoke alarm powered by a non-replaceable, ten-year life battery shall be provided with a means of activating the power prior to installation and deactivating the battery at the end of useful battery life. The deactivation means shall require the use of a tool, or equivalent, and shall render the unit resistant to being reinstalled. The deactivation means shall also serve to discharge the battery(ies) completely. Both the activation and deactivation means shall be designed to operate one time only. The manufacturer's published instructions shall provide the user with information describing this one-time operation. See 101.1(p).

15.2 Battery removal/deactivation indicator

15.2.1 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;

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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.

15.2.2 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 indication. The indication includes but not limited to the following:

a) A warning flag that is exposed when the battery is deactivated and the cover closed;

b) A hinged cover that is resistant to being closed when the battery is deactivated;

c) An audible or audible and tactile trouble signal on an AC powered smoke alarm with battery back-up when the battery is deactivated;

d) An arrangement to render the unit resistant to reinstallation; or

e) A local audible, local audible and tactile, or local visual indication at the control panel.

15.2.3 When a warning flag, or equivalent, is employed to comply with the requirement of 15.2.1 or 15.2.2, it shall be marked as required in 99.6 (Marking).

16 Firmware Update (if provided)

16.1 General

16.1.1 A firmware release level shall identify the firmware of a product. A new release level shall be assigned due to any changes in the firmware.

16.1.2 Program software and code shall not be accessible for modification by the user.

16.2 Firmware update

16.2.1 Products capable of receiving a firmware update shall provide a means of indicating the current firmware version of the unit

16.2.2 The manufacturer shall provide documentation which details the differences:

a) From the original to each subsequent firmware version and

b) Between subsequent versions (if applicable).

16.2.3 Firmware updates for smoke alarms shall not occur when the battery (primary or secondary) supply associated with the device has been depleted to the trouble point (refer to 56.2, Battery trouble voltage determination).

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16.2.4 Products capable of receiving a firmware update shall be tested and evaluated for the following type of applicable firmware updates when the alarm device or accessory is subjected to the specified operating conditions:

a) Authentic Firmware Update:

1) Normal standby condition – smoke alarm shall operate as intended after receiving an authentic firmware update.

2) Alarm condition – when detecting smoke during a fire event, a firmware update shall not interfere with alarm detection and signaling.

3) Loss of power – smoke alarm shall comply with 16.2.6 or 16.2.7.

4) Firmware transmission (data) interruption – smoke alarm shall comply with 16.2.6 or 16.2.7.

b) Duplicate firmware version update:

1) Normal standby condition – smoke alarm shall operate as intended after receiving a duplicate firmware update.

c) Corrupt firmware update:

1) Normal standby condition – smoke alarm shall comply with 16.2.6 or 16.2.7.

d) Unsigned manufacturer firmware update:

1) Normal standby condition – smoke alarm shall comply with 16.2.6 or 16.2.7.

16.2.5 Successful firmware updates shall result in the smoke alarm or accessory operating as intended following the update and comply with all applicable requirements as defined within this standard.

16.2.6 For products capable of receiving an automatic (no end user interaction) update, such as the use of WiFi, failure to successfully update the firmware shall result in the alarm and accessory if provided, reverting to the previous firmware version and the alarm and accessory if provided shall operate as originally intended. At a minimum, Section 38, Normal Operation Test shall be conducted. As an alternative, failure to update or revert to the previous firmware revision shall result in a trouble signal.

16.2.7 For products requiring physical interaction to install a firmware update, such as the use of a USB connection, failure to update the firmware shall result in the alarm and accessory if provided, reverting to the previous firmware version and the alarm and accessory if provided, shall operate as originally intended. At a minimum, Section 38, Normal Operation Test shall be conducted. As an alternative, failure to update or revert to the previous firmware version may result in a trouble signal.

16.2.8 For products that are capable of receiving firmware updates, manufacturers shall provide a means for the end user to obtain the manual for the updated firmware if any user discernible functionality has changed.

16.2.9 Where firmware updates alter the alarm threshold or smoke detection algorithm, the alarm (with firmware updates) shall be tested according to Section 42, Sensitivity Test, Section 50, Fire Tests, and Section 51, Smoldering Smoke Test.

16.2.10 An alarm with firmware updates shall also be subjected to the Smoldering Polyurethane Foam Tests, 52, and Cooking Nuisance Smoke Test, 53.

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CONSTRUCTION

ASSEMBLY

17 General

17.1 Remote accessories

17.1.1 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.

17.2 Smoke sensitivity adjustment (single criteria)

17.2.1 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 42.1.1 (Sensitivity Test). 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.

17.3 Radioactive materials

17.3.1 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.

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

17.4 Supplementary signaling feature

17.4.1 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.

17.5 Insect guards

17.5.1 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).

17.5.2 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).

17.6 Supplementary heat sensor

17.6.1 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 connected in the smoke alarm circuit or be intended for connection to a separate circuit.

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17.6.2 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.

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17.6.3 A fixed-temperature heat alarm shall operate within the temperature tolerance range according to its rating as specified in the operating temperature test of the Standard for Single and Multiple Station Heat Alarms, UL 539.

18 Servicing and Maintenance Protection

18.1 General

18.1.1 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.

18.1.2 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 (5.9 in) of any side or behind the mechanism, unless guarded.

18.1.3 In determining compliance with 18.1.2 only uninsulated live parts in circuits above 30 Vrms shall be considered.

18.1.4 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.

18.1.5 Other arrangements of location of components and/or guarding shall be also acceptable where electrical components are accessible for service as indicated by 17.1.1 (Remote accessories).

18.1.6 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.

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

18.2 Sharp edges

18.2.1 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.

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19 Enclosure

19.1 General

19.1.1 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.

19.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two shall be evaluated in determining compliance with the requirement specified in 19.1.1.

19.1.3 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.

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

19.1.5 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.

19.1.6 To comply with 19.1.4 and 19.1.5, 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) The manufacturer's published instructions shall describe the location and method(s) of applying a sealing compound that has been found appropriate for the intended use.

19.1.7 Representative smoke alarms, unless otherwise noted, shall be subjected to the Smoke Entry (Stack Effect) Test, Section 45.

19.1.8 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.

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

19.2 Cast metal enclosures

19.2.1 The thickness of cast metal used for an enclosure shall be as indicated in Table 19.1, Cast-metal enclosures. Cast metal having a thickness 0.8 mm (1/32 in) less than that indicated in Table 19.1. Cast-metal enclosures 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.

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Table 19.1
Cast-metal enclosures

Use or dimensions of area involved	Minimum thickness			
	Die-cast metal,		Cast metal of other than the die-cast type,	
	mm	(in)	mm	(in)
Area of 155 cm^2 (24 in^2) or less and having no dimension greater than 152 mm (6 in)	1.6	(1/16)[a]	3.2	(1/2)
Area greater than 155 cm^2 (24 in^2) or having any dimension greater than 152 mm (6 in)	2.4	(3/32)	3.2	(1/8
At a threaded conduit hole	6.4	(1/4)	6.4	(1/4)
At an unthreaded conduit hole	3.2	(1/8)	3.2	(1/8)

[a] The area limitation for metal 1.6 mm (1/16 in) thick is obtained by the provision of reinforcing ribs subdividing a larger area.

19.2.2 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.

19.2.3 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.

19.3 Sheet metal enclosures

19.3.1 The thickness of sheet metal employed for the enclosure of a smoke alarm shall not be less than that indicated in Table 19.2, 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.

Table 19.2
Sheet metal enclosures

Maximum dimensions of enclosure				Minimum thickness of sheet metal								
Length or width,		Area,		Steel, zinc-coated,			Steel, uncoated,			Brass or aluminum,		
mm	(in)	cm^2	$(in)^2$	mm	(in)	GSG	mm	(in)	GSG	mm	(in)	AWG
305	(12)	581	(90)	0.86	(0.034)	20	0.81	(0.032)	20	1.14	(0.045)	16
610	(24)	2322	(360)	1.14	(0.045)	18	1.07	(0.042)	18	1.47	(0.058)	14
1219	(48)	7742	(1200)	1.42	(0.056)	16	1.35	(0.053)	16	1.91	(0.075)	12
1524	(60)	9678	(1500)	1.78	(0.070)	14	1.70	(0.067)	14	2.41	(0.095)	10
1524	(Over 60)	9678	(Over 1500)	2.46	(0.097)	12	2.36	(0.093)	12	3.10	(0.122)	8

19.3.2 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 1.59 mm (1/16 in).

19.3.3 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.

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19.3.4 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 25.1, Mounting of components.

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

19.3.6 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 36.

19.4 Nonmetallic enclosures

19.4.1 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 19.2, or Thickness of glass covers, Table 19.3. See also Tests on Polymeric Materials, Section 79.

Table 19.3
Thickness of glass covers

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

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

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

19.4.3 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 Flame test – 127-mm (5-in), 79.4.

b) Enclosures containing power limited circuits with a voltage not exceeding 30 volts AC, 42.4 volts-peak, or 60 volts DC – minimum flammability rating of:

1) V-2, or

2) HB and successful completion with the Flame test – 19-mm (3/4-in), as described in 79.3.

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

19.4.4 For 19.4.3, Flammability ratings are defined in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

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19.5 Ventilating openings

19.5.1 Ventilating openings in an enclosure, including 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 will permit passage of a rod having a diameter of 3.6 mm (9/64 in) for circuits greater than 30 V rms (42.4 V peak). An enclosure for fuses or other overload protective devices 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 paragraph apply with the cover open for circuits greater than 30 V rms (42.4 V peak).

19.5.2 Perforated sheet metal and sheet metal employed for expanded metal mesh shall not be less than 1 mm (0.039 in) in average thickness, 1.2 mm (0.047 in) when zinc coated.

19.5.3 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 (0.02 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 product has an area of not more than 465 cm^2 (72 in^2) and has no dimension greater than 300 mm (12 in), or

b) The width of an opening so protected is not greater than 90 mm (3-1/2 in).

19.5.4 The wires forming a screen employed as a smoke chamber cover shall be not less than 0.032 mm^2 (22 AWG) for steel and not less than 0.025 mm^2 (20 AWG) for aluminum.

19.6 Covers

19.6.1 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.

19.6.2 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.

19.6.3 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 99.1(s).

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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.

19.6.4 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." « Fusible (s) de circuit à l'intérieur – Débranchez l'alimentation pour effectuer une réparation ».

19.6.5 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.

19.7 Glass panels

19.7.1 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 19.3.

19.7.2 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.

19.7.3 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 Sections 37 – 89.

20 Corrosion Protection

20.1 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.

20.2 The requirement of 20.1 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.

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

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

20.5 Hinges and other attachments shall be resistant to corrosion.

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

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21 Field Wiring Connections

21.1 Permanent connection

21.1.1 A 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 the National Electrical Code, ANSI/NFPA 70.

21.2 Field wiring compartment

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

21.2.2 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.

21.3 Field wiring terminals (general)

21.3.1 A field-wiring terminal to which field-wiring connections are made shall comply with the requirements in 21.3.2 – 21.3.5 and:

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

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

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

d) 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.

21.3.2 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 5.3 mm^2 (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.

21.3.3 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 mm^2 (14 AWG) and a 2.8 mm (No. 4) diameter screw is appropriate for use for the connection of a 0.65 mm^2 (19 AWG) or smaller conductor.

21.3.4 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.

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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.

21.3.5 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.

21.4 Special field-wiring terminals (qualified application)

21.4.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in 21.4.2 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, push-in terminals (screwless) 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.

21.4.2 Any of the terminal configurations listed in 21.4.1 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 mm^2 (26 AWG) for a jacketed, multi-conductor cable or 0.82 mm^2 (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; and

d) The special field-wiring terminal assembly shall comply with the strain relief test as outlined in 80.3, Special field-wiring terminals.

21.5 Field wiring leads

21.5.1 Power supply leads provided for field connection shall not be less than 6 in (152 mm) long; shall be provided with strain relief; and shall not be smaller than 0.82 mm^2 (18 AWG). 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.

21.5.2 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 mm^2 (16 AWG), for a single conductor, 0.65 mm^2 (19 AWG) for two or more conductors, and 0.32 mm^2 (22 AWG) for four or more conductors of a multiconductor cable. The conductor shall be solid, bunch tinned

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stranded, or stranded copper. Stranded copper wire, consisting of not more than seven strands, shall be used only for 0.82 mm^2 (18 AWG) and larger conductors.

21.6 Grounding terminals and leads

21.6.1 Except as permitted by 21.6.9, 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 Primary power supply – battery, 86.3.1) by means of other than metal enclosed wiring system.

21.6.2 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.

21.6.3 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.

21.6.4 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.

21.6.5 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 color 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.

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

21.6.7 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.

21.6.8 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.

21.6.9 An equipment grounding terminal or lead is not required for a smoke alarm provided with an overall nonmetallic enclosure and cover and which is not intended to be internally serviced or a smoke alarm provided with an overall nonmetallic 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.

21.7 Power supply cord

21.7.1 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.

21.7.2 The flexible cord shall be minimum 0.82 mm^2 (18 AWG) and rated for use at the voltage and ampacity rating of the smoke alarm. Acceptable cord types are Type SP-1, SPT-1, SP-2, SPT-2, SV, SVT, SJ, SJT, SPE-1, SPE-2, SVE, or the equivalent in accordance with the National Electrical Code, ANSI/NFPA 70.

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21.7.3 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.

21.7.4 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 80.

22 Remote Power Supply

22.1 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 manufacturer's published 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 mm^2 (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.

22.2 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. However, the installation wiring diagram or manufacturer's published instructions shall be marked to specify that the wiring to be used shall be in accordance with the provisions of Articles 210 and 300.3 (B) of the National Electrical Code, ANSI/NFPA 70. Additionally, the resistance of the interconnecting wiring shall be a maximum of 10 ohms, unless otherwise specified by the manufacturer.

23 Internal Wiring

23.1 General

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

23.1.2 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.

23.1.3 When the use of a short length of insulated conductor is not feasible, such as for a short coil lead or the like, electrical insulating tubing shall be used. The tubing shall not be subjected to sharp bends, tension, compression, or repeated flexing and shall not contact sharp edges, projections, or corners. The wall thickness of the tubing shall comply with 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).

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23.1.4 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 23.4, Barriers.

23.1.5 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.

23.2 Wireways

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

23.3 Splices

23.3.1 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 seconds and the connection is subjected to 100 percent inspection and testing with the same pull force by the manufacturer.

23.3.2 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.

23.3.3 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.

23.4 Barriers

23.4.1 A metal barrier shall have a thickness at least equal to that required by Table 19.2, 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 its deformation is readily accomplished so as to defeat its purpose. Any clearance between the edge of a barrier and a compartment wall shall not exceed 1.6 mm (1/16 in).

23.5 Strain relief

23.5.1 A strain relief means shall be provided for the field 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 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, 80.

24 Bonding for Grounding

24.1 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.

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24.2 Except as indicated in 24.3, uninsulated metal parts of electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors, and other electrical components shall be

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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.

24.3 Metal parts as described below are not required to comply with the requirement specified in 24.2:

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 do not become energized.

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

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

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

24.4 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.

24.5 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.

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

COMPONENTS

25 General

25.1 Mounting of components

25.1.1 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 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.

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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 direct contact by persons.

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

25.1.2 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 permitted.

25.1.3 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.

25.2 Operating components

25.2.1 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.

25.2.2 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 permitted.

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

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

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

25.3 Current-carrying parts

25.3.1 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.

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

26 Bushings

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

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26.2 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.

26.3 Ceramic materials and some molded compositions are permissible for insulating bushings. Separate bushings of wood and of hot-molded shellac shall not be used.

26.4 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.

26.5 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.

26.6 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.

27 Electrical Insulating Material

27.1 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.

27.2 Polymeric materials shall be used for the sole support of uninsulated live parts only when determined to be equivalent to the materials indicated in 27.1.

27.3 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.

27.4 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 27.1.

Table 27.1
Thickness of flat sheets of insulating material

Maximum dimensions				Minimum thickness,[a]	
Length or width,		Area,			
mm	(in)	cm^2	(in^2)	mm	(in)
152	(6)	232.4	(36)	1.6	(1/16)
305	(12)	928.8	(144)	3.2	(1/8)
610	(24)	2322	(360)	9.5	(3/8)
1219	(48)	7432	(1152)	12.7	(1/2)
1219	(48)	11148	(1728)	15.9	(5/8)
Over 1219	(Over 48)	Over 11148	(Over 1728)	19.1	(3/4)

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

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27.5 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 27.1.

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

27.6 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).

28 Lampholders and Lamps

28.1 A smoke alarm intended to be connected to a utility supply, either directly or via a separate power supply as described in 18.1 shall be provided with a steady or pulsed "power-on" lamp to indicate energization of the unit. If pulsed, the lamp shall flash at least once per minute.

28.2 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.

28.3 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.

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

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

28.6 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.

29 Photocell Illuminating Lamps and Light Emitting Diodes (LEDs)

29.1 General

29.1.1 An LED used as a light source of a smoke alarm employing a photocell light assembly shall comply with electrical supervision requirements specified in 41.5, Battery powered (primary or secondary) smoke alarms, and the reliability prediction specified in Section 7, Smoke Alarm Reliability Prediction.

29.1.2 To be determined reliable, an LED shall comply with 7.4 and with the requirements specified in 41.3.6. 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 Quality assurance program, 29.2.

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29.1.3 A reliable LED that complies with the requirement specified in 29.1.2 shall additionally comply with the requirements specified in the Reduction in Light Output Test, Section 46, and the electrical supervision requirements described in 41.3.2 – 41.3.5.

29.2 Quality assurance program

29.2.1 Light emitting diode (LED) manufacturer

29.2.1.1 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 percent production tests of light output, forward conduction, leakage, and reverse breakdown are performed on the finished LED.

29.2.2 Smoke alarm manufacturer

29.2.2.1 The smoke alarm manufacturer shall conduct the following minimum quality assurance program 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; or

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

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

1) Light output;

2) Maximum forward voltage drop at specified forward current; and

3) Maximum reverse leakage current at specified reverse voltage.

29.2.2.2 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 percent inspection for light output.

30 Protective Devices

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

31 Printed Wiring Boards

31.1 Printed-wiring boards shall be suitable for the application. The securing of components to the board shall be made in the intended manner and the spacings between circuits shall comply with the requirements for Spacings, Section 36. The board shall be reliably mounted so that deflection of the board

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during installation or servicing shall not result in damage to the board or in developing a risk of fire or electric shock.

31.2 All printed-wiring boards shall have a minimum flammability rating of V-2, rated for direct support of current-carrying parts, and be suitable for the soldering process used.

32 Switches

32.1 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.

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

32.3 An alarm silencing switch or equivalent means shall be provided so that its off-normal position results in an audible smoke alarm trouble signal, or following alarm silencing the unit automatically returns to normal condition after a timed interval as specified in Section 13, Alarm Silencing Feature.

33 Transformers and Coils

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

33.2 A transformer shall meet the requirements of the Standard for Specialty Transformers, UL 506.

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

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 21.6.1 and 21.6.2.

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

34 Dropping Resistors

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

35 Power Supplies

35.1 Primary power supply

35.1.1 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.

35.1.2 When a separate power supply is provided, it shall have limited output energy consisting of an open circuit voltage not in excess of 30 volts rms, 42.4 volts 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.

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35.2 Secondary power supply

35.2.1 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 minutes 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 41.5, Battery powered (primary or secondary) smoke alarms. Smoke alarms consisting of battery primary power shall not be subject to this requirement.

35.2.2 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, 86.3.

35.2.3 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.

35.2.4 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.

35.2.5 The discharge condition of a non-rechargeable or rechargeable type battery shall be monitored where a trouble indication, as described in 41.5.3 is obtained. The monitoring shall take place whether the alarm is operating on the primary supply or on the standby supply.

36 Spacings

36.1 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 36.1.

Exception: In accordance with Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, for printed-wiring boards having a flammability classification of V-0, spacings (other than spacings to dead metal traces, between primary and secondary circuits, and at field wiring terminals) are not specified between traces of different potential connected in the same circuit when:

a) The spacings are adequate to comply with the requirements in 87.4, Evaluation of reduced spacings on printed-wiring boards; or

b) An analysis of the circuit indicates that no more than 12.5 mA of current is available between short-circuited traces having reduced spacings.

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Table 36.1
Minimum spacings

Point of application	Voltage range[f]	Minimum spacings[a,b]			
		Through-air,		Over-surface,	
		mm	(in)	mm	(in)
To walls of enclosure					
Cast metal enclosures	0 – 300	6.4	(1/4)	6.4	(1/4)
Sheet metal enclosures	0 – 300	12.7	(1/2)	12.7	(1/2)
Installation wiring terminals					
With barriers	0 – 30	3.2	(1/8)	4.8	(3/16)
	31 – 150	3.2	(1/8)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)
Without barriers	0 – 30	4.8	(3/16)	4.8	(3/16)
	31 – 150	6.4	(1/4)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.5	(3/8)
Rigidly clamped assemblies[c]					
100 volt-amperes maximum[d,e]	0 – 30	0.8	(1/32)	0.8	(1/32)
Over 100 volt-amperes[e]	0 – 30	1.2	(3/64)	1.2	(3/64)
	31 – 150	1.6	(1/16)	1.6	(1/16)
	151 – 300	2.4	(3/32)	2.4	(3/32)
Other parts	0 – 30	1.6	(1/16)	3.2	(1/8)
	31 – 150	3.2	(1/8)	6.4	(1/4)
	151 – 300	6.4	(1/4)	9.	(3/8)

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

[b] Measurements are to be made with solid wire of adequate ampacity for the applied load connected to each terminal. In no case is the wire to be smaller than 1.3 mm^2 (16 AWG).

[c] Rigidly clamped assemblies include such parts as contact springs on relays or cam switches, printed-wiring boards, and similar assemblies.

[d] Spacings less than those indicated, and not less than 0.4 mm (1/64 in), are appropriate for the connection of integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 0.8 mm (1/32 in).

[e] When spacings between traces on a printed-wiring board are less than the minimum specified, the boards shall be covered with a conformal coating, and the combination shall be evaluated to the requirements in Conformal Coatings of Printed-Wiring Boards, Section 87.

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

36.2 The spacings shall not be less than that indicated in Table 36.1 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.

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36.3 The Through Air and Over Surface spacings of Table 36.1 measured at an individual component part shall be judged on the basis of the volt-amperes used and controlled by the individual component.

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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.

36.4 The spacing requirements specified of Table 36.1 do not apply to the inherent spacings inside motors, except at wiring terminals, nor to inherent spacings for a component provided as part of the 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 of Table 36.1.

36.5 The "To Walls of Enclosure" spacings of Table 36.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

36.6 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.

36.7 Spacings on printed-wiring boards which are less than those indicated in Table 36.1 shall be provided with a coating in compliance with Conformal Coatings on Printed-Wiring Boards, Section 87.

PERFORMANCE

37 General

37.1 Test units

37.1.1 Smoke alarms and power supply units that are fully representative of production units shall be used for the tests specified in Sections 38 – 98, 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 production gas sensitivity, for multi-criteria smoke alarms.

37.1.2 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 35.1.2 shall be tested as a combination, and the applicable requirements of the test also applied to the power supply unit. See Section 88, Power Supply Tests.

37.2 Performance of single sensor components of multi-criteria smoke alarms

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

37.2.2 The performance of the multi-criteria smoke alarm shall meet the requirements of this standard except for the smoke sensitivity limit specified in Table 37.1 and Table 37.2. Manufacturers shall provide samples that reflect and information that identifies the combined and discreet maximum and minimum sensitivities of each constituent sensor.

Table 37.1
Most sensitive visible smoke obscuration limits (gray smoke)

Percent per m	(Percent per ft)	OD per m	(OD per ft)
1.6	(0.5)	0.0072	0.0022
Note: Refer to Annex B for the calculation of obscuration and optical density.			

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Table 37.2
Measuring Ionization Chamber (MIC) measurement

93 pA (maximum)
*NOTE: Smoke Density X is derived as follows: X = (Io - I) / Io *Where:* Io is the quiescent chamber current in clean air in pA, and I is the reduced chamber current when smoke is present in pA.
Refer to Annex B for the calculation of obscuration and optical density.

37.3 Test voltages

37.3.1 Unless otherwise specified, the test voltage for each test shall be as specified in Table 37.3 and at rated frequency.

Table 37.3
Test voltages

Nameplate voltage rating	Test voltage[a]
110 to 120	120
220 to 240	240
Other	Maximum marked nameplate rating
[a] Smoke alarms rated at frequencies other than 60 Hz shall be tested at their rated nameplate voltage and frequency.	

37.4 Test samples and data

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

a) At least 28 assembled 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 percent from any other unit in each setting (max, min, or nominal), 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 42. 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 46.2.

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) Manufacturer's Published Instructions, Section 8 and INSTRUCTIONS, General, Section 101.

f) A copy of the Technical Bulletin if applicable. See 102.1.5.

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g) Where applicable, samples of conformal coated printed-wiring boards, as specified in Conformal Coatings on Printed-Wiring Boards, Section 87.

h) Power supplies, if the smoke alarms are intended to be employed with specific power supply.

37.4.2 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 Battery tests, 86.3.

37.4.3 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.

37.4.4 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 tests, 86.3.

37.5 Component reliability data

37.5.1 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.

37.5.2 The data required by 37.5.1 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 37.4, Temperature test;

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 29, 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; and

i) Component failure rate data at rated values and derated values.

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Table 37.4
Maximum temperature rises

Materials and components	Normal standby, °C	(°F)	(Signaling) alarm condition, °C	(°F)
A. COMPONENTS				
1. Capacitors:[a, b]				
a. Electrolytic types	25	(45)	40	(72)
b. Other types	25	(45)	65	(117)
2. Rectifiers – At any point				
a. Germanium	25	(45)	50	(90)
b. Selenium	25	(45)	50	(90)
c. Silicon				
(i) Maximum 60 percent of rated voltage	50	(90)	75	(135)
(ii) 61 percent or more of rated voltage	25	(45)	75	(135)
3. Relay, solenoid, transformer, and other coils with:				
a. Class 105 insulation system:				
Thermocouple method	25	(45)	65	(117)
Resistance method	35	(63)	75	(135)
b. Class 130 insulation system:				
Thermocouple method	45	(81)	85	(153)
Resistance method	55	(99)	95	(171)
c. Class 155 insulation system:				
(i) Class 2 transformers:				
Thermocouple method	95	(171)	95	(171)
Resistance method	115	(207)	115	(207)
(ii) Power transformers:				
Thermocouple method	110	(198)	110	(198)
Resistance method	115	(207)	115	(207)
d. Class 180 insulation system:				
(i) Class 2 transformers:				
Thermocouple method	115	(207)	115	(207)
Resistance method	135	(243)	135	(243)
(ii) Power transformers:				
Thermocouple method	125	(225)	125	(225)
Resistance method	135	(243)	135	(243)
4. Resistors:[c]				
a. Carbon	25	(45)	50	(90)
b. Wire wound	50	(90)	125	(225)
c. Other	25	(45)	50	(90)
5. Solid state devices	See footnote d			
6. Other components and materials:				
a. Fiber used as electrical insulation or cord bushings	25	(45)	65	(117)

Table 37.4 Continued on Next Page

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Table 37.4 Continued

Materials and components	Normal standby, °C	(°F)	(Signaling) alarm condition, °C	(°F)
b. Varnished cloth insulation	25	(45)	60	(108)
c. Thermoplastic materials	Rise based on temperature limit of the material			
d. Phenolic composition used as electrical insulation or as parts whose malfunction or deterioration results in a risk of electric shock, explosion, fire, or injury to persons[e]				
e. Wood or other combustibles	25	(45)	125	(225)
f. Sealing compound	25	(45)	65	(117)
g. Fuses	25	(45)	65	(117)
B. CONDUCTORS				
1. Appliance wiring material[f]	25 °C (45°F) less than the temperature limit of the wire			
2. Flexible cord (for example, SJO, SJT)	35	(63)	35	(63)
3. Conductors of field-wired circuits to be permanently connected to the product	35	(63)	35	(63)
C. GENERAL				
1. All surfaces of the product and surfaces adjacent to or upon which the product is be mounted	65	(117)	65	(17)
2. Surfaces normally contacted by the user in operating the unit (such as control knobs, push buttons, and levers):				
a. Metal	35	(63)	35	(63)
b. Nonmetallic	60	(108)	60	(108)
3. Surfaces subjected to casual contact by the user (such as the enclosure or grille):				
a. Metal	45	(81)	45	(81)
b. Nonmetallic	65	(117)	65	(117)

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

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

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

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

1) The integrated circuit (microcircuits) complies with the requirements of MIL-STD.883H..

2) The semiconductor devices comply with the requirements of MIL-STD 750E.

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

4) Each assembled production unit is subjected to a burn-in test, under the condition which results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F) followed by a Normal Operation Test, Section 38.

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

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

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