UL 2075

Gas and Vapor Detectors and Sensors

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UL Standard for Safety for Gas and Vapor Detectors and Sensors, UL 2075

First Edition, Dated November 5, 2004

Revisions: This Standard contains revisions through and including September 28, 2007.

Summary of Topics

These revisions have been issued to update the effective date of the Standard. No changes in requirements are involved.

A change in an effective date is indicated by a note following the affected item, and giving both the previous effective date and the new date the requirement becomes effective.

The following table lists the future effective dates with the corresponding reference.

Future Effective Date	References
September 1, 2009	Entire standard

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Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revisions dated September 28, 2007 include a reprinted title page (page1) for this Standard.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: http://ulstandardsinfonet.ul.com/ulforeword.html

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

This Standard consists of pages dated as shown in the following checklist:

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UL 2075

Standard for Gas and Vapor Detectors and Sensors

First Edition

November 5, 2004

The most recent designation of ANSI/UL 2075 as an American National Standard (ANSI) occurred on July 11, 2007. The ANSI approval for this standard does not include Supplement SA or Appendix A.

This ANSI/UL Standard for Safety, which consists of the First Edition, with revisions through September 28, 2007, is under continuous maintenance, whereby each revision is ANSI approved upon publication.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc. and is not part of the ANSI standard.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. 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 http://csds.ul.com.

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INTRODUCTION

1 Scope

Effective date for 1 changed from November 5, 2006 to September 1, 2009

1.1 These requirements cover toxic and combustible gas and vapor detectors and sensors intended to be portable or employed in indoor or outdoor locations in accordance with the National Electrical Code, NFPA 70. A gas detector and/or sensor and/or vapor detector, as covered by these requirements, consists of an assembly of electrical components coupled with a sensing means inside a chamber, or by separate components to detect toxic and/or combustible gases or vapors. The detector includes provision for the connection to a source of power and signaling circuits.

1.2 These requirements cover the following types of detectors:

a) Detectors intended for monitoring the environment and detectors intended for open area protection and for connection to a compatible power supply or control unit for operation as part of gas detection or emergency signaling systems;

b) Detectors intended solely for control of ventilation or shut off devices such as fans or control valves;

c) Detectors intended for both the above applications;

d) Sensors and sensing circuits intended for use with or in gas detectors, alarms or gas detection circuits within fuel cell systems;

e) Portable gas detectors;

f) Multi-gas gas detectors;

g) Multi-gas sensors and

h) Equipment intended for use in hazardous locations. Note, the equipment must comply with the applicable hazardous location requirements prior to evaluation to UL 2075.

1.3 These requirements also cover all remote accessories that are intended to be connected to a gas or vapor detector and/or sensor.

1.4 This standard does not cover the following:

a) Control units to which the detectors are intended to be connected that are covered by the Standard for Control Units for Fire-Protective Signaling Systems, UL 864;

b) Control units to which the detectors are intended to be connected that are covered by the Standard for General Purpose Signaling Devices and Systems, UL 2017;

c) Self-contained single and multiple station carbon monoxide alarms or residential combustible gas detectors, not intended for connection to a system control unit, that are covered by the Standard for Single and Multiple Station Carbon Monoxide Alarms, UL 2034 or Residential Gas Detectors, UL 1484;

d) Automatic flammable vapor sensor systems and components covered by the Standard for Automatic Flammable Vapor Sensor Systems and Components, Z21.94/CSA 6.3.

1.4 revised July 11, 2007

1.5 Users of these requirements will additionally need to ensure that influencing factors not addressed in this standard for the end product installation, such as mechanical movement, field placement of conductive material, and product damage, will not affect the system for insulation coordination or performance operation. Examples are the deformation of the enclosure, movement of the fittings for conduit or armored cable, or the improper installation of field wiring.

2 General

Effective date for 2 changed from November 5, 2006 to September 1, 2009

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component.

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

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

b) Is superseded by a requirement in this standard.

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

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

2.2 Units of measurement

2.2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.3 Undated references

2.3.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

No Text on This Page

3 Glossary

Effective date for 3 changed from November 5, 2006 to September 1, 2009

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

3.2 ALARM SIGNAL – A signal intended to indicate an emergency condition.

3.3 ALARM VERIFICATION – The process that confirms the presence of an abnormal concentration of a gas vapor for a predetermined period before an alarm signal is indicated.

3.4 COMPONENT, LIMITED-LIFE – A component that is expected to fail and be periodically replaced and the failure of which is supervised, when failure of the component affects the intended operation, sensitivity, or both. Typical examples of such components include incandescent lamps, electronic tube heaters, and functional heating elements.

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

3.6 GAS OR VAPOR DETECTOR, TWO-WIRE TYPE – A detector that signals over, and obtains its power from, the initiating device circuit of an emergency system control unit. It is not prohibited to provide additional terminals or leads for annunciation or control of supplementary functions. This may be referred to as an alarm and/or detector throughout this Standard.

3.7 LIMITED OUTDOOR ENVIRONMENT – An ambient air environment that is not climate controlled and is not in direct contact with the elements of nature, such as wind, rain, sleet or snow. Examples of limited outdoor environments include parking garages, construction complexes, sports venues, boats and recreational vehicles.

3.8 LOWER EXPLOSIVE LIMIT (LEL) – Volume ratio of flammable gas or vapor in air below which an explosive gas atmosphere does not form, expressed as a percentage.

3.9 MANUFACTURER’S TEST PROGRAM – The tests described in Section 51 through Section 57, Manufacturing and Production Tests, of this standard are to be conducted by the manufacturer on a periodic or 100 percent basis.

3.10 OPEN PATH DETECTOR – An apparatus for the detection and measurement of combustible or toxic gases or vapors in ambient air by measuring the spectral absorption associated with the gases or vapors over extended optical paths, ranging typically from one meter to a few kilometers.

The apparatus can measure the integral concentration of the absorbing gas over the optical path in units such as LEL meter for combustible gases and ppm meter for toxic gases.

3.11 PPM – Gas concentration in parts per million. Ten thousand parts per million is equivalent to 1 percent gas by volume.

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

a) The potential between the part and earth ground or any other accessible part is more than 42.4 volts peak, and

b) The continuous current flow through a 1500-ohm resistor connected across the potential exceeds 0.5 milliampere.

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

a) The open circuit voltage is more than 42.4 volts peak and the energy available to the circuit under any condition of load, including short circuit, results in a current of 8 amperes or more after 1 minute of operation, or

b) A power of more than 15 watts shall only be delivered in an external resistor connected between the two points.

3.14 SENSITIVITY – Relative degree of response of a detector alarm or sensor. A high sensitivity denotes response to a lower concentration of gas or vapor than a low sensitivity under identical conditions.

3.15 SENSOR The component or combination of components of the detector/alarm that responds to and in turn provides a usable output signal in the presence of a combustible and/or toxic gas.

3.16 TROUBLE SIGNAL – A visible or audible signal intended to indicate a fault or trouble condition, such as an open or shorted condition of a component in the device or an open or ground condition in the connected wiring. The signal is indicated at the control unit to which the detector is connected.

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

a) Low-Voltage Circuit – A circuit classified as low-voltage is one involving a potential of not more than 30 volts alternating current (ac) [42.4 volts peak or direct-current (dc)], and supplied from a circuit whose power is limited to a maximum of 100 volt-amperes (VA).

b) High-Voltage Circuit – A circuit classified as high-voltage is one having circuit characteristics in excess of those of a low-voltage circuit.

4 Alarm, Sensor and/or Detector Reliability Prediction

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4.1 The maximum failure rate for an alarm, detector assembly or circuit shall be 4.0 failures per million hours as calculated by a full part stress analysis prediction as described in Section 2.0 of MIL-HDBK 217F (December 2, 1991) or 3.5 failures per million hours as calculated by a simplified parts count reliability prediction as described in Appendix A of MIL-HDBK 217F, or equivalent. A ″Ground Fixed″ (GF) environment is to be used for all calculations. When actual equivalent data is available from the manufacturer it is not prohibited that it be used in lieu of the projected data for the purpose of determining reliability.

4.2 The maximum failure rate for a sensor or individual component is 2.5 failures per million hours as calculated by a full part stress analysis prediction as described in Section 3.4 of MIL-HDBK 217F (December 2, 1991) or equivalent. A ″Ground Fixed″ (GF) environment is to be used for all calculations. When actual equivalent data is available from the manufacturer it is not prohibited that it be used in lieu of the projected data for the purpose of determining reliability.

4.3 Any component whose failure:

a) Results in energization of an audible trouble signal, energization of a separate visual indication, or de-energization of a power-on light;

b) Does not effect the normal operation or sensitivity; or

c) Is evaluated by specific performance tests included in the standard;

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

4.4 An integral or remote accessory, such as an integral transmitter or remote sounding appliance, is not required to be included in the reliability prediction except for those components whose failure affects the normal operation of the detector.

4.5 A custom integrated circuit (CHIP) employed in an 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 an evaluation of data in a 3000-hour burn-in test, or equivalent. (See Supplement SA for information on evaluation methods.)

4.6 A sensor, or a sensing component supervision system, shall be provided with the following:

a) Reliability data developed using the Military Standardization Handbook, MIL 217-F or equivalent demonstrating a predicted failure rate of not more than 2.5 failures per million hours operation (see 4.4); or

b) Supervision of the predicted failure modes other than for loss of electrical continuity. Documentation of the failure modes resulting from aging for the sensor or the sensing components and identification of failure modes addressed by the supervision system shall be provided. The manufacturer shall submit a test method to render the sensor unresponsive to the gas concentrations identified in Section 15 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 17. All predicted failure modes shall result in a trouble signal; or

c) Supervision of the sensor drift beyond 5% of the predicted operating range.

5 Installation and Operating Instructions

Effective date for 5 changed from November 5, 2006 to September 1, 2009

5.1 A copy of the installation and operating instructions and related schematic wiring diagrams and installation drawings, shall be used as a reference in the examination and test of the detector.

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

6 Compatibility

Effective date for 6 changed from November 5, 2006 to September 1, 2009

6.1 The interconnection of the product with other products shall be evaluated for the purpose of operating as a coordinated system relative to the intended alarm signaling and without risk of fire, shock, or injury to persons.

6.2 The requirements in 6.1 apply to:

a) Separate products connected to any circuit and by which the operating parts of the product are actuated for signaling and/or action and

b) Separate or incorporated appliances or units by which signals are indicated or actions carried out.

6.3 Power circuits interconnecting products shall have compatible voltage and current ratings.

6.4 All equipment directly connected to the product shall be evaluated for the application.

CONSTRUCTION

ASSEMBLY

7 General

Effective date for 7 changed from November 5, 2006 to September 1, 2009

7.1 Remote access

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

7.2 Sensitivity indicating means

7.2.1 Each alarm or detector shall be provided with a means for measuring or indicating the nominal sensitivity or sensitivity range of the detector as described in 7.2.2, or a sensitivity test feature as described in 7.2.3, after it has been installed as intended. Removal of a snap-on cover to gain access to the sensitivity control is permissible only when no high-voltage parts are exposed or able to be contacted by the user.

7.2.2 The test feature is to verify that the sensitivity of the detector is within its marked range. Unless it is employed on a detector that has other means of measuring its sensitivity, the test feature shall consist of either an electrical means or a mechanical device which simulates a specified level of gas at the sensor.

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

ALL PRODUCTS

8 General

Effective date for 8 changed from November 5, 2006 to September 1, 2009

8.1 A product shall use materials that have been determined to comply with the requirements for the particular use, as indicated by the performance requirements of this standard.

8.2 Metals shall not be used in such combination as to cause galvanic action that increases the risk of fire, electric shock, injury to persons, or impairs the operation of a product associated with the safety of life and/or the protection of property.

8.3 When breakage or deterioration of a part such as an enclosure, frame, or guard, results in a risk of injury to persons, then the part shall be constructed to meet the demand or expected loading conditions.

8.4 The requirement in8.3 also applies to those positions of a part adjacent to a moving part identified to involve a risk of injury to persons.

9 Enclosure

Effective date for 9 changed from November 5, 2006 to September 1, 2009

9.1 General

9.1.1 All electrical parts of a product shall be enclosed to provide protection of internal components and prevent contact with uninsulated live parts.

9.1.2 Enclosures shall have the strength and rigidity to resist the abuses to which the product is likely to be subjected during intended use without increasing the risk of fire, electrical shock, or injury to persons.

9.2 Metallic material

9.2.1 An enclosure of metal shall have dimensions as specified in Tables 9.1, 9.2, or 9.3 or shall comply with the test requirements in Mechanical Strength Tests for Metal Enclosures and Guards, Section 43.

Table 9.1
Cast-metal electrical enclosures

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

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

9.2.2 When threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or when a construction that is determined to be the equivalent is used, there shall not be less than 3-1/2 nor more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing is capable of being attached.

9.2.3 When threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall not be less than five full threads in the metal. There shall be a smooth, rounded inlet hole for the conductors which shall provide protection to the conductors determined to be the equivalent to that provided by a standard conduit bushing.

9.2.4 At any point where conduit or metal-clad cable is attached to the enclosure the sheet metal shall be a minimum of 0.032 inch (0.81 mm) thick, or shall be formed or reinforced so that it shall have the minimum stiffness of an uncoated flat sheet of steel.

9.2.5 With reference to Table 9.1 a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

a) Single sheet with single formed flanges (formed edges),

b) A single sheet which is corrugated or ribbed, and

c) An enclosure surface loosely attached to a frame, for example, with spring clips.

9.3 Polymeric materials

9.3.1 Polymeric materials used as an enclosure shall comply with the applicable portion of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and also with the additional requirements specified in this standard.

9.3.2 Polymeric material that is not used as an enclosure, but is attached to or exposed on the outside of a product, such as a viewing window, shall have flammability characteristics as shown in Table 9.2.

Table 9.2
Flammability characteristics of polymeric material

Polymeric material area/dimensions	Flammability rating
0.24 inches ^{3} (4 cm^3) and 2.4 inches (61 mm) maximum length	None
Greater than 0.24 inches ^{3} (4 cm^3) and less than 2 square feet (0.19 m^2), 6 feet (1.83 m) maximum length	HB, V-2, V-1, V-0 or 5V
Greater than 2 square feet (0.19 m^2) and less than 10 square feet (0.93 m^2), 6 feet (1.83 m) maximum length	V-1, V-0 or 5V
Greater than 10 square feet (0.93 m^2), or longer than 6 feet (1.83 m)	Maximum flame spread rating of 200 as specified in the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723 or radiant panel as specified in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

9.3.3 Conductive coatings applied to nonmetallic surfaces, such as the inside surface of an enclosure, shall comply with the appropriate requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, unless flaking or peeling of the coating does not result in the reduction of spacings or the bridging of live parts.

9.3.4 A polymeric enclosure intended for connection to a rigid metallic conduit system shall comply with the requirements for polymeric enclosure rigid metallic conduit connections in the Standard for Enclosures for Electrical Equipment, UL 50.

9.3.5 The continuity of a conduit system shall be provided by metal-to-metal contact and not rely on a polymeric material and shall comply with the requirements for polymeric enclosure bonding in the Standard for Enclosures for Electrical Equipment, UL 50.

9.4 Sensitivity adjustment

9.4.1 A field sensitivity adjustment, when provided, shall be accessible with the sensor detector or alarm installed as intended, marked to indicate the direction of sensitivity (high or low), and shall employ a mechanical stop at both extremes. Removal of a snap-on cover to gain access to the sensitivity control is permissible only when no hazardous voltage parts are able to be contacted by the user. Adjustment extremes shall not exceed the values specified by the manufacturers operating range for the unit.

9.5 Supplementary signaling feature

9.5.1 A supplementary signaling feature, such as a transmitter for remote signaling, included integrally with the device, shall be evaluated to the applicable requirements and determined suitable for it's intended application.

9.6 Sharp edges

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

9.7 Ventilating openings

9.7.1 Ventilating openings in an enclosure for hazardous-voltage circuits, including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening will permit passage of a rod having a diameter of 9/64 inch (3.6 mm). An enclosure for a fuse(s) or other overload protective device provided with ventilating openings, shall afford 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 constructed to reduce the risk of damage to functional internal components during such cleaning operations.

9.7.2 Except as noted in 9.7.3, perforated sheet metal employed for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) in average thickness [0.046 inch (1.17 mm) when zinc coated].

9.7.3 Expanded metal mesh 0.021 inch (0.53 mm) thick, or zinc coated perforated sheet metal 0.024 inch (0.61 mm) thick, shall be used only when the following conditions are met:

a) The indentation of the guard or enclosure does not alter the clearance between uninsulated live parts and grounded metal so as to reduce the spacings below the minimum values required; and either

b) The exposed mesh on any one side or surface of the product has an area of not more than 72 square inches (465 cm^2) with no dimension greater than 12 inches (305 mm) or

c) The width of an opening so protected is not more than 3-1/2 inches (88.9 mm).

9.7.4 The wire forming a screen protecting hazardous-voltage parts shall not be smaller than 16 AWG (1.3 mm^2) and the screen openings shall not be greater than 1/2 square inch (3.2 cm^2).

9.8 Covers

9.8.1 An enclosure cover shall be hinged, sliding, pivoted, or similarly attached when:

a) It provides ready access to fuses or any other overcurrent protective device requiring renewal or

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

For the purpose of this requirement intended operation is considered to be operation of a switch for testing or operation of any other component of the device that requires such action in connection with its intended performance. This requirement does not apply to the battery replacement aspect of a device employing a battery as either the main or standby power supply.

9.8.2 A cover that is intended to be removed only for periodic maintenance shall be secured by any one of the following or equivalent means: positive snap catch, plug-in or twist action, snap tab with one screw, or two or more screws.

9.8.3 When a cover is not intended to be removed for cleaning or maintenance, and the device is intended to be returned to the factory for servicing, the cover shall be secured so that it is not readily removed. Exposed screw slots or nuts, other than a tamper-proof type, shall be sealed or covered.

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

9.8.4 A hinged cover is not required where the only fuse(s) enclosed is intended to provide protection to portions of internal circuits, such as may be employed on a separate printed-wiring board or circuit subassembly, to prevent circuit damage resulting form a fault. Such a fuse(s) shall only be used when the word ″CAUTION″ and the following, or equivalent marking is located on the cover of a device employing hazardous-voltage circuits: ″Circuit Fuse(s) Inside – Disconnect Power Prior to Servicing″.

9.8.5 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 a means determined to be equivalent.

9.9 Battery Removal Indicator

9.9.1 Removal of a battery from a battery-operated gas detector or alarm shall result in a readily apparent and prominent visual indication. The visual indication shall consist of:

a) A warning flag that will be exposed with the battery removed and the cover closed,

b) A hinged cover that cannot be closed with the battery removed, or

c) An equivalent arrangement.

9.9.2 If a warning flag, or equivalent, is employed to comply with the requirement of 9.9.1, it shall be marked as required in 49.1.1 (k).

9.10 Transparent panels

9.10.1 Glass covering an enclosure opening shall be held securely in place so that it does not displace in service and shall provide mechanical protection of the enclosed parts. The thickness of a glass cover shall not be less than that indicated in Table 9.3.

Table 9.3
Thickness of glass covers

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

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

9.10.2 A transparent material other than glass employed as a cover over an opening in an enclosure shall:

a) Be mechanically equivalent to glass,

b) Not distort, and

c) Not become less transparent at the temperature to which it is subjected under normal service conditions.

9.10.3 A lens, light filter, or similar part of a gas or vapor detector shall be constructed of a material whose transparency will not be diminished by the conditions to which it will be exposed in service, as represented by the performance tests of this Standard.

9.11 Accessibility of uninsulated live parts, film-coated wire, and moving parts

9.11.1 To reduce the risk of unintentional contact and risk of electric shock from an uninsulated live part or film-coated wire, and injury to persons from a moving part, an opening in an enclosure shall have a minor dimension less than 1 inch (25.4 mm), and such a part or wire shall not be contacted by the probe illustrated in Figure 9.1.

9.11.2 The probe mentioned in 9.11.1 shall be applied to any depth that the opening will permit. The probe shall be rotated or angled before, during, and after insertion through the opening to any position that is required in order to examine the enclosure. The probe illustrated in Figure 9.1 shall be applied in any possible configuration and, when necessary, the configuration shall be changed after insertion through the opening.

9.11.3 The probe mentioned in 9.11.1 shall be used as a measuring instrument to evaluate the accessibility provided by an opening, and not as an instrument to evaluate the strength of a material. It shall be applied with the minimum force required to determine accessibility.

9.11.4 During the examination of a product to determine whether it complies with the requirement in 9.11.1, a part of the enclosure that is to be opened or removed by the operator without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) shall be opened or removed.

10 Spacings

Effective date for 10 changed from November 5, 2006 to September 1, 2009

10.1 A product shall provide maintained spacings between uninsulated live parts and the enclosure or dead metal parts, and between uninsulated live parts of opposite polarity. The spacings shall not be less than those indicated in Table 10.1.

Figure 9.1
Articulated probe

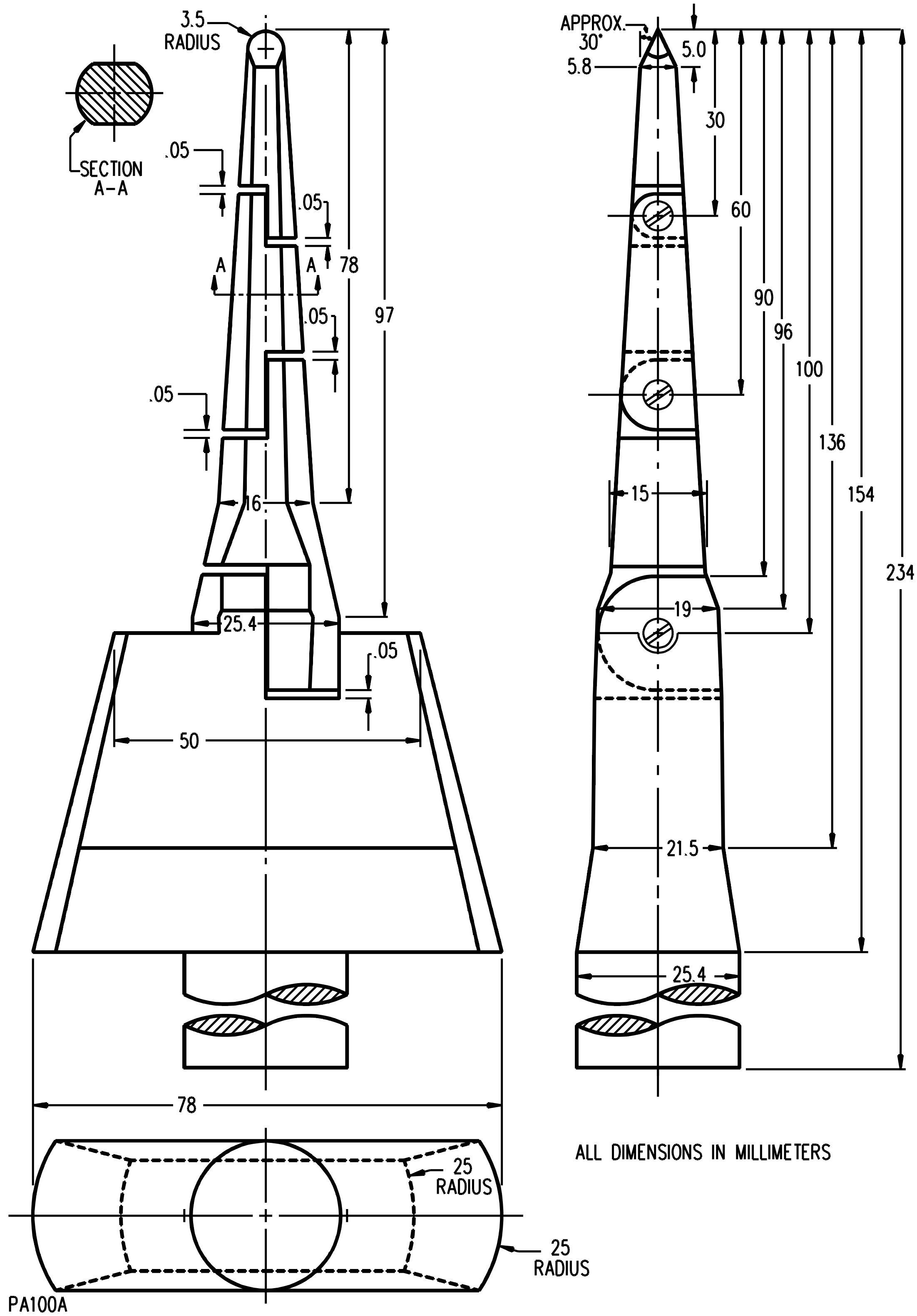

Table 10.1
Minimum spacings

Point of application	Minimum spacings				
	Voltage range,	Through air,		Over surface,	
	volts	inch	(mm)	inch	(mm)
To walls of enclosure					
Cast metal enclosures	0 – 300	1/4	6.4	1/4	6.4
Sheet metal enclosures	0 – 50	1/4	6.4	1/4	6.4
	51 – 300	1/2	12.7	1/2	12.7
Installation wiring terminals:					
(General application)[a,b]	0 – 30	3/16	4.8	3/16	4.8
	31 – 150	1/4	6.4	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Installation wiring, except solder-type terminals	0 – 30	1/8	3.2	1/8	3.2
	31 – 150	3/16	4.8	3/16	4.8
	151 – 300	1/4	6.4	1/4	6.4
Rigidly clamped assemblies [c]					
100 volt-amperes maximum	0 – 30	1/32[d]	0.8[d]	1/32[d]	0.8[d]
	0 – 30	3/64	1.2	3/64	1.2
	31 – 150	1/16	1.6	1/16	1.6
	151 – 300	3/32	2.4	3/32	2.4
Other parts	0 – 30	1/16	1.6	1/16	1.6
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5

[a] Measurements are to be made with solid wire of adequate ampacity for the applied load connected to each terminal. In no case shall the wire be smaller than 18 AWG (0.82 mm^2).

[b] Spacing requirements apply also to solder-type terminals

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

[d]Spacings less than those indicated are permitted at integrated circuits and similar components where the spacing between adjacent connecting wires on the component is less than 1/32 inch (0.8 mm).

10.2 PCBA Clearance A (Equivalency)

10.2.1 Other than as noted in 10.1, the requirements of this section may be used to evaluate clearances less than those specified for the end product while maintaining the same overvoltage withstand capability for the equipment.

10.2.2 A clearance, less than the specified minimum through air spacing, may be suitable if acceptable results are obtained when tested in accordance with Section 41, Dielectric Voltage-Withstand Tests, using a voltage with a value in accordance with Table 10.2. For specified minimum clearances between the values in Table 10.2, interpolation may be used to determine the test voltage.

Table 10.2
Test voltages for verifying through air spacings (clearances)

End-product Standard specified minimum through air spacing,		Test voltages, kilovolts									
		ac impulse, ac peak, or dc					ac rms				
		Altitude[a], m or (air pressure, kPa)[b]					Altitude[a], m or (air pressure, kPa)[b]				
Inches	(mm)	0 (101.3)	200 (98.8)	500 (95.0)	1000 (90.0)	2000 (80.0)	0 (101.3)	200 (98.8)	500 (95.0)	1000 (90.0)	2000 (80.0)
1/64	(0.4)	1.7	1.7	1.7	1.6	1.5	1.2	1.2	1.2	1.2	1.1
1/32	(0.8)	2.2	2.1	2.1	2.0	1.9	1.5	1.5	1.5	1.4	1.3
3/64	(1.2)	2.75	2.7	2.65	2.5	2.3	1.95	1.9	1.9	1.75	1.6
1/16	(1.6)	3.3	3.3	3.2	3.0	2.7	2.4	2.3	2.3	2.1	1.9
3/32	(2.4)	4.4	4.3	4.1	3.9	3.5	3.1	3.0	2.9	2.8	2.5
1/8	(3.2)	5.3	5.2	5.0	4.8	4.3	3.7	3.7	3.6	3.4	3.0
3/16	(4.8)	6.9	6.8	6.6	6.2	5.6	4.9	4.8	4.7	4.4	4.0
1/4	(6.4)	8.3	8.2	7.9	7.5	6.8	5.9	5.9	5.6	5.3	4.8
3/8	(9.5)	10.9	10.7	10.3	9.8	8.8	7.7	7.7	7.3	7.0	6.3
1/2	(12.7)	14.0	13.7	13.2	12.5	11.2	9.9	9.7	9.3	8.9	7.9
1	(25.4)	25.5	24.6	24.0	22.7	20.2	18.2	17.6	17.1	16.2	14.4

[a] Next lower specified altitude to be used for intermediate altitudes.

[b] Values of air pressure in kilopascals are provided to permit testing at pressures simulating elevations different from the elevation of the test facility.

10.2.3 The withstand capability of a clearance is related to air pressure, therefore, the selection of test voltage is to be based on the altitude of the test location.

10.3 PCBA Clearance B (Controlled Overvoltage)

10.3.1 The requirements of this section may be used to evaluate clearances where the levels of overvoltage are controlled.

10.3.2 Control of overvoltages may be achieved by either:

a) Providing overvoltage devices or systems as an integral part of the product; or

b) Marking the product with the rating of overvoltage control to which the product is to be connected, and the energy handling capability of the overvoltage device, if appropriate.

10.3.3 With reference to the marking in 10.3.2, the users of this standard must determine the appropriate method to state that the overvoltage control device or system should comply with the requirements in 10.3.4. One of the alternatives to marking the product would be to provide the information in published documentation.

10.3.4 Devices or systems, including filters or air gaps, used to control overvoltages in accordance with this section shall be evaluated using the requirements within this Standard and/or within the Standard for Transient Voltage Surge Suppressors, UL 1449 as applicable. If used in products having short circuit withstand ratings, the suppressors shall also withstand the available current when tested in accordance with UL 1449.

10.3.5 If a clearance is used to perform the function of controlling overvoltages, then consideration must be given to the ability of the clearance to handle the energy which may be available, to the overvoltage breakdown level of other clearances, and to the changes which may occur in and to an electric field when arc-over occurs.

10.3.6 Line connected devices and circuits shall be assigned both a phase-to-ground rated system voltage and an overvoltage category as specified in Table 10.3. Circuits, line connected or secondary, employing the clearances of Table 10.3, shall be protected for the rated impulse withstand voltage peak identified in Table 10.3. The switching test detailed in Section 10.5, Switching Test, should be conducted unless circuit analysis reveals that the appropriate protection is provided wherever Table 10.3 clearances are used.

10.3.7 Clearances are to be:

a) Evaluated by the dielectric voltage-withstand test in 10.2.2; or

b) Selected and measured in accordance with the dimensions in Table 10.3.

10.3.8 Clearances selected and measured in accordance with the dimensions in Table 10.3 do not require testing.

Table 10.3
Minimum clearances for equipment[a,e]

Phase-to-ground[b] rated system voltage (rms and dc)				Rated impulse withstand voltage peak, kV[d]	Clearance, mm			
Overvoltage category[c]					Pollution degree[f]			
I	II	III	IV		1	2	3	4
50	–	–	–	0.33	0.01	0.2	0.8	1.6
100	50	–	–	0.50	0.04	0.2	0.8	1.6
150	100	50	–	0.80	0.10	0.2	0.8	1.6
300	150	100	50	1.5	0.5	0.5	0.8	1.6
600	300	150	100	2.5	1.5	1.5	1.5	1.6
1000	600	300	150	4.0	3.0	3.0	3.0	3.0
1500	1000	600	300	6.0	5.5	5.5	5.5	5.5
–	1500	1000	600	8.0	8.0	8.0	8.0	8.0
–	–	1500	1000	12.0	14.0	14.0	14.0	14.0
–	–	–	1500	16.0	19.4	19.4	19.4	19.4

[a] The minimum values for pollution degrees 2, 3, and 4 are premised on the concept that pollution which may be present in these micro-environments may bridge small clearances.

[b] For ungrounded systems or systems with one phase grounded, the phase-to-ground voltage is considered to be the same as the phase-to-phase voltage for the purposes of using this table.

[c] Typical examples of categories for products are given below. Users of this standard will need to establish that rated impulse voltage values are appropriate for the expected applications of the products covered.

Category IV – Primary Supply Level. Overhead lines and cable systems including distribution and its associated overcurrent protective equipment (equipment installed at the service entrance).

Category III – Distribution Level. Fixed wiring and associated equipment (not electrical loads) connected to the primary supply level, Category IV.

Category II – Load Level. Appliances and portable equipment and the like connected to the distribution level, Category III.

Table 10.3 Continued on Next Page

Table 10.3 Continued

Phase-to-ground[b] rated system voltage (rms and dc)				Rated impulse withstand voltage peak, kV[d]	Clearance, mm			
Overvoltage category[c]					Pollution degree[f]			
I	II	III	IV		1	2	3	4

Category I – Signal Level. Special equipment or parts of equipment such as low-voltage electronic logic systems, remote controls, signaling and power limited (per NEC Article 725) circuits connected to the load level, Category II.

[d] Value to use based on the rating of the overvoltage protection means.

[e] Linear interpolation of the values is permitted.

[f] See 10.4.

10.4 Pollution degree

10.4.1 Pollution degrees based on the presence of contaminants and possibility of condensation or moisture at the creepage distance are as follows:

a) Pollution Degree 1 – No pollution or only dry, nonconductive pollution. The pollution has no influence.

b) Pollution Degree 2 – Normally, only nonconductive pollution. However, a temporary conductivity caused by condensation may be expected.

c) Pollution Degree 3 – Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation that is expected.

d) Pollution Degree 4 – Pollution that generates persistent conductivity through conductive dust or rain and snow.

10.5 Switching test

10.5.1 Where required by 10.1 – 10.4, Clearance B (Controlled Overvoltage), line and load terminals of a device are to be monitored for generated voltages during normal operation, including adjusting switches and controls, at rated operational voltage under load and no-load conditions. Generated voltages shall not be greater than the rated impulse withstand voltage peak specified in Table 10.3 for the device. This monitoring is to be done using an oscillographic study during a suitable test such as an overload test.

11 Corrosion Protection

Effective date for 11 changed from November 5, 2006 to September 1, 2009

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

11.2 The requirement in 11.1 applies to all sheet steel or cast iron enclosures, and to all springs and other parts upon which mechanical operation depends. It does not apply to minor parts, such as washers, screws, and bolts where the failure of such unprotected parts does not result in a risk of fire or electric shock, or injury to persons, or impair the operation of the device. Parts made of polished or treated stainless steel do not require additional protection. Bearing surfaces shall be of materials that prevent binding due to corrosion.

11.3 Metal shall not be used in combinations tending to cause galvanic action which adversely affects cabinets or enclosures.

11.4 Hinges and other attachments shall be resistant to corrosion.

11.5 Nonferrous cabinets and enclosures require no special corrosion protection.

WIRING

12 Permanent Connection

Effective date for 12 changed from November 5, 2006 to September 1, 2009

12.1 General

12.1.1 A gas or vapor detector intended for permanent connection to a hazardous voltage circuit shall be provided with wiring terminals or leads for the connection of conductors of at least the size required by the National Electrical Code, ANSI\NFPA 70–1996, or the Canadian Electrical Code, Part 1 (CSA Standard C22.1), corresponding to the rating of the unit.

12.2 Field-wiring compartment for hazardous voltage connection

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

12.2.2 Protection for internal components and wire insulation from sharp edges shall be provided by insulating barriers or metal barriers having smooth rounded edges.

12.3 Field-wiring terminals

12.3.1 Terminal parts to which field connections are to be made shall consist of binding screws with terminal plates having upturned lugs or a means determined to be equivalent to hold the wires in position. Other terminal connections shall be provided only when determined to be equivalent.

12.3.2 When a wiring-binding screw is employed at a field-wiring terminal the screw shall not be smaller than a No. 6 (3.5 mm diameter).

12.3.3 Except as noted in 12.3.4, a terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick and shall not have less than two full threads in the metal.

12.3.4 Wiring terminal assemblies that are used for field connections shall be prevented from turning.

12.4 Field-wiring leads

12.4.1 Power supply leads provided for field connection shall not be less than 6 inches (152 mm) long, provided with strain relief, and shall be no smaller than 18 AWG (0.82 mm^2). The insulation, when thermoplastic, shall not be less than 1/32 inch (0.8 mm) thick.

Exception No. 1: A lead is not prohibited from being less than 6 inches long when it is evident that the use of a longer lead results in damage to the insulation.

Exception No. 2: Solid copper leads as small as 26 AWG (0.13 mm^2) are not prohibited from use when:

a) The current does not exceed 1 ampere for lengths up to 2 feet (61 cm) and the current does not exceed 0.4 ampere for lengths from 2 feet up to 10 feet (3.05 m);

b) There are two or more conductors and they are covered by a common jacket, or the equivalent; and

c) The assembled conductors comply with the requirements of the Strain Relief Tests, Section 18.

12.4.2 Leads provided for field connection to power limited signaling circuits, such as those employed for connection to remote signaling devices, shall not be smaller than 16 AWG (1.3 mm^2), for a single conductor; 19 AWG (0.65 mm^2) for two or more conductors; and 26 AWG (0.13 mm^2) for four or more conductors of a multiconductor cable. The conductor shall be solid, bunch tinned stranded, or stranded copper. Stranded copper wire consisting of not more than seven strands shall be employed only for 18 AWG (0.82 mm^2) and larger conductors.

12.5 Grounded supply terminals and leads

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

12.5.2 A field-wiring lead provided for connection of a neutral supply conductor shall be finished to show a white or gray color and shall be readily distinguishable from other leads. No leads other than neutral conductors shall be so identified.

12.5.2 revised July 11, 2007

12.6 Internal Wiring

12.6.1 The internal wiring of a gas detector shall consist of conductors having insulation rated for the potential involved and the temperature to which it may be subjected. The wiring shall be arranged in an orderly fashion, routed away from moving parts and sharp projections and held in place with clamps, string ties, or the equivalent, unless of sufficient rigidity to retain a shaped form.

12.6.2 Leads 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.

12.6.3 If the use of a short length of insulated conductor is not feasible, e.g., a short coil lead or the like, electrical insulating tubing may be employed. The tubing is not to be subjected to sharp bends, tension, compression, or repeated flexing, and is not to contact sharp edges, projections, or corners. The wall thickness is to conform to the requirements for such tubing, except that the thickness at any point for the smaller sizes of polyvinyl chloride tubing is to be not less than 0.017 inch (0.5 mm). For insulating tubing of other types, the thickness is to be not less than that providing mechanical strength, dielectric properties, heat- and moisture-resistant characteristics, and the like at least equal to those of 0.017 inch (0.5 mm) thick polyvinyl chloride tubing.

12.6.4 Wireways shall be smooth and entirely free from sharp edges, burrs, fins, moving parts, and the like, which may cause abrasion of the conductor insulation. Holes in sheet metal partitions through which insulated wires pass shall be provided with a bushing if the wall is 0.042 inch (1.07 mm) or less in thickness. Holes in walls thicker than 0.042 inch (1.07 mm) shall have a bushing or smooth, rounded edges.

12.6.5 All joints and connections shall be mechanically secure and shall provide bonded electrical contact without strain on connections and terminals.

12.6.6 Stranded conductors clamped under wire binding screws or similar parts shall have the individual strands soldered together or be equivalently arranged.

12.6.7 A splice shall be provided with insulation equivalent to that of the wires involved.

12.6.8 Uninsulated live parts or moving parts involving a risk of injury shall be located, guarded, or enclosed so as to reduce the likelihood of contact by persons during servicing conditions such as relamping, changing fuses, adjusting controls, and operating switches.

12.6.9 If the linear distance from a component requiring servicing and uninsulated current carrying parts over 30 volts is less than 6 inches (152 mm), protection by insulating tape, barriers or the equivalent, shall be provided.

12.6.10 Internal wiring of circuits which operate at different potentials shall be separated by barriers or shall be segregated, unless the conductors of the circuits of lower voltage are provided with insulation for the highest voltage.

12.6.11 Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means which ensures permanent separation.

12.6.12 A metal barrier shall have a thickness at least as great as that required by Table 12.1, based on the size of the barrier. A barrier of insulating material shall not be less than 0.028 inch (0.71 mm) in thickness and shall be of greater thickness if its deformation may be readily accomplished so as to defeat its purpose. Any clearance between the edge of a barrier and a compartment wall shall not be more than1/16 inch (1.6 mm).

Table 12.1
Minimum thickness of sheet metal for electrical enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch [MSG]	(cm)	inch [GSG]	(mm)
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	[24]		[24]	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	[22]		[22]	
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	[20]		[20]	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	[18]		[18]	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	[16]		[16]	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	[15]		[15]	
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	[14]		[14]	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	[13]		[13]	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	[12]		[12]	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	[11]		[11]	
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0		90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	[10]		[10]	

Table 12.1 Continued on Next Page

Table 12.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Uncoated,		Metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch [MSG]	(cm)	inch [GSG]	(mm)

[a] See 9.2.5.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

Table 12.1 Continued on Next Page

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Table 12.1 Continued

Without supporting frame[a]		With supporting frame or equivalent reinforcing[a]		Minimum thickness	
Maximum width,[b] inches (cm)	Maximum length,[c] inches (cm)	Maximum width,[b] inches (cm)	Maximum length, inches (cm)	Uncoated, inch (cm) [MSG]	Metal coated, inch (mm) [GSG]
[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a flange at least 1/2 inch (12.7 mm) wide.					

13 Servicing Protection

Effective date for 13 changed from November 5, 2006 to September 1, 2009

13.1 General

13.1.1 Uninsulated live parts of high-voltage circuits, hazardous moving parts, and sharp corners and projections, shall be formed, located, guarded, or enclosed so as to prevent contact by persons during servicing such as relamping, fuse or rod replacement, battery replacement, adjusting of controls, and routine maintenance.

13.2 Trained service personnel

13.2.1 The requirements in 13.2.2 and 13.2.3 apply for non-household products intended to be serviced by trained service personnel.

Exception: Any part that is exposed only during operator servicing and complies with the Electric Shock Current Test, Section 19, is not required to comply with the requirements in 13.2.2 or 13.2.3.

13.2.2 When the linear distance from a component requiring servicing and all uninsulated current carrying parts of high-voltage circuits are less than 6 inches (152 mm), then protection by properly applied insulating tape, barriers, or protection determined to be the equivalent, shall be provided.

13.2.3 In lieu of the minimum 6 inches (152 mm) requirement in 13.2.2:

a) An interlock shall be provided on the cover to de-energize all live parts in the enclosure, or

b) The words ″CAUTION – De-energize Unit Prior to Servicing″ or wording determined to be equivalent, shall be permanently and prominently marked on the cover front.

PERFORMANCE

ALL PRODUCTS

14 General

Effective date for 14 changed from November 5, 2006 to September 1, 2009

14.1 Except as otherwise indicated, the performance of a product shall be investigated by subjecting three representative samples, in commercial form, to the applicable tests described in Sections 15 – 39.

14.2 Unless otherwise specified, the test voltages for each test of a product are to be at the rated frequency of the product as noted in Table 14.1.

Table 14.1
Test voltages

Unit rated voltage, nameplate	Test voltage
110 – 120	120
220 – 240	240
Other rating	Marked rating
Battery circuit	Nominal battery voltage

15 Sensitivity requirements

Effective date for 15 changed from November 5, 2006 to September 1, 2009

15.1 A sensor, detector or alarm shall operate within the sensitivity parameters defined by the manufacturer but must not exceed the sensitivity limits defined in:

a) This standard; and

b) The Standard for Single and Multiple Station Carbon Monoxide Alarms, UL 2034; or

c) The Standard for Residential Gas Detectors, UL 1484. A detector must produce an alarm signal at or below 25% of the LEL. This performance requirement applies to residential and commercial and industrial applications for detectors and/or their control assemblies that are intended for use in ordinary (non-hazardous) locations; or

d) The limits specified by the applicable Time Weighted Average (TWA) concentration as specified by the National Institute for Occupational Safety and Health; or

e) Standards such as the Instrument Society of America Standard, Performance Requirements for Combustible Gas Detectors, ANSI ISA 12.13.01. A detector can produce an alarm signal up to and above the LEL. This performance requirement applies to industrial applications for detectors and/or their control assemblies that are intended for use in hazardous locations.

15.2 A detector and/or sensor manufacturer that makes any claims regarding special features of construction or superior performance that exceed the requirements outlined in this Standard, all such claims shall be verified and the test procedures shall be extended or supplemented where necessary to verify their claimed performance.

15.3 The performance of a detector shall be verified for each gas that it is intended to detect.

15.4 The performance of a sensor shall be verified for each gas that the sensor is intended to detect.

15.5 The use of a General-Purpose Signaling System that utilizes sensors, detectors or alarms as initiating devices shall be verified in accordance with this Standard and other applicable UL Standards such as UL 864 and UL 2017.

15.6 Calibration

15.6.1 For detectors or sensors that are to be field calibrated, the procedure shall be outlined in the Instruction Manual and verified based on the frequency and method outlined within the Instruction Manual. If calibration is not required or calibration time frames are in excess of 30 days, the sensor shall comply with the reliability and/or electrical supervision requirements outlined within this Standard.

15.7 Test equipment

15.7.1 The alarm or detector may be installed in a chamber, having a volume of at least 1 cubic foot (0.0283 m^3), constructed so as to permit accurate monitoring and control of chamber air temperature and humidity and oxygen and gas concentrations. The following conditions shall be established within the test chamber and maintained throughout the test, unless otherwise specified by the instruction manual:

a) Ambient temperature at 23 ±3°C (73.4 ±5°F) or a higher temperature if specified by the manufacturer,

b) Relative humidity at 50 ±20 percent,

c) Oxygen concentration at 20.9 ±1 percent, and

d) Supply voltage, if applicable, adjusted to 100 percent of rated input voltage.

For alarms or detectors that are not installed within the test chamber, an equivalent test chamber or method to monitor and maintain the appropriate test conditions may be implemented.

15.8 Selectivity

15.8.1 The alarm, detector or sensor shall not produce an alarm or alarm signal when exposed sequentially, as described in 15.8.3 – 15.8.6, to the concentrations of gases and vapors shown in Table 15.1. Alternatively, for combustible and toxic gas detectors other than CO alarms intended for residential or commercial applications, the cross sensitivity and contamination gases and gas concentrations are to be specified by the manufacturer and outlined in the users manual. The gases and concentrations identified in the users manual shall constitute the list of gases to be used for selectivity testing.

Table 15.1
Gas and vapor concentrations

Substance	Concentration, ppm
Methane	500
n-Butane	300
n-Heptane	500
Ethyl acetate	200
Isopropyl alcohol	200
Carbon dioxide	5000
Ammonia	100
Ethanol	200
Toulene	200
Trichloroethane	200
Acetone	200

15.8.2 Calculate the interior volume of the test chamber used in 15.7. Deduct the volume of the device under test (as provided by the manufacturer). From this volume, calculate the amount of each test substance necessary to supply the concentrations identified in Table 15.1.

15.8.3 Ensure that the chamber has been well ventilated with fresh air. Place the device in operation inside the test chamber for 15 ±5 minutes. Close and seal the chamber to prevent air infiltration.

15.8.4 Using a syringe or equivalent device, add the calculated amount of the first substance into the chamber at a rate and in a location such that it is well mixed with the air and does not cause localized high concentrations.

15.8.5 Allow the device to remain in the chamber for 2 hours. During this time the alarm shall not sound.

15.8.6 Purge the chamber with clean air to remove all of the test atmosphere. Maintain clean air in the chamber for a recovery time of 16 hours or as specified by the manufacturer. In no case shall recovery time exceed 16 hours. Reseal the chamber and repeat the test using another substance from Table 15.1 until the alarm has been exposed to all substances. It is not required that exposure to the substances be in any particular order.

15.8.7 Following this test, the sensitivity test, see 15.1 – 15.5, using the target gas concentration is to be performed on the detector, alarm or sensor. All samples used for and tested to the requirements of the Selectivity Test, Section 15.8, shall comply with these requirements.

16 Sensitivity requirements

Effective date for 16 changed from November 5, 2006 to September 1, 2009

16.1 A detector or sensor shall operate for all conditions of its intended performance, at all sensitivity settings, when energized from a source of rated voltage, under all conditions covered both in the installation instructions and in any supplementary information provided by the manufacturer.

16.2 Detectors or sensors with alarm capabilities shall consistently alarm at levels within 5 percent of the gas concentration levels specified by the manufacturer's installation and operation instructions.

16.3 For multiple station alarm units, the activation of one station's alarm shall result in the actuation of all connected alarms, with the initiating alarm being uniquely identified.

16.4 Detectors or sensors with the capability of detecting multiple gases or vapors, as specified by the manufacturer, shall be tested for the detection of, and proper response to, each specified gas or vapor, individually.

17 Electrical Supervision Test

Effective date for 17 changed from November 5, 2006 to September 1, 2009

17.1 General

17.1.1 Alarms, detectors or sensors shall be electrically supervised so that any of the following conditions which prevents operation for an alarm signal from the alarm device shall result in an audible trouble signal within 200 seconds of the occurrence of the fault:

a) An instantaneous failure or removal of a limited life component,

Exception: The power source of a battery operated alarm.

b) An open in an externally connected alarm circuit

c) Electronically or optically detectable failure modes resulting from aging of the sensor or the sensing components, or

d) A ground fault in any externally connected wiring.

17.1.1.1 If the drop test affects the product's intended operation, the product shall comply with 17.1.1.

17.1.2 The wiring extending between alarms or sensor wired to a control assembly shall be electrically supervised so that a short or multiple ground fault, which prevents operation for an alarm signal, shall result in an audible trouble signal or result in an alarm signal. An open in any of the wiring between alarms is not required to be indicated by a trouble signal if the operation as a single station alarm is not prevented. This requirement does not apply to the interconnected wiring of alarms intended to be connected by a Class 1 wiring method.

Exception: A sensor with a failure rate less than 2.5 failure per million hours is not required to be supervised.

17.1.3 For air aspirated assemblies, the sample draw portion of the system shall be electrically supervised to monitor for partial and complete blockage of the sample stream. For this test, the sample port(s) shall be restricted to the blockage specified by the manufacture that impedes the assemblies ability to comply with the defined performance criteria.

17.1.4 To determine if an device complies with the requirements for electrical supervision, the device is to be energized in the standby condition, and the type of fault to be detected is then to be introduced. Each fault shall be applied separately, the results noted and the fault removed. The device is then to be restored to the standby condition prior to establishing the next fault.

17.1.5 A fault condition (open, ground, or short), of other than the gas alarm circuit of a device with a non-gas alarm feature shall not prevent alarm signal operation as a gas alarm or sensor. For this test the alarm or sensor is to be energized from a rated source of supply in the normal standby condition and the fault is to be applied. With the fault applied the alarm or sensor is then to be subjected to a gas concentration level as specified in section 15.

17.2 AC powered units

17.2.1 Failure of an ac power source to a sensor, detector or alarm shall be indicated by de-energization of a power-on lamp.

17.2.2 Neither loss nor restoration of power shall cause an alarm signal under either momentary or extended (at least 1/2 hour) power outage conditions. Momentary energization of the alarm circuit (maximum of 1 second), and energization of the trouble circuit (maximum of 2 minutes), is not considered an alarm signal. A gradual increase to 110 percent of rated voltage or reduction to 0 volts from rated voltage at a rate of not greater than 5 volts per minute shall not result in energization of the alarm signal for more than 1 second.

17.2.3 Loss of power to a single detector or alarm while connected to a control panel, while energized in the standby condition, shall not result in a false alarm and shall not prevent the operation of the remaining units from alarming.

17.3 Battery powered units

17.3.1 A detector or alarm that uses a battery as the main source of supply shall be capable of producing an alarm signal for at least 12 hours at the battery voltage and/or current at which an audible trouble signal is obtained. Following the alarm signal, the source of supply shall then be capable of providing 7 days of audible trouble signal indication. The trouble signal is to be produced every 30 - 60 ±10% seconds for seven consecutive days.

17.3.2 To determine compliance with 17.3.1, three samples shall be equipped with batteries which have been depleted to the trouble signal level. The samples are to be placed in alarm for 12 hours. After the 12 hours of alarm, the trouble signal shall persist for at least 7 consecutive days. A fresh battery is depleted by applying a 1 percent or smaller loading factor based on the ampere hour rating of the battery. For example, a 1000 milliampere-hour rated battery would be depleted by applying a 10 milliamperes (1 percent load) or less drain continuously until the battery voltage reaches the predetermined test level.

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

17.3.4 To determine compliance with 17.3.3, two samples of an alarm that locks-in on alarm shall be equipped with batteries which have been depleted and stabilized at just above the trouble signal level. The samples are then to be placed in alarm and the battery voltage monitored. The samples shall automatically transfer to audible trouble when the battery trouble voltage is reached. The trouble signal shall persist for seven consecutive days. If the battery voltage recovers to a point where the trouble signal is not longer emitted, the unit shall be placed into alarm again until the trouble signal is reinstituted.

17.4 Component failure

17.4.1 If failure of a critical, limited life electronic component, such as opening or shorting of an electrolytic capacitor, is not indicated by an audible trouble or alarm signal, then a reliable component shall be used. The reliable component shall fall within the reliability prediction described in 3.5 and 3.6.

17.5 External wiring

17.5.1 An open or ground fault in the loop wiring connected from a single station detector, sensor or alarm to additional remote alarms that prevent operation for alarm signals from any of the interconnected alarms, shall not cause an alarm signal but shall result in an audible trouble signal. A short or double ground fault in the leads resulting in an audible trouble signal or an alarm signal is not prohibited.

17.5.2 An open, ground fault, or short in extra-low voltage circuit wiring among multiple station interconnected alarms or any wiring extending to a remote signaling device is not required to be indicated by a trouble signal if the fault does not prevent operation of any of the interconnected units as a single station alarm. A ground fault shall prevent operation for alarm only if the interconnected wiring is to be made in accordance with Class 1 requirements of the National Electrical Code, ANSI/NFPA 70, or the Canadian Electrical Code, Part I (CSA Standard C22.1). The installation wiring diagram shall indicate the type of connections to be employed.

17.5.3 An open, ground fault, or short in the extra-low voltage circuit conductors extending between the output of a separate power supply and an alarm, which prevents operation of the alarm, shall result in de-energization of the alarm power-on light.

18 Strain Relief Tests

Effective date for 18 changed from November 5, 2006 to September 1, 2009

18.1 Cord-connected products

18.1.1 When tested in accordance with 18.1.2, the strain-relief means provided on a flexible cord shall be capable of withstanding for 1 minute, without displacement or damage to the wire insulation, a direct pull of 35 lbf (156 N) applied to the cord, with the connections within the product disconnected.

18.1.2 A 35-lb (15.9-kg) weight is to be suspended on the cord and so supported by the product that the strain-relief means is stressed from any angle that the construction of the product permits. The means of affording strain relief does not meet the requirement when, at the point of connection of the conductors, there is movement of the cord indicating stress has been transmitted to the connections.

18.1.3 When the strain relief is a constructed or molded polymeric material, requirements in 18.1.2 are to be completed after the Mold Stress-Relief Distortion Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is conducted.

18.2 Field-connection leads

18.2.1 Each lead used for field connections, including a battery clip lead assembly, shall withstand for 1 minute a pull of 10 lbf (44.5 N) without any evidence of damage or of transmittal of stress to internal connections. The means of affording strain relief does not meet the requirement when, at the point of connection of the conductors, there is movement of the wire indicating stress has been transmitted to the connections.

18.2.2 When the strain relief is dependent upon a polymeric material, the requirement in 18.2.1 is to be completed after the Mold Stress-Relief Distortion Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is conducted.

19 Circuit Measurement Test

Effective date for 19 changed from November 5, 2006 to September 1, 2009

19.1 Current input

19.1.1 Except for a battery operated device, the input current of a single or multiple station detector shall not exceed 10 percent over the unit's marked input current rating under any conditions of intended use (standby, alarm, or other).

19.2 Battery trouble voltage determination

19.2.1 An increase in the internal resistance, or a decrease in terminal voltage, of a battery employed as the primary source of power to an alarm shall not impair operation of an alarm signal before a trouble signal is obtained. In addition, any combination of voltage and resistance at which a trouble signal is obtained shall be greater than the battery voltage and resistance combination over a 12-month period at ambient conditions. See Battery Tests, Section 46.

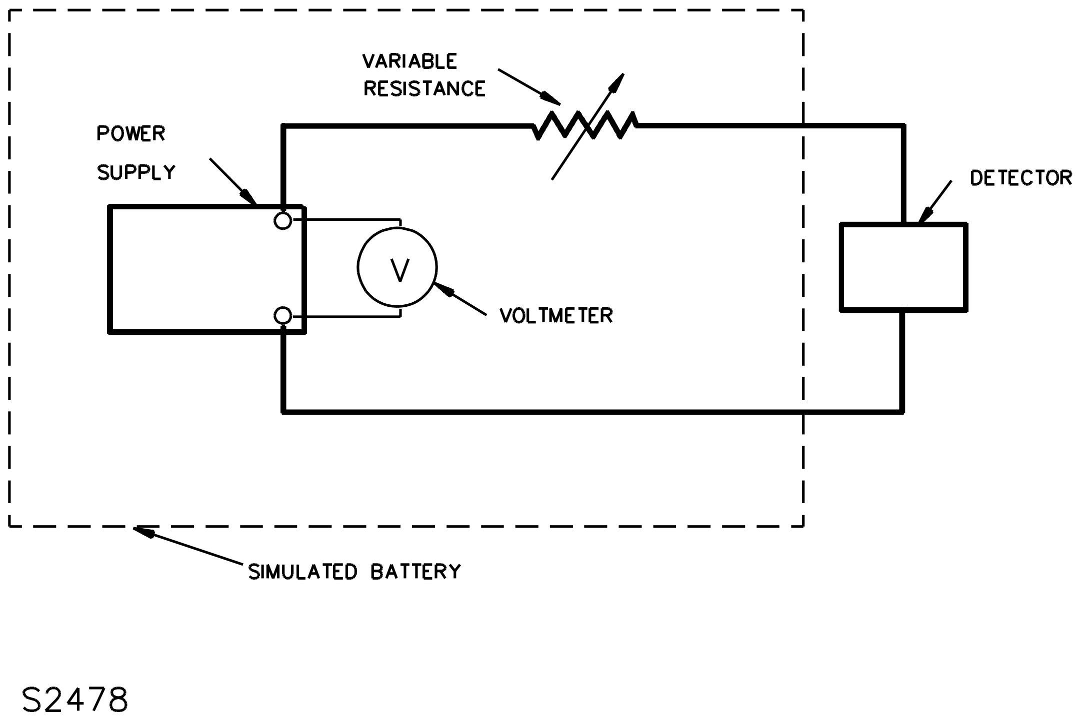
19.2.2 The trouble level of a battery operated alarm shall be determined (using the test circuit in Figure 19.1 and the voltage-resistance curves of Figure 19.2) for each of the following voltages:

a) Rated battery voltage,

b) Trouble level voltage (assuming minimal or no series resistance) and

c) Voltage between rated and trouble level voltage.

Figure 19.1
Test circuit

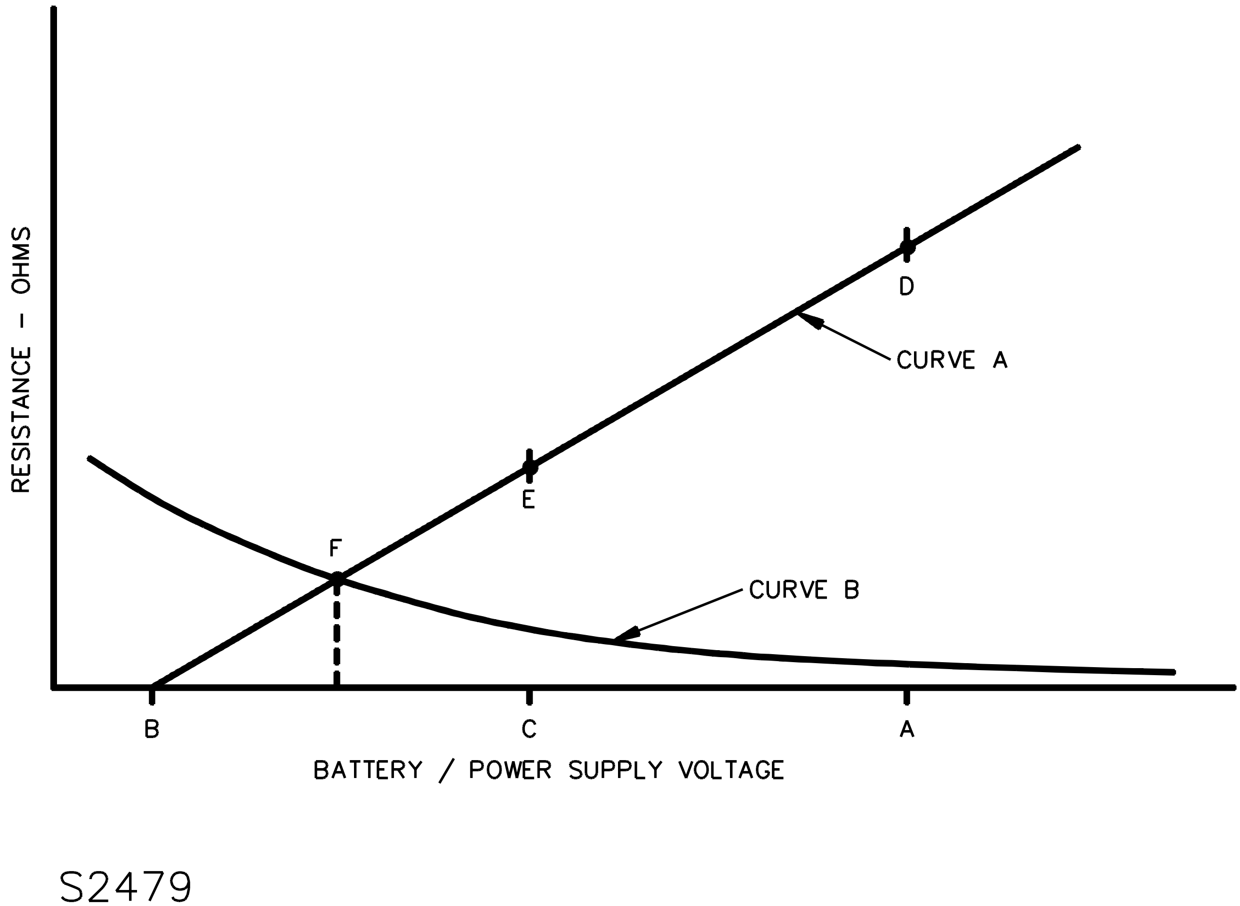


20 Electric Shock Current Test

Effective date for 20 changed from November 5, 2006 to September 1, 2009

20.1 If the open circuit potential between any part that is exposed, during operator maintenance or servicing, and either earth ground or any other exposed accessible part exceeds 42.4 volts peak, the part shall comply with the requirements of 20.2 and 20.4, as applicable.

Figure 19.2
Trouble level determination graph



A – Rated battery voltage.

B – Trouble level voltage (assuming minimal resistance).

C – Voltage value between rated and trouble level.

D – Trouble level resistance at rated battery voltage.

E – Trouble level resistance at voltage value C.

F – Maximum permissible battery resistance and minimum voltage after 6 months in long-term battery test.

Curve A – Sample plot of voltage vs. resistance (alarm trouble level curve) at which a trouble signal in an alarm is obtained. Audibility measurement is to be made at points between D and F.

Curve B – Sample plot of battery internal resistance vs. battery open circuit voltage derived from long term (minim 6 months) battery test. Shape and slope of curve, as well as point of intersection with Curve A, will vary depending on battery used.

20.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 20.1 when the resistor is connected between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part.

Table 20.1
Maximum current during operator servicing

Frequency, hertz[a]	Maximum current through a 500-ohm resistor milliamperes peak
0 – 100	7.1
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000	19.6
5000	22.0
6000	25.1
7000 or more	27.5

[a] Linear interpolation between adjacent values may be used to determine the maximum allowable current corresponding to frequencies not shown. The table applies to repetitive non-sinusoidal or sinusoidal waveforms.

20.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 20.2 shall not exceed 809 milliamperes, regardless of duration of the value determined by the following equation:

$$T \leq \left(\frac{20\sqrt{2}}{I}\right)^{1.43}$$

in which:

T is the interval, in seconds, between the time that the instantaneous value of the current first exceeds 7.1 milliamperes and the time that the current falls below 7.1 milliamperes for the last time;and

I is the peak current in milliamperes.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. Typical calculated values of maximum acceptable transient current duration are shown in Table 20.2.

Table 20.2
Maximum transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak, seconds
7.1	7.22
8.5	5.58
10.1	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	0.919
40.0	0.609
50.0	0.443
60.0	0.341
70.0	0.274
80.0	0.226
90.0	0.191
100.0	0.164
150.0	0.092
200.0	0.061
250.0	0.044
300.0	0.034
350.0	0.027
400.0	0.023
450.0	0.019
500.0	0.016
600.0	0.013
700.0	0.010
800.0	0.0083

20.4 The maximum capacitance between the terminals of a capacitor that is accessible during operator servicing shall comply with the following equations:

$$C = \frac{88,400}{E^{1.43}(\ln E - 1.26)} \quad \text{for} \quad 42.4 \le E \le 400$$

or

$$C = 35,288 E^{-1.5364} \quad \text{for} \quad 400 \le E \le 1000$$

in which:

C is the maximum capacitance of the capacitor in microfarads and

E is the potential in volts across the capacitor prior to discharge; E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover.

Typical calculated values of maximum capacitance are shown in Table 20.3.

Table 20.3
Electric shock

Potential across capacitance prior to discharge, volts	Maximum capacitance, microfarads
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.7
100	38.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.0

Table 20.3 Continued on Next Page

Table 20.3 Continued

Potential across capacitance prior to discharge, volts	Maximum capacitance, microfarads
45	150.0
42.4	169.0

20.5 With reference to the requirements in 20.2 and 20.3, the current is to be measured while the resistor is connected between ground and each accessible part individually or all accessible parts collectively if the parts are simultaneously accessible. The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, if the parts are simultaneously accessible.

20.6 With reference to the requirements in 20.5, parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements one hand is to be considered to be able to contact parts simultaneously if the parts are within a 4- by 8-inch (102- by 203-mm) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 6 feet (1.83 m) apart.

20.7 Electric shock current refers to all currents, including capacitively coupled currents.

20.8 If the product has a direct-current rating, measurements are to be made with the product connected in turn to each side of a 3-wire, direct current supply circuit.

20.9 Current measurements are to be made with any operating control, or adjustable control that is subject to user operation, in all operating positions, and either with or without a vacuum tube, separable connector, or similar component in place. These measurements are to be made with controls placed in the position that causes maximum current flow.

21 Overvoltage Test

Effective date for 21 changed from November 5, 2006 to September 1, 2009

21.1 Except for a battery operated device, a unit shall operate as fully intended when connected to a supply source of 110 percent of rated value. When the rated value is a voltage range, the overvoltage level shall be 110 percent of the higher limit of the range. Sensitivity shall remain within the limits specified in Section 15.

21.2 For multiple station detectors or alarms, the devices are to be tested for their intended operation with the minimum number of stations specified by the installation instructions interconnected with zero added line resistance between alarms.

21.3 Three units shall be subject to this test, each being energized in standby condition at the overvoltage level for a minimum of 16 hours, or for as long as recommended by the manufacturer, and then tested for proper operation and sensitivity.

22 Undervoltage Test

Effective date for 22 changed from November 5, 2006 to September 1, 2009

22.1 A sample lot of three devices shall each operate as intended when energized from a supply source of 85 percent of the test voltage specified by the manufacturer. For units powered by a primary battery, the test shall be conducted at the battery trouble signal voltage level. Sensitivity shall remain within the limits specified in Section 15.

22.2 For multiple station detectors or alarms, the devices are to be tested for their intended operation with the minimum number of stations specified by the installation instructions interconnected with zero added line resistance between alarms.

22.3 For devices provided with a standby battery, the test is to be conducted at 85 percent of the charged battery voltage. When the standby battery provides a trouble signal requiring replacement at higher than 85 percent of the charged battery voltage, the test is to be conducted at the battery trouble signal voltage level.

22.4 Three units shall be subjected to this test, first being energized at the rated voltage, after which the voltage is to be reduced to 85 percent of this level, battery operated devices are to be operated at the trouble level voltage, and then tested for proper operation and sensitivity.

23 Drop Test

Effective date for 23 changed from November 5, 2006 to September 1, 2009

23.1 This test is to be conducted only on portable devices intended for transient use, such as a travel or personal alarm or hand-held detector, and is not to be conducted on devices intended for stationary installation.

23.2 A device shall withstand five drops from a height of 7 feet (2.1 m) onto a tiled concrete floor without exposure of internal hazardous-voltage parts. The sample is to be held so that each impact with the floor is at a different location on the unit. Dislodgement of parts is permitted when:

a) The dislodged part does not affect operation or sensitivity of the unit,

b) The dislodged part is replaceable (such as a cover),

c) There are no hazardous voltage parts exposed, and

d) The condition is visually obvious.

For equipment that has a drop height limit specified in the users manual the drop height specified in the users manual shall be used. Portable devices shall be dropped from a minimum height of 3.28 feet (1 meter).

23.3 Each of two units is to be raised to a height as specified in 23.2 and permitted to drop five times onto a concrete floor covered with 1/8 inch (3.2 mm) thick uncushioned vinyl tile. Following the drops the unit is to be examined for damage and tested for sensitivity. Sensitivity measurements recorded after the drop test shall comply with the limits outlined in Section 15.

24 Dust Test

Effective date for 24 changed from November 5, 2006 to September 1, 2009

24.1 The sensitivity of a sensor, detector or alarm shall not be affected by an accumulation of dust, nor shall an alarm or trouble signal be produced.

24.2 To determine compliance with 24.1 one sample, in its intended mounting position is to be placed, de energized, in an air tight chamber having an internal volume of at least 3 cubic feet (0.09 m^3).

24.3 Approximately 2 ounces (0.06 kg) of cement dust, maintained in an ambient room temperature of 23 ±3°C (73 ±5°F) at 20 – 50 percent relative humidity and capable of passing through a 200 mesh screen is to be circulated for 15 minutes, by means of compressed air or a blower, so as to completely envelop the sample in the chamber. The air flow is to be maintained at an air velocity of approximately 50 fpm (0.25 m/s).

24.4 Following the exposure to dust, the unit is to be removed carefully, mounted in its intended position, energized from a source of supply at the rated level, and tested for sensitivity. Sensitivity measurements shall be within the limits outlined in Section 15.

25 Static Discharge Test

Effective date for 25 changed from November 5, 2006 to September 1, 2009

25.1 The components of a detector or sensor shall be shielded so that its operation is not adversely affected when subjected to static electric discharges. Operation of the trouble circuit during this test is not considered a failure if the subsequent operation of the device is not impaired. Operation of the alarm shall terminate in less than 5 seconds. The test is to be conducted in an ambient temperature of 23 ±3°C (73.4 ±5°F), at a relative humidity of 10 ±5 percent and a barometric pressure of not less than 700 mm of mercury (93 kPa).

25.2 Each of two devices is to be mounted in its intended mounting position and connected to a source of supply at the rated level. If a device is intended to be installed on a metal junction box, the device is to be connected to earth ground. A 250-picofarad, low-leakage capacitor, rated 10,000 volts dc, is to be connected to two 3-foot (0.9-m) leads which are rated for more than 30 volts. A 1500-ohm resistor is to be inserted in series with one lead. The end of each lead is to be attached to a 1/2-inch (12.7-mm) diameter metal test probe with a spherical end and mounted on an insulating rod. The capacitors are to be charged by touching the ends of the test leads to a source of 10,000 volts dc for a minimum of 2 seconds for each discharge. One probe is to be touched to the device and the other probe is then to be touched to earth ground.

25.3 Ten discharges are to be applied to different points on the exposed surface of the device. The capacitors are to be recharged for each discharge. Five discharges of positive polarity are to be made with one lead connected to earth ground the other lead probed on the alarm surface followed by five discharges with the polarity reversed. For an alarm intended to be serviced by the consumer ten additional discharges shall be applied as described above, except each lead shall be probed, in turn, on all internal parts capable of being contacted by the user.

25.4 Following the discharges the device is to be tested for sensitivity. Sensitivity measurements shall be within the limits outlined in Section 15.

26 Replacement Test, Head and Cover

Effective date for 26 changed from November 5, 2006 to September 1, 2009

26.1 A device employing a cover that is intended to be attached or closed by a snap type action or a removable head, shall withstand 50 cycles of removal and replacement, or opening and closing as applicable, of the cover.

26.2 A unit is to be installed as intended in service and the cover or head removed and replaced, or opened and closed, as recommended by the manufacturer. The unit is then to be subjected to the Jarring Test, Section 27.

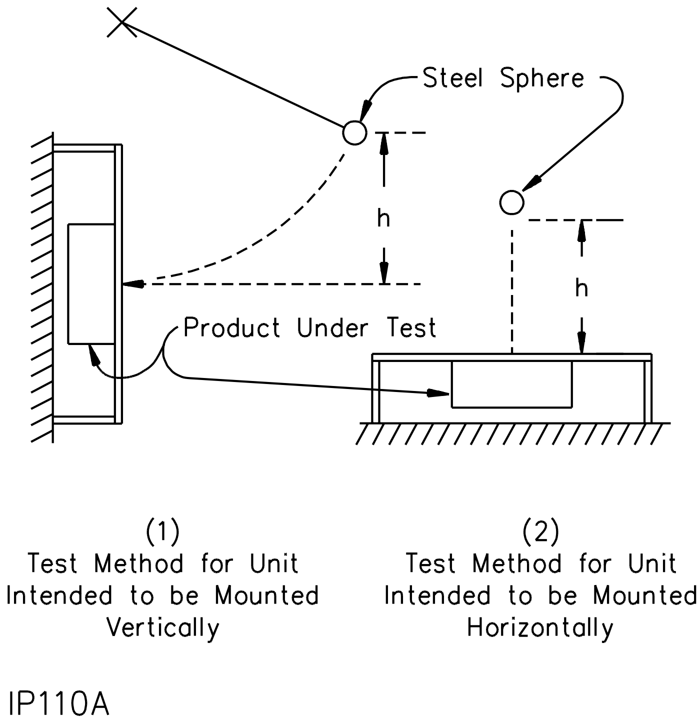
27 Jarring Test

Effective date for 27 changed from November 5, 2006 to September 1, 2009

27.1 A device shall withstand jarring resulting from impact and vibration without causing signaling operation of any part and without impairing its subsequent intended operation.

27.2 A control unit and associated equipment, when provided, are to be mounted as intended to the center of a piece of plywood 6 feet by 4 feet (1.8 m by 1.2 m) and nominally 3/4-inch (19.1-mm) thick. The control unit is to be secured in place at all four corners. A 3 foot-pound (4.08 J) impact is to be applied to the center of the reverse side of the plywood by means of a 1.18 pound (540 g), 2-inch (51-mm) diameter steel sphere. The sphere is to be either swung through a pendulum arc from a height of 2.54 feet (775 mm), or dropped from a height of 2.54 feet (775 mm). See Figure 27.1.

Figure 27.1
Jarring test



27.3 During this test the control unit is to be in its intended mounting position, in the standby condition, and connected to a rated source of supply voltage.

28 Flooding with Undiluted Gas Test

Effective date for 28 changed from November 5, 2006 to September 1, 2009

28.1 The gas sensing element of combustible gas sensors, detectors and/or alarms, other than the manually aspirated type, shall be subjected to a step change in gas concentration from 0 – 100 percent gas-by-volume. The device shall produce an output indication corresponding to a concentration of at least 60 percent of the lower explosive limit or to full-scale concentration, whichever is lower, within 10 seconds of exposure to the 100 percent gas-by-volume.

28.2 Manually aspirated devices shall be subjected to a test whereby, using the shortest possible sample tube, they are aspirated at the rate which is recommended by the manufacturer. The sample inlet is to be connected to a source of 100 percent gas-by-volume. During this test the instruments shall produce an output indication corresponding to at least 60 percent of the lower explosive limit or to full scale, whichever is lower, within 10 seconds.

28.3 Toxic gas sensors, detectors or instruments shall be subject to the most applicable toxic flooding type requirements or to 100% of the maximum allowable gas concentration as specified in the users manual for the sensor, detector or instrument, whichever is worst case.

29 Variable Ambient Temperature Test

Effective date for 29 changed from November 5, 2006 to September 1, 2009

29.1 Operation in high and low ambient

29.1.1 A sensor, detector or alarm shall operate for its intended signaling performance when tested at ambient temperatures as defined in the operating manual or at 0°C and 49°C (32°F and 120°F) at a relative humidity as indicated below. Two samples, one at maximum and one at minimum sensitivity, are to be maintained at both ambient temperatures for at least 3 hours so that thermal equilibrium is reached. The samples shall then be tested for sensitivity while connected to a source of supply that is in accordance with 14.2.

29.1.2 Sensitivity measurements are to be recorded before and during the Variable Ambient Temperature Test, Section 15.1 – 15.6, using the specified gas concentrations. Sensitivity tests are to be performed at each of the highest and lowest ambient conditions as defined in the operation manual, or each of the two ambient conditions as follows:

49 ±2°C, Relative humidity = 40 ±10 percent

0°C, Relative humidity = 15 ±5 percent

Oxygen Concentration = 20.9 ±1 percent

All alarm samples tested as part of the tests in this section shall comply with these requirements.

29.1.3 For sensor, detectors or alarms intended for permanent installation in unconditioned areas, two samples are to be subjected to the following ambient environments and test parameters as outlined in 29.1.4.

29.1.4 Two samples, one at maximum and one at minimum sensitivity, are to be independently maintained at both ambient temperatures for a period of 14 days. At the end of the 14 day conditioning environment, and while still in the ambient environment, the samples are to be subjected to the Sensitivity test as outlined in Section 15.

66 ±2°C , Relative humidity = 40 ±10 percent

minus 40 ±2°C, Relative humidity = 0 percent

29.1.5 For manufacturers that reference operating temperatures in excess of 38 °C and the device is not intended for use in unconditioned areas, the variable ambient test is to be conducted at the manufacturers recommended operating temperature plus 11 °C. The sample conditioning requirements outlined in 29.1.4 shall be applied.

29.1.6 Both samples shall operate as intended in both ambient conditions. The sensitivity readings shall not, in any case, exceed the limits specified in Section 15.1 – 15.5.

29.2 Effect of shipping and storage

29.2.1 The sensitivity of sensors, alarms or detectors shall not be impaired by exposure to high and low temperatures representative of shipping and storage as well as storage in point-of-purchase packaging.

29.2.2 A minimum of two samples, in point of purchase packaging, one at maximum and one at minimum sensitivity, are to be subjected, in turn, to a temperature of 70°C (158°F) at 50 ±30 percent RH for a period of 24 hours, allowed to cool to room temperature for at least 1 hour, exposed to a temperature of minus 40°C (minus 40°F) for at least 3 hours, and then warmed up to room temperature for at least 3 hours. The same two samples are then to be subjected to a temperature of 70°C at 50 ±30 percent RH for 45 days. The alarms are then to be tested for sensitivity while connected to a source of supply in accordance with 14.2.

29.2.3 Sensitivity measurements shall be recorded, before and after the Effect of Shipping and Storage Test in 29.2 using the gas concentrations specified in 15 – 15.4.

30 Humidity Testing

Effective date for 30 changed from November 5, 2006 to September 1, 2009

30.1 General

30.1.1 Sensitivity measurements are to be recorded before and during exposure to the humidity conditioning in accordance with the sensitivity requirements in Section 15. Immediately following this test the Leakage Current Test identified in Section 31 followed by the Dielectric Voltage-Withstand Test identified in Section 41 are to be conducted.

30.2 High humidity (non-condensing) test

30.2.1 Two detectors or sensors, one at maximum and one at minimum sensitivity, shall operate for their intended signaling performance when exposed for 168 hours to air having a relative humidity of 95 ±4 percent at a temperature of 52 ±3°C (125 ±5°F), or as specified within the instruction manual, while energized from a source of rated supply.

30.2.2 Measurement devices shall be calibrated by first being exposed to 50 percent humidity for a minimum of 2 hours, or as long as recommended by the manufacturer. The sensing element shall then be subjected to 95 ±4 percent at a temperature of 52 ±3°C (125 ±5°F) for 168 hours or to the non-condensing specifications identified within the instruction manual. The sensing element is then to be exposed to the calibration gas mixture having a relative humidity ranging between 10 percent relative humidity and the test level relative humidity specified in the instruction manual, while energized from the rated source of supply.

30.3 Low humidity test

30.3.1 Two detectors or sensors, one at maximum and one at minimum sensitivity, are to be operated for their intended signaling performance when exposed for 168 hours to air having a relative humidity of 7.5 ±0.5 percent at a temperature of 22 ±3 °C (72 ±5 °F), or as specified in the instruction manual, while energized from a rated source of supply.

31 Leakage Current Test

Effective date for 31 changed from November 5, 2006 to September 1, 2009

31.1 When the open circuit potential is greater than 42.4 volts peak, as measured between any accessible part and earth ground, or any other accessible part, the leakage current at any accessible part shall not be more than the following values when tested in accordance with the procedures below:

a) 0.5 milliampere for an ungrounded (2-wire) portable, stationary, or fixed product;

b) 0.5 milliampere for a grounded (3-wire) portable product; and

c) 0.75 milliampere for a grounded (3-wire) stationary or fixed product.

Exception: Exception: When an electromagnetic radiation suppression filter is necessary for the product to function as intended, the leakage current shall not be more than 2.5 milliamperes when the product complies with the following conditions:

a) The product is provided with grounding means in accordance with the applicable requirements for a cord-connected product in the Standard for Control Units for Fire Protective Signaling Systems, UL 864;

b) With the filter removed from the product, the leakage current does not exceed the limits specified in 30.1 (a) and (b) as applicable; and

c) The product is marked in accordance with the applicable requirements in the Standard for Control Units for Fire Protective Signaling Systems, UL 864.

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31.2 With reference to the requirement in 31.1, leakage current refers to all currents, including capacitively coupled current, that may be conveyed between exposed conductive surfaces of the equipment and ground, or between exposed conductive surfaces of the equipment.

31.3 Leakage currents from all exposed surfaces are to be measured to the grounded supply conductor individually, as well as collectively, where exposed surfaces are simultaneously accessible, and from one exposed surface to another where the exposed surfaces are simultaneously accessible. A part is considered to be an exposed surface unless it is guarded by an enclosure considered to protect against the risk of electric shock. Surfaces that can be readily contacted by one or both hands of a person at the same time are considered to be simultaneously accessible. For the purpose of these requirements, one hand is considered to be able to contact parts simultaneously when the parts are within a 4 by 8 inch (102 by 203 mm) rectangle. Two hands of a person are considered to be able to contact parts simultaneously when the parts are not more than 6 feet (1.8 m) apart.

31.4 When all accessible surfaces are bonded together and connected to the grounding conductor of the power supply cord, it is not forbidden to measure the leakage current between the grounding conductor and the grounded supply conductor. When exposed dead metal parts of a product are connected to the neutral supply conductor this connection is to be open during the measurement.

31.5 When a conductive surface other than metal is used for the enclosure, or part of the enclosure, the leakage current is to be measured using a 4 by 9 inch (10 by 20 cm) metal foil in contact with the surface. When the surface is less than 4 by 9 inches (10 by 20 cm), the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the product.

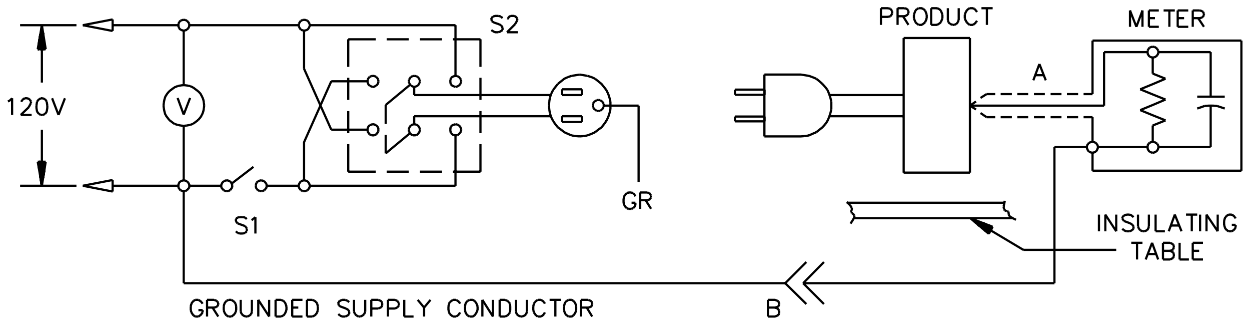
31.6 The measurement circuit for the leakage current test is to be as illustrated in Figure 31.1. The measurement instrument is below. The meter used for a measurement is only required to indicate the same numerical value for the particular measurement as would the defined instrument. It is not required to have all of the attributes of the defined instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad,

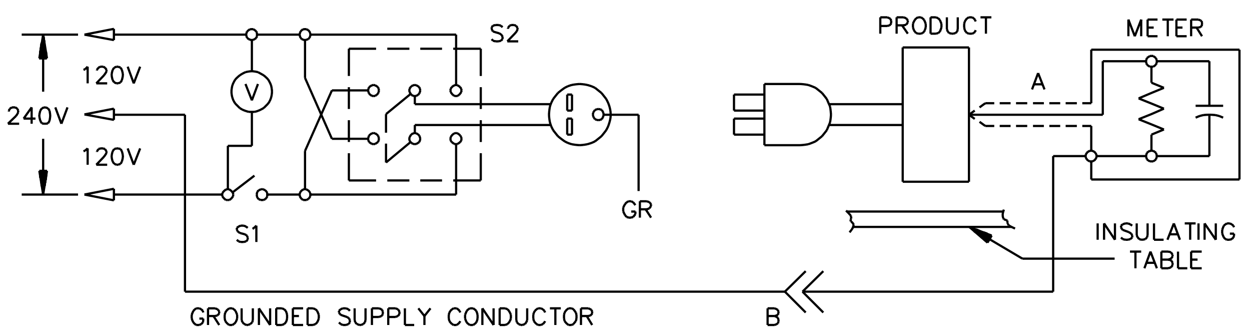
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor, and

c) Over a frequency rang of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 milliampere or 0.75 milliampere, the measurement is to have an error of not more than 5 percent at 60 hertz.

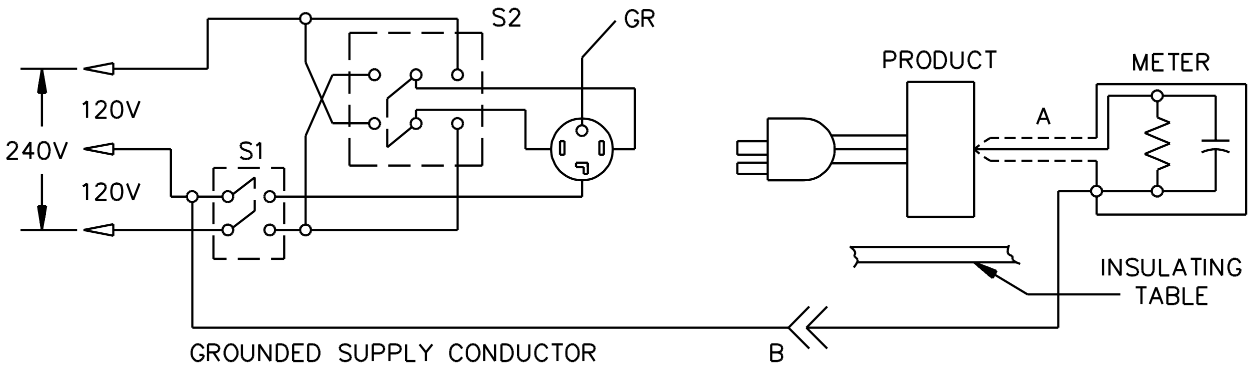
Figure 31.1
Leakage-current measurement circuits



LC100



LC200



31.7 Unless the meter is being used to measure leakage current from one part of a product to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

31.8 A sample of the product is to be tested initially in the as-received condition with all switches closed, but with its grounding conductor, when provided, open at the attachment plug. A product that has not been energized for a minimum of 48 hours prior to the test, and that is at room temperature, is considered to be in the as-received condition. The supply voltage is to be the maximum voltage marked on the product, but not less than 120 or 240 volts. The test sequence, with reference to the measuring circuit illustrated in Figure 31.1, is to be as follows:

a) With switch S1 open, the product is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2 and with the product switching devices in all of their normal operating positions;

b) Switch S1 is then to be closed, energizing the product, and within 5 seconds the leakage current is to be measured using both positions of switch S2 and with the product switching devices in all their normal operating positions;

c) Leakage current is to be monitored until thermal stabilization occurs. Both positions of S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation of the product as in the Temperature Test, Section 33.

32 Transient Tests

Effective date for 32 changed from November 5, 2006 to September 1, 2009

32.1 General

32.1.1 An alarm or detector shall operate for its intended signaling performance and its sensitivity shall not be affected adversely when two representative samples (one preset to the maximum and one preset to the minimum production sensitivity) are subjected to 500 supply line (hazardous-voltage) transients, 500 internally induced transients, extraneous transients (radiated), and 60 supply line (low-voltage) circuit transients, while energized from a source of supply in accordance with 14.2 and connected to the device(s) intended to be used with the alarm.

32.1.2 Different alarms or detectors may be used for each of the four tests in 32.1.1. The alarms or detectors shall not false alarm for more than 1 second. Alarms using a primary battery as a power supply are to be subjected to the extraneous transients test only. If an alarm or detector is intended for multiple-station connection, the transient tests are to be conducted with the maximum number of alarms intended to be connected.

32.1.3 Sensitivity measurements shall not exceed the limits specified in Section 15.

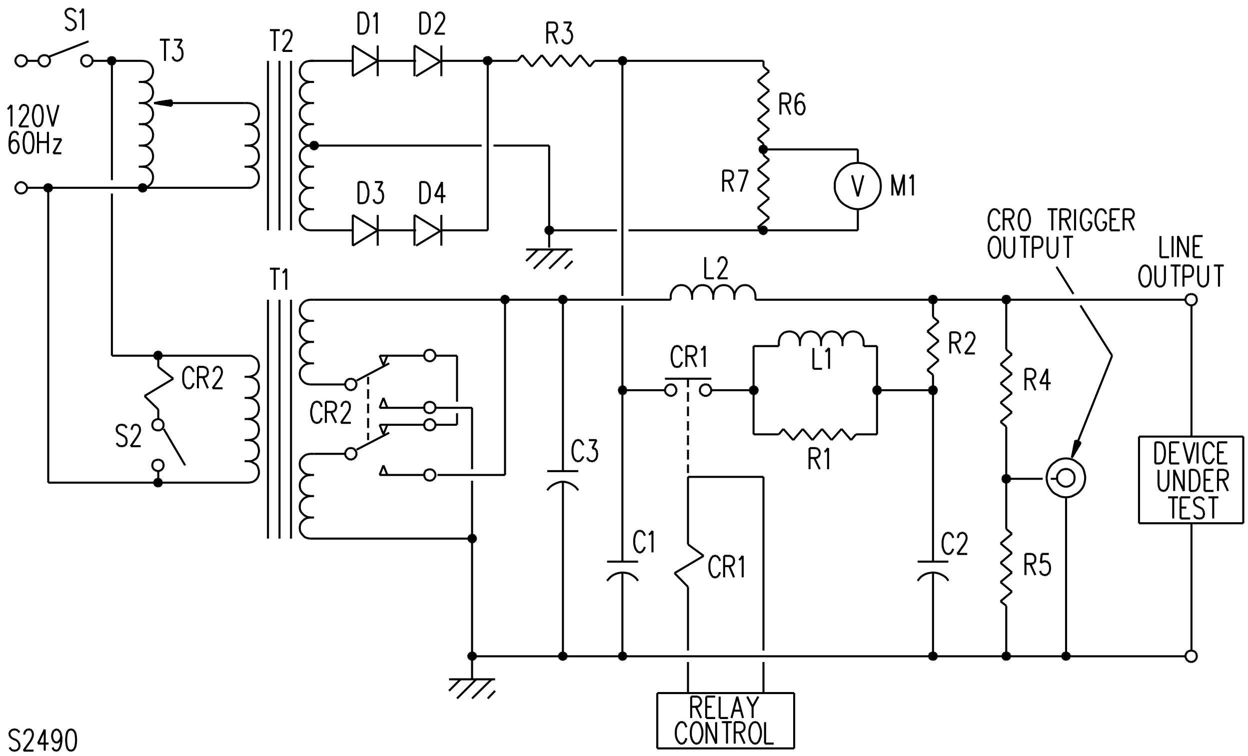
32.2 Supply line (hazardous-voltage) transients

32.2.1 For this test, the alarm or detector is to be connected to a transient generator, consisting of a 2 kilovolt-amperes isolating power transformer and control equipment capable of producing the transients described in 32.2.2. See Figure 32.1. The output impedance of the transient generator is to be 50 ohms.

32.2.2 The transients produced are to be oscillatory and have an initial peak voltage of 6000 volts. The rise time is to be less than 1/2 microsecond. Successive peaks of the transients are to decay to a value of not more than 60 percent of the value of the preceding peak. Each transient is to have a total duration of 20 microseconds.

32.2.3 Each unit is to be subjected to 500 oscillatory transient pulses induced at a rate of once every 10 seconds. Each transient pulse is to be induced 90 degrees into the positive half of the 60 hertz cycle. A total of 250 pulses are to be applied so that the polarity of the transients is positive with reference to earth ground, and the remaining 250 pulses are to be negative with respect to earth ground.

Figure 32.1
Surge generator circuit



C1	– Capacitor, 0.025 uF, 10 kV
C2	– Capacitor, 0.006 uF, 10 kV
C3	– Capacitor, 10 uF, 400 V
CR1	– Relay, coil 24 V, dc contacts, 3-pole, single throw, each contact rated 25 A, 600 V, ac maximum: All three poles wired in series
CR2	– Relay, coil 120 V, ac contacts, DPDT. Provides either 120 V or 240 V test circuit.
D1	– D4 – Diodes, 25 kV PIV each
L1	– Inductor 15 uH [33 turns, 22 AWG wire, wound on 0.835 inch (21.2 mm) diameter PVC tubing]
L2	– Inductor, 70 uH [45 turns, 14 AWG wire, wound on 2.375 inch (60.33 mm) diameter PVC tubing]
M1	– Meter, 0–20 V, dc
R1	– Resistor, 22 ohms, 1 W, composition
R2	– Resistor, 12 ohms, 1 W, composition
R3	– Resistor, 1.3 megohms (12 in series, 110K Ohms each, 1/2 W)
R4	– Resistor, 47K ohms (10 in series, 4.7K Ohms each, 1/2 W)
R5	– Resistor, 470 ohms, 1/2 W
R6	– Resistor, 200 megohms, 2 W, 10 kV
R7	– Resistor, 0.2 megohms (2 in series, 100K ohms each, 2 W, carbon)
S1	– Switch, SPST
S2	– Switch, SPST, key-operated, 120 V, ac, 1 A
T1	– Transformer, 2 kVA, 120 V primary, 1:1 (120 V or 240 V output)
T2	– Transformer, 90 VA, 120/15,000 V
T3	– Variable autotransformer, 2.5 A

32.3 Internally induced transients

32.3.1 The alarm or detector is to be energized in the standby condition while connected to a source of supply in accordance with 14.2. The supply is to be interrupted for approximately 1 second at a rate of not more than 6 cycles per minute for a total of 500 cycles. Following the test, the alarm or detector is operated for its intended signaling performance.

32.4 Extraneous transients

32.4.1 Alarms or detectors shall not false alarm or produce a false alarm signal and their intended operation shall not be impaired when subjected to extraneous transients generated by the devices and appliances described in 32.4.2. In addition, the alarm or detector shall respond to specified gas as defined in Section 32.4.2, during application of the transient condition.

32.4.2 Two alarms or detectors or two sets of alarms or detectors are to be energized from a source of rated voltage and frequency and subjected to transients generated from the following devices located 1 foot (305 mm) from the alarm, interconnecting wires, or both. The time of application for the condition specified in 32.4.2(a) is to be at least 2 minutes. The conditions specified in 32.4.2 (c), (d), and (e) are to be applied for 10 cycles, each application of 2 seconds duration, except the last application shall be of a 10-minute duration. Near the end of the last cycle, an abnormal amount of gas is to be introduced into the alarm chamber to determine whether the unit is operational for specified gas with the transient applied. For the condition specified in 32.4.2 (b), the 1-foot distance is to be measured from the transmitter-receiver (walkie-talkie or cellular phone) antenna to the surface of the alarm or detector.

a) Sequential arc (Jacob’s ladder) generated between two 15 inch (381 mm) long, 14 AWG (2.1 mm^2) solid copper conductors attached rigidly in a vertical position to the output terminals of an oil burner ignition transformer or gas tube transformer rated 120 volts, 60 hertz primary, 10,000 volts, 60 hertz, 23 milliamperes secondary. The two wires are to be formed in a taper starting with an 1/8 inch (3.2 mm) separation at the bottom (adjacent to terminals) and extending to 1-1/4 inches (31.8 mm) at the top.

b) Energization and transmission of random voice message of five separate transmitter-receiver units (walkie-talkies or cellular phones) in turn, each having a 5 watt output and operating in the following nominal frequencies:

1) 27 megahertz,

2) 150 megahertz,

3) 450 megahertz,

4) 866 megahertz, and

5) 910 megahertz.

A total of six energizations are to be applied from each transmitter-receiver; five to consist of 5 seconds on and 5 seconds off, followed by one consisting of a single 15-second energization. For this test, the walkie-talkies or cellular phones are to be in the same room and on the same plane as the alarm under test.

c) Energization of an electric drill rated 120 volts, 60 hertz, 2.5 amperes.

d) Energization of a soldering gun rated 120 volts, 60 hertz, 2.5 amperes.

e) Energization of a 6-inch (152-mm) diameter solenoid-type vibrating bell [a] with no arc suppression and rated 24 volts.

32.5 Supply line (extra-low-voltage) circuit transients

32.5.1 Each of two extra-low-voltage alarms or detectors are to be subjected to 60 transient voltage pulses. The pulses are to be induced into the alarm circuit intended to be connected to the extra-low-voltage initiating device circuit of a system control unit and the extra-low-voltage power supply circuit of the alarm or detector.

32.5.2 For this test, each circuit is to be subjected to five different transient waveforms having peak voltage levels in the range of 100 to 2400 volts, as delivered into a 200 ohm load. A transient waveform at 2400 volts shall have a pulse rise time of 100 volts per microsecond, a pulse duration of approximately 80 microseconds, and an energy level of approximately 1.2 joules. Other applied transients shall have peak voltages representative of the entire range of 100 to 2400 volts, with pulse durations from 80 to 110 microseconds, and energy levels not less than 0.3 joule or greater than 1.2 joules.

33 Stability Tests

Effective date for 33 changed from November 5, 2006 to September 1, 2009

33.1 General

33.1.1 There shall not be false alarms or false alarm signals of an alarm or detector set at the maximum sensitivity setting when two representative samples are placed in the test chamber as specified in Section 15.7. Two additional samples are to be tested as described in 33.3. Momentary energization of the alarm (maximum of 1 second) does not constitute a false alarm during this test. Alarms are to be conditioned for not less than 48 hours under the ambient conditions specified in Section 15.7. For carbon monoxide alarms and detectors that can be exposed to low concentrations of gas over the life of the product, the additional requirements outlined in UL 2034 shall be applied.

a) Ten cycles of temperature variation between 0 and 49°C (32 and 120°F) are to be conducted. The time of cycling from one extreme to the other is to be a maximum of 1 hour and a minimum of 5 minutes, and not less than 15 minutes at each temperature level.

b) Fifty cycles of momentary (approximately 1/2 second) interruption of the alarm power supply at a rate of not more than 6 cycles per minute are to be conducted, followed by 10 cycles of very rapid OFF – ON switching (each consisting of 3 OFF – ON sequences in 1-1/2 seconds) to simulate a loose wire connection in the home or an automatic reclosing circuit in the distribution line, at not more than 1 cycle per minute. It is not prohibited that battery operated alarms be tested in conjunction with the Battery Replacement Test, Section 47.8.

c) A minimum of 37 cycles of power interruption of the alarm or detector power supply at a cycle and rate as follows:

1) The power to the alarm or detector shall be interrupted (switched OFF) for approximately ½ second followed by switching the power ON to the device.

[a] Edwards Model 439D-6AW vibrating bell rated 0.075 amperes, 20/24 volt dc or equivalent.

2) Following the first ½ second power interruption, the device shall not produce a false alarm or false alarm signal and shall operate as intended.

3) The time delay needed to reconduct items i and ii shall be variable to allow for verification of normal operation.

4) Steps 1, 2 and 3 are to be sequentially reconducted a minimum of 37 times by incrementally increasing the power interruption time identified in step i a maximum of 5 seconds each cycle not to exceed a cumulative power interruption time of 3 minutes.

33.2 Air Velocity Variation

33.2.1 Detectors or alarms are to be subjected to operation for 90 days in an area that has been determined to be equivalent to the installation instructions or a typical residential atmosphere shall be applied with an air velocity of 300 ±25 feet per minute (1.5±0.13 m/s) or a typical commercial application shall consist of an air velocity of 1000 ±25 feet per minute (5.1±0.13 m/s) in an ambient as specified in 15.7.

33.3 Pressure

33.3.1 For this test the samples shall remain in the test chamber as specified in section 15.7 for a minimum of 5 minutes prior to subjecting the samples to the test gas concentration as specified in section 51.1. The test condition shall not result in a false alarm and shall not prevent the samples from alarming within the required parameters.

33.3.2 The pressure shall be maintained at the specified levels for 5 min, before a reading is accepted or a test is made. Readings shall be taken with clean air or standard test gas respectively.

33.3.3 The variation of the indications at 95 kPa and 110 kPa from the indication at 100 kPa shall not exceed ±10 % of the measuring range or ±30 % of the indication, whichever is the greater.

33.3.4 A minimum of two representative alarm samples shall be subjected to the sequential series of tests as outlined in Sections 15.1 – 15.6, 15.8, 32, 29.1 and 29.2 of this standard. The samples are to be tested sequentially to the tests included in these sections in the following order: Section 15.6, Sections 15.1 – 15.5, Section 15.8, Section 32, Section 29.1 and Section 29.2. The sensitivity readings shall not, in any case, exceed the limits specified in Section 15.1 through 15.5

33.3.5 A total of four sensors, detectors or alarms employing a maximum sensitivity setting are to be mounted in a position of normal use, energized from a source of supply in accordance with Section 14.2, and subjected to the tests in Section 33.

34 Temperature Test

Effective date for 34 changed from November 5, 2006 to September 1, 2009

34.1 The materials or parts employed in the construction of a gas or vapor detector or sensor shall not be adversely affected by the temperatures attained under any condition of intended operation.

34.2 A material or part is to be considered as being adversely affected if it is subject to a temperature rise greater than that indicated in Table 34.1.

Table 34.1
Maximum temperature rises

Device or material	Normal standby (continuous),		Alarm condition (short term),	
	°C	(°F)	°C	(°F)
A. MOTORS				
1. Class A insulation systems on coil windings of an alternating current motor:				
a) In an open motor and on vibrator coils				
Thermocouple or resistance method	75	135	75	135
b) In a totally enclosed motor				
Thermocouple or resistance method	80	144	80	144
2. Class B insulation systems on coil windings of an alternating current motor:				
a) In an open motor				
Thermocouple or resistance method	95	171	95	171
b) In a totally enclosed motor				
Thermocouple or resistance method	100	180	100	180
B. COMPONENTS				
1. Capacitors[a]	25	45	40	72
2. Fuses	25	45	25	45
3. Relays, transformers, and other coils with:				
a) Class 105 insulated windings				
Thermocouple method	65	117	65	117
Resistance method	75	135	75	135
b) Class 130 insulated windings				
Thermocouple method	85	153	85	153
Resistance method	95	171	95	171
4. Resistors[b]				
a) Carbon	25	45	25	45
b) Wire wound	50	90	325	585
5. Sealing compounds	See footnote c			
6. Solid state devices	See footnote a or d			
C. INSULATED CONDUCTORS[e]				
1. Appliance wiring material	25°C (77°F) less than the established temperature rating of the wire			
D. ELECTRICAL INSULATION – GENERAL				
1. Fiber used as electrical insulation or cord bushings	25	45	65	117
2. Phenolic composition used as electrical insulation or as parts where failure will result in a hazardous condition	25	45	125	225

Table 34.1 Continued on Next Page

Table 34.1 Continued

Device or material	Normal standby (continuous),		Alarm condition (short term),	
	°C	(°F)	°C	(°F)
3. Printed wiring boards	Based on maximum use temperature rating of printed wiring board material			
E. GENERAL				
1. Mounting surfaces	25	45	65	117
2. Wood or other combustible material	25	45	65	117
3. Enclosure surfaces	40	72	40	72

[a] In lieu of complying with these temperature limits, these components may be evaluated in accordance with the appropriate sections of Cat. No. RDH-376, Reliability Design Handbook (March 1976), IIT Research Institute.

[b] In lieu of complying with these temperature limits, a resistor may be acceptable if it dissipates not more than one-half of its maximum power rating under the test conditions specified.

[c] Unless a thermosetting material, the maximum sealing compound temperature, when corrected to a 25°C (77°F) ambient temperature, is 15°C (27°F) less than the softening point of the compound as determined by the Ball and Ring Apparatus, ASTM E28-67(1982).

[d] The temperature of a solid-state device, such as a transistor, SCR, integrated circuit, shall not exceed 50 percent of its rating during the Normal Standby Condition, or 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 considered as 0 percent. For integrated circuits, the loading factor shall not exceed 50 percent of its rating under the Normal Standby Condition and 75 percent under any other condition of operation. Both solid-state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:

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

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

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

[e] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code, ANSI/NFPA 70, the maximum allowable temperature rise in any case is 25°C (77°F) less than the temperature limit of the wire in question.

34.3 The classes of material used for electrical insulation referred to include the materials:

a) Class 105 – Impregnated cotton, paper, and similar organic materials when impregnated, and film coatings as applied to coil windings and

b) Class 130 – Inorganic materials such as mica.

34.4 The temperature of a component exceeding that indicated in Table 34.1 shall be employed only when reliability data is provided by the manufacturer to justify its use.

34.5 During intended operation, the temperature of a surface that is capable of being contacted by the user shall not exceed the value given in Table 34.2. When the test is conducted at a room temperature other than 25°C (77°F), the results are to be corrected to that temperature.

Exception: Surfaces other than handles or knobs that are accessible are not to exceed the surface temperature values in Table 34.2 when marked in accordance with 49.1.13.

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Table 34.2
Maximum surface temperatures

Location	Composition of surface[a]			
	Metal,		Nonmetallic,	
	°C	(°F)	°C	(°F)
Handles, knobs or surfaces that are grasped for lifting, carrying or holding	50	122	60	144
Handles or knobs that are contacted but do not involve lifting, carrying, or holding, and surfaces subject to contact during intended use or maintenance	60	140	85	185
Other surfaces	70	148	95	203

[a] A handle, knob, or similar part made of a nonmetallic material that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is to be considered a nonmetallic part.

34.6 All values for temperature rises apply to equipment intended for use with ambient temperatures normally prevailing in occupiable spaces which usually are not higher than 25°C (77°F). When equipment is intended specifically for use with a prevailing ambient temperature constantly more than 25°C (77°F), the test of the equipment is made with the higher ambient temperature, and the allowable temperature rises specified in Table 34.1 are to be reduced by the amount of the difference between the higher ambient temperature and 25°C (77°F). A temperature is considered to be constant when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5 minute intervals, indicate no change.

34.7 Temperature measurements on equipment intended for recessed mounting shall be made with the unit installed in an enclosure of 3/4-inch (19.1-mm) wood having clearances of 2 inches (50.8 mm) on the top, sides and rear, and the front extended to be flush with the unit's cover.

34.8 Except at coils, temperatures are to be measured by thermocouples consisting of wire not larger than 24 AWG (0.21 mm^2) or by the change-in-resistance method. The thermocouple method is not to be employed for a temperature measurement at any point where supplementary thermal insulation is employed.

34.9 Thermocouples consisting of 30 AWG (0.06 mm) iron and constantan wires and a potentiometer-type indicating instrument are to be used whenever referee temperature measurements by thermocouples are necessary.

34.10 The temperature of a copper coil winding is determined by the change-in-resistance method, wherein the resistance of the winding at the temperature to be determined is compared with the resistance at a known temperature by means of the formula:

$$T = (R/r)(234.5 + t) - 234.5$$

in which:

T is the temperature to be determined in degrees C,

R is the resistance in ohms at the temperature to be determined,

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

t is the known temperature in degrees C

34.11 It is generally necessary to de-energize the winding prior to measuring R. The value of R at shutdown is determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown; a curve of the resistance values and time is plotted and extrapolated to give the value of R at shutdown.

34.12 The circuit of a current-regulating resistor or reactor, provided as a part of a control unit, is to be adjusted for the maximum resistance or reactance at normal current.

34.13 A control unit which provides only one circuit of series-connected audible signal appliances is to be tested with the current-regulating resistor or reactor adjusted for use with one appliance.

34.14 A control unit which provides more than one circuit of series-connected audible signal appliances is to be tested with the current-regulating resistor of all circuits adjusted for use with the number of appliances producing the maximum wattage dissipation by the resistor.

34.15 It is acceptable to test a control which provides one or more circuits of series-connected audible signal appliances for loads other than those specified above when the minimum number of appliances is indicated on the installation wiring diagram.

34.16 The duration of the test-operating condition is not to be less than:

a) Operation until constant temperatures are attained during the normal supervisory condition of any control unit.

b) Operation for 1 hour during the normal signaling condition of a control unit intended to be actuated by automatic devices such as fire-alarm thermostats, water flow detectors, and sprinkler-supervisory attachments. This test operation is considered to apply to a control unit which is intended to produce a continuous signal until an actuating device is restored to normal or until a circuit-resetting device is operated manually.

c) Operation until constant temperatures are attained during the normal signaling condition of a control unit intended for watchman's supervisory signaling service.

d) Operation for 15 minutes during the normal signaling condition of a control unit intended to be actuated by coded manual fire-alarm boxes.

e) Operation of a rectifier at its maximum rated output until constant temperatures are attained.

34.17 In a control unit having provision for multiple zones, 10 percent of the total number of zones shall be energized during the alarm condition.

34.18 For Zone systems with 3 or less zones, all zones are to be energized. In no case shall less than 3 zones be energized for zone systems greater than 3 zones.

34.19 A control unit which is intended to provide coded impulse signals is to be operated by a testing device, such as a timer switch, at a rate of 120 impulses per minute.

Exception: When the signal impulses are produced normally by a device which is part of the control unit assembly, the test impulses are to be at the rate of the intended operation of the device.

34.20 When a time-limit cutout is provided as a part of the control unit tested, and is not intended to limit the time of alarm-signal operation, it is to be shunted out of the circuit for the duration of the test.

34.21 To determine that a unit complies with the requirements in 34.1 it is to be connected to a supply circuit of rated voltage and frequency and operated continuously under representative normal service conditions that are intended to produce the highest temperatures.

35 Abnormal Operation Test

Effective date for 35 changed from November 5, 2006 to September 1, 2009

35.1 A device or control unit, although normally operated only for a limited period, shall be capable of being operated continuously under abnormal conditions without resulting in any risk of fire.

35.2 To determine that a control unit or device complies with the requirement in 35.1 it is to be operated under the most severe abnormal conditions that will be encountered in service while connected to a rated source of supply.

35.3 A unit designed for local system service, and intended to produce a continuous signal until the initiating device is restored to normal, or until reset manually, is to be operated:

a) Until constant temperatures are attained, when intended for use with automatically operated initiating devices, or

b) For 1 hour, when intended for use with noncoded manually operated initiating devices.

35.4 In determining that a control unit complies with the requirement in 35.1 with respect to installation-wiring circuit fault conditions, the fault conditions are to be maintained continuously until constant temperatures are attained, or until burnout occurs when the fault does not result in the operation of an overload-protective device.

35.5 A variable autotransformer used as means of output voltage adjustment is to be adjusted to a position corresponding to 50 percent of its maximum mechanical adjustment range, and a resistive or inductive load, as identified in the instruction manual is to be connected to the output or outputs of the power supply. This load is to be sufficient to draw either 125 percent of rated output current or the maximum current that the output delivers in the application, whichever is lower. The input of the power supply is to be connected to a voltage source in accordance with Table 14.1. The test is to be continued until ultimate results are obtained, such as burnout or stabilization of temperatures.

35.6 There shall not be emission of flame or molten metal or other manifestation of a fire, or risk of electrical shock, when each output circuit of a control unit is individually shorted. Accessible fuses shall be replaced with either a non-interchangeable type fuse of the same rating, or by an interchangeable fuse of the same size but having the highest available current rating for that size.

35.7 All openings of the unit enclosure are to be covered with surgical cotton. Metal enclosures are to be connected to ground through a fuse of the same rating as indicated by the marked rating of the control unit.

35.8 At the conclusion of the test the cotton shall not have ignited and the enclosure grounding fuse shall not have opened.

35.9 Products with provisions for connection to a telephone, telegraph, or outside wiring as covered by Article 800 of the National Electrical Code, ANSI/NFPA 70, the product shall comply with the overvoltage test described in the Standard forTelephone Equipment, UL 1459.

36 Overload Test

Effective date for 36 changed from November 5, 2006 to September 1, 2009

36.1 Control Panel, Detector or Alarm

36.1.1 A detector or alarm other than that operating from a primary battery shall operate as intended after being subjected to 50 cycles of alarm signal operation at a rate of not more than 6 cycles per minute with the supply circuit to the alarm at 115 percent of the rated test voltage. Each cycle shall consist of starting with the system or device energized in the standby condition, initiation of an alarm or alarm signal by exposure to an elevated gas concentration or equivalent means, and restoration of the alarm to standby.

36.1.2 Rated test loads are to be connected to those output circuits of the system or device which are energized from the control panel, detector or alarm power supply, such as remote indicators, relays, and the like. The test loads shall be those devices, or a device determined to be equivalent, normally intended for connection. If an equivalent load is employed for a device consisting of an inductive load, a power factor of 60 percent is to be employed. The rated loads are established initially with the alarm connected to a source of supply in accordance with 14.2 followed by increasing the voltage to 115 percent of rating.

36.1.3 For dc signaling circuits, an equivalent inductive test load is to have the required dc resistance for the test current and the inductance (calibrated) to obtain a power factor of 60 percent when connected to a 60 hertz ac voltage equal to the rated dc test voltage. When the inductive load has both the required dc resistance and the required inductance, the current will be equal to 0.6 times the current measured with the load connected to a dc circuit when the voltage of each circuit is the same.

36.2 Separately energized circuits

36.2.1 Separately energized circuits of a system or device such as dry contacts, shall be capable of operating as intended after being subjected for 50 cycles of signal operation at a rate of not more than 6 cycles per minute while connected to a source of supply in accordance with 14.2, with 150 percent rated loads at 60 percent power factor applied to output circuits which do not receive energy from the alarm. There shall not be electrical or mechanical failure of the switching circuit.

36.2.2 The test loads shall be set at 150 percent of rated current while connected to a separate power source of supply in accordance with 14.2.

37 Endurance Test

Effective date for 37 changed from November 5, 2006 to September 1, 2009

37.1 A signaling detector, alarm or control unit shall be capable of operating in the intended manner after being subjected to 6000 cycles of signal operation at a rate of not more than 15 cpm with the control unit supply circuit at rated voltage and frequency and with rated devices or equivalent loads connected to the output circuits. There shall not be electrical or mechanical failure or evidence of approaching failure of the device's components.

37.2 An operating device, such as a switch, relay or coding mechanism, except a time-limit cutout, supplied as part of a device, shall perform as intended when operated for the number of cycles and at the rate indicated in Table 37.1. When an electrical load is involved, the contacts of the device are to make and break the normal current at the rated voltage. The load is to represent that which the device is intended to control. It is not prohibited that the endurance tests of these devices be conducted in conjunction with the endurance test on a control unit.

Table 37.1
Endurance test cycles

Intended signaling performance of operating-device circuit	Impulse type	Signal impulses	
		Total number of impulses	Impulses per minute
Daily use	Coded[a] Noncoded[b]	1,000,000 30,000	60 Intended rate of impulse device
Occasional use	Coded[a] Noncoded[b]	250,000 6,000	60 Intended rate of impulse device

[a] Coded refers to a recognizable group of impulses defining location of source of signal.

[b] Noncoded refers to a repetitive or continuous stream of impulses that does not define location or source of signal.

37.3 A printer, whether separate or integral with a device or control unit, shall operate as intended after being subjected to 500,000 cycles of operation. A cycle shall consist of one full line of print or a status change recording if the printer is intended for use with a specific device.

37.4 When a time-limit circuit is provided as a part of a control unit tested, it is to be shunted out of the circuit for the duration of this endurance test.

37.5 A unit employing either power-supply circuitry or circuitry for the power-supply battery charger shall operate as intended following 6000 cycles operation as described below.

Exception: Exception: For a unit employing only a battery charger, the product shall operate as intended after 500 cycles as specified in 37.6 and 37.7.

37.6 With the input connected to a voltage source in accordance with Table 37.2, a load or loads drawing maximum rated output power are to be alternately applied and removed, or reduced to the manufacturer's specified minimum value, at a rate of no more than 15 cycles per minute. Each cycle is to consist of the load application followed by the load removal (or reduction) for an equal time.

Table 37.2
Values of test voltages

Control unit rated voltage, nameplate	Test voltage
110 – 120	120
220 – 240	240
Other	Marked rating
Battery circuit	Nominal battery voltage

37.7 For a unit employing battery charger circuitry, the input circuit is to be connected to a source having a rated voltage defined in Table 37.2. A load, drawing maximum charging current to a discharged battery as defined in 37.8 – 37.11 is to be applied to the charger circuitry for 5-second intervals for a total of 500 cycles.

37.8 The terminal voltage of a battery discharge as specified in 37.9 – 37.11 shall not be less than 85 percent of the marked ratings of the output circuits.

37.9 The battery is first to be charged by applying ac input power to the product for 48 hours, during which the product is to be operated continuously with normal standby load connected. Next the ac input is to be disconnected and terminal voltage of the battery is to be measured one minute after disconnection.

37.10 The battery is then to be discharged by maintaining the normal standby load connected to the output for the applicable period specified in (a), (b), or (c):

a) 24 hours, when the product is intended for use in a local, proprietary, or central station signaling system;

b) 60 hours when the product is intended for use in an auxiliary or remote station signaling system; or

c) 4 hours when standby power is intended to be used in conjunction with an engine-driven generator.

37.11 At the conclusion of the discharge period the maximum rated load is to be applied for 5 minutes. Battery terminal voltage of the discharged battery is then to be measured.

38 Burnout Test

Effective date for 38 changed from November 5, 2006 to September 1, 2009

38.1 A continuous-duty resistor shall not be burned out or adversely affected by carrying the full normal current on any step continuously. A resistor intended for intermittent use shall be able to carry its rated current on any step for as long a time as permitted by the character of the apparatus which it controls.

38.2 There shall not be manifestation of a risk of fire or electric shock when an unreliable component, such as an electrolytic capacitor, is opened or shorted. The device is to be connected to a source of rated voltage and frequency and with the enclosure grounded. Each fault is to be applied separately until temperatures stabilize or burnout occurs. Components operating at 50 percent or less of the manufacturer’s ratings, or those known to be highly reliable, are not included under this requirement.

38.3 When a time-limit cutout or a mercury-tube switch is employed in such a manner that a fault, either a short circuit or a ground, will cause it to carry current in excess of its maximum normal load, the cutout or switch shall be capable of withstanding, without introducing a risk of fire, a short circuit as described in 38.4 – 38.6.

38.4 The time-limit cutout or mercury-tube switch is to be connected in series with a protective fuse(s) of the marked maximum rating with which it is intended to be used, as indicated by the marking of the control unit. The cutout or switch is to be tested while mounted normally in the control unit; all openings of the enclosure of the control unit are to be covered with surgical cotton, and the enclosure, if of metal, is to be connected to ground through a fuse of the same rating as the protective fuse mentioned in 38.10.

38.5 The open-circuit voltage of the test circuit is to be within 5 percent of the rated voltage of the control unit circuit in which the device is applied, except that a voltage of more than 105 percent of the rated voltage may be employed if agreeable to those concerned. The source of current and the test circuit are to be of sufficient capacity to deliver 1000 amperes when the system is short-circuited at the testing terminals.

38.6 There shall not be ignition of the cotton or of insulation on circuit conductors, emission of flame or molten metal (mercury excepted), from the enclosure, blowing of the fuse in the grounding conductor, damage to other parts of the control unit, or any manifestation of a risk of fire. The burnout of pigtail leads or of a thermal element, or the welding of contacts, is not prohibited.

38.7 The cutout or switch is to be tested while mounted normally in the device; all openings of the enclosure of the device are to be covered with surgical cotton, and the enclosure, when of metal, is to be connected to ground through a fuse of the same rating as the protective fuse mentioned in 38.10.

38.8 When a power transformer other than a transformer supplying a low-voltage circuit is operated as described below, there shall not be damage to the enclosure or emission of flame or molten metal.

38.9 The device is to be operated continuously at the voltage and frequency specified in 14.2 with the enclosure grounded. The load connected to the output terminals is to be a resistance of such value that three times the full-rated current will be drawn from the secondary winding of the device, and operation is to be continued until constant temperatures are attained on the enclosure or until burnout occurs.

38.10 A circuit on which a transformer is tested is to be protected by fuses rated at least ten times the primary current rating of the transformer. Opening of the fuses is not prohibited. The test is to be conducted with the output terminals short-circuited, when such a condition results in less than three times full-rated current being drawn from the secondary. When other means of limiting the load to less than three times normal is inherent in or provided as part of the device, these features are to be given consideration and the burnout test conducted at the maximum load permitted by the limiting features. These features may be external to the transformer and include, but are not limited to, the following:

a) Nonresettable thermal elements that are integral with the transformer windings;

b) Wire wound, or other types of resistors that limit the load current;

c) Positive temperature coefficient (PTC) resistors;

d) Inherent limitation due to impedance of the transformer windings; and

e) Nonreplaceable fusing elements that are soldered into the product.

38.11 A transformer supplying a low-voltage circuit is to be tested with output (secondary) wiring terminals short circuited.

39 Power Supply Tests

Effective date for 39 changed from November 5, 2006 to September 1, 2009

39.1 When a separate power supply, other than a battery, is used to provide energy to one or more alarms, it is to be subjected to the test in 39.2 and 39.3.

39.2 The volt-amperes capacity of the output circuit of a power supply that is separate from the alarms shall not be more than 100 volt-amperes and not more than 30 volts, 60 hertz, 42.4 volts peak or dc.

39.3 To determine compliance with the requirements in 39.2, a variable resistive load is to be connected to the output circuit of the power supply. With the power supply connected to a rated source of supply, the load is to be varied from open circuit to short circuit in an elapsed time of not less than 1-1/2 minutes and not more than 2-1/2 minutes. Voltage and current measurements are to be recorded for each value and the maximum volt-amperes is to be calculated. When an overcurrent device is provided it is not prohibited that it be shunted out during the test.

40 Tests of Thermoplastic Materials

Effective date for 40 changed from November 5, 2006 to September 1, 2009

40.1 General

40.1.1 Thermoplastic materials intended for the sole support of current-carrying parts or as an enclosure of a device shall be subjected to the following tests. Where possible a complete unit shall be used.

Exception No. 1: Parts that are molded from materials classified 5VA by the vertical burning tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are not required to be subjected to the 3/4 inch flame test described in 40.3 or the 5 inch flame test described in 40.4.

Exception No. 2: Parts that are molded from materials that are classified 5VB, V-O, or V-2 by the vertical burning test described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, are not required to be subjected to the 3/4 inch flame test as described in 40.3. Such parts are required to be subjected to the 5 inch flame test described in 40.4.

40.2 Accelerated air-oven aging test

40.2.1 There shall not be excessive warping or exposure of un-insulated hazardous-voltage circuit parts so as to impair operation or provide access to un-insulated hazardous-voltage circuit parts when representative samples of a plastic material are aged for 7 days in a circulating-air oven maintained at 90°C (194°F), or for 28 days at a temperature of 70°C (158°F), and in both cases at a relative humidity of 0 – 10 percent.

40.2.2 At least three representative samples are to be mounted on a support as intended in service and placed in the oven. At the end of the aging period indicated in 40.2.1, the samples are to be removed, permitted to cool, and then examined for adverse distortion. It is not prohibited for the cover to fall off the unit during the test when no hazardous-voltage circuit parts are exposed and the cover can be replaced as intended.

40.3 Flame test (3/4 inch)

40.3.1 When equipment is tested as described in 40.3.2 – 40.3.6 the material shall not flame for more than 1 minute after two 30-second applications of a test flame, with an interval of 1 minute between applications of the flame. The sample shall not be completely consumed.

40.3.2 Three samples of the equipment are to be placed in a forced draft circulating air oven maintained at a uniform temperature no less than 10°C (18°F) higher than the maximum temperature of the material measured under normal operating conditions, and no less than 70°C (158°F) in any case. The samples are to remain in the oven for 7 days. After cooling to room temperature for a minimum of 4 hours, the samples are to be tested as described in40.3.3 – 40.3.6.

Exception: Testing is required on only three unconditioned test samples when both of the following conditions are met:

> *a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging and*

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

40.3.3 Three samples of the part are to be subjected to the 3/4 inch flame test. In the performance of the test the equipment is to be supported in its normal operating position in a draft free location.

40.3.4 Nonpolymeric portions are not to be removed and, as far as is possible, the internal mechanism of the equipment is to be in place. The flame is to be applied to an inside surface of the sample at a location judged as capable of becoming ignited because of its proximity to a source of ignition. Each sample is to be tested with the flame applied to a different location.

40.3.5 With reference to 40.3.4, the sections judged capable of becoming ignited are to be those adjacent to coil windings, splices, open-type switches, or arcing.

Exception: Natural gas having a heat content of 1000 Btu\ft3 (37 MJ\m3 at 23°C) has been found to provide similar results and is appropriate for use.

40.3.6 When one sample from a set of three does not comply with the above, an additional set of three samples shall be tested. All samples from the second set shall comply.

40.4 Flame test (5 inch)

40.4.1 When equipment is tested as described below, all of the following results shall be obtained:

a) The material shall not continue to burn for more than 1 minute after the fifth 5-second application of the test flame, with an interval of 5 seconds between applications of the flame.

b) Flaming drops or flaming or glowing particles that ignite surgical cotton 305 mm (12 inches) below the test specimen shall not be emitted by the test sample at any time during the test, and

c) The material shall not be destroyed in the area of the test flame to such an extent that the integrity of the part is affected with regard to containment of fire or exposure of high voltage parts.

40.4.2 Three samples of the complete equipment, or three test specimens of the molded part, are to be subjected to this test. Consideration is to be given to leaving in place components and other parts that influence the performance. The test samples are to be conditioned in a full draft circulating air oven for 7 days at 10°C (18°F) over the maximum use temperature and not less than 70°C (158°F) in any case. Prior to testing the samples are to be conditioned for a minimum of 40 hours at 23.0 ±2°C (73.4 ±3.6°F) and 50 ±5 percent relative humidity. The flame is to be applied to an inside surface of the sample at a location judged as capable of becoming ignited because of its proximity to a source of ignition. When more than one part is near a source of ignition, each sample is to be tested with the flame applied to a different location.

Exception: Only three unconditioned test samples are required for testing when both of the following conditions are met:

a) The material does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging and

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric part.

40.4.3 The three samples shall perform as described in 40.4.1. When one sample does not comply, the test is to be repeated on a set of three new samples with the flame applied under the same conditions as for the unsuccessful sample. All three new specimens shall comply.

40.4.4 The Bunsen or Tirrill burner with a tube length of 9.5 ±0.3 mm (0.374 ±0.12 inch), and an inside diameter of 100 ±10 mm (3.94 ±0.39 inches), is to be placed remote from the specimen, ignited, and adjusted so that when the burner flame is 127 mm (5 inches), the height of the inner blue cone is 38 mm (1-1/2 inches).

40.4.5 The tube is not to be equipped with end attachments, such as stabilizers.

40.4.6 When a complete enclosure is used to conduct the flame test, the sample is to be mounted as intended in service in a draft-free test chamber, enclosure, or laboratory hood. A layer of surgical cotton is to be located 305 mm (12 inches) below the point of application of the test flame. The 127-mm (5-inch) flame is to be applied to any portion of the interior of the part judged as capable of being ignited (by its proximity to live or arcing parts, coils, wiring, or other possible sources of ignition) at an angle of 20 degrees from the vertical so that the tip of the blue cone touches the specimen. The test flame is to be applied to three different locations on each of the three samples tested. A supply of technical-grade methane gas is to be used with a regulator and meter for uniform gas flow.

Exception No. 1: In cases where mounting the sample as intended for service impairs the application of the flame the sample shall be mounted to best conduct the test.

Exception No. 2: The flame is to be applied to the outside of an enclosure when the equipment is of the encapsulated type, or of a size that prohibits the flame being applied inside.

Exception No. 3: Natural gas having a heat content of 1000 Btu/ft3 (37 MJ/m3 at 23°C) has been found to provide similar results and is appropriate for use.

40.4.7 The flame is to be applied for 5 seconds and removed for 5 seconds. The operation is to be repeated until the specimen has been subjected to five applications of the test flame.

41 Class 2 and Class 3 Power-Limited Circuits Test

Effective date for 41 changed from November 5, 2006 to September 1, 2009

41.1 General

41.1.1 All field-wiring circuits that derive energy from power sources connected to a product shall be classified as Class 1, 2, or 3 circuits. A circuit shall be labeled Class 1 unless otherwise identified in the installation documentation and marking on the product.

41.1.2 All power source(s) supplying a Class 2 or Class 3 power-limited circuit shall be either inherently limited requiring no over-current protection, or limited by a combination of a power source and over-current protection such that a power-limited circuit shall have electrical characteristics as described in Tables 41.1 and 41.2 for ac circuits or Tables 41.3 and41.4 for dc circuits.

Table 41.1
Power source limitations for alternating current Class 2 and Class 3 circuits – inherently limited power source

Circuit		Inherently limited power source (overcurrent protection not required)			
		Class 2			Class 3
Circuit voltage V_{max} (volts)[a]		**0 – 20**	**over 20 – 30**	**over 30 – 150**	**over 30 – 100**
Power limitations $(VA)_{max}$ (volt-amps)[a]		–	–	–	–
Current limitations I_{max} (amps)[a]		8.0	8.0	0.005	$150/V_{max}$
Maximum overcurrent protection (amps)		–	–	–	–
Power source maximum nameplate ratings	VA (volt-amps)	5.0 x V_{max}	100	0.005 x V_{max}	100
	Current (amps)	5.0	$100/V_{max}$	0.005	$100/V_{max}$

Voltage ranges shown are for sinusoidal ac in indoor locations or where wet contact is not probable. For non-sinusoidal or wet contact conditions, see footnote b.

[a] V_{max}: Maximum output voltage regardless of load with rated input applied.

I_{max}: Maximum output current under any noncapacitive load, including short-circuit, and with overcurrent protection bypassed, when used. When a transformer limits the output current, I_{max} limits apply after one minute of operation. Where a current-limiting impedance, listed for the purpose, or as part of a listed product, is used in combination with a nonpower-limited transformer or a stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after 5 seconds.

VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed, when used. Current-limiting impedance shall not be bypassed when determining I_{max} and VA_{max}.

[b] For non-sinusoidal ac, V_{max} shall not be greater than 42.4 volts peak. Where wet contact (immersion not included) is probable, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 15 volts for sinusoidal ac and 21.2 volts peak for non-sinusoidal ac.

Table 41.2
Power source limitations for alternating-current Class 2 and Class 3 circuits – not inherently limited power source

Circuit		Not inherently limited power source (overcurrent protection required)			
		Class 2			Class 3
Circuit voltage V_{max} (volts)[a]		**0 – 20**	**over 20 – 30**	**over 30 – 100**	**over 100 – 150**
Power limitations $(VA)_{max}$ (volt-amps)[a]		250[b]	250	250	NA
Current limitations I_{max} (amps)[a]		$1000/V_{max}$	$1000/V_{max}$	$1000/V_{max}$	1.0
Maximum overcurrent protection (amps)		5.0	$100/V_{max}$	$100/V_{max}$	1.0
Power source maximum nameplate ratings	VA (volt-amps)	5.0 x V_{max}	100	100	100
	Current (amps)	5.0	$100/V_{max}$	$100/V_{max}$	$100/V_{max}$

Voltage ranges shown are for sinusoidal ac in indoor locations or where wet contact is not probable. For non-sinusoidal or wet contact conditions, see footnote c.

[a] V_{max}: Maximum output voltage regardless of load with rated input applied.

I_{max}: Maximum output current under any noncapacitive load, including short-circuit, and with overcurrent protection bypassed, when used. When a transformer limits the output current, I_{max} limits apply after one minute of operation. Where a current-limiting impedance, listed for the purpose, or as part of a listed product, is used in combination with a nonpower-limited transformer or a stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after 5 seconds.

VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed, when used. Current-limiting impedance shall not be bypassed when determining I_{max} and VA_{max}.

[b] When the power source is a transformer, VA_{max} is 350 or less where V_{max} is 15 or less.

[c] For non-sinusoidal ac, V_{max} shall not be greater than 42.4 volts peak. Where wet contact (immersion not included) is probable, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 15 volts for sinusoidal ac and 21.2 volts peak for non-sinusoidal ac.

Table 41.3
Power source limitations for direct-current
Class 2 and Class 3 circuits - inherently limited power source

Circuit		Inherently limited power source[a] (overcurrent protection not required)				
		Class 2				Class 3
Circuit voltage V_{max} (volts)[b]		0 – 20	over 20 – 30	over 30 – 60	over 60 – 150	over 60 – 100
Power limitations $(VA)_{max}$ (volt-amps)[b]		–	–	–	–	–
Current limitations I_{max} (amps)[a]		8.0	8.0	150/ V_{max}	0.005	150/V_{max}
Maximum overcurrent protection (amps)		–	–	–	–	–
Power source maximum nameplate ratings	VA (volt-amps)	5.0 x V_{max}	100	100	0.005 x V_{max}	100
	Current (amps)	5.0	100/ V_{max}	100/ V_{max}	0.005	100/ V_{max}
Voltage ranges shown are for continuous dc in indoor locations or where wet contact is not probable. For interrupted dc or wet-contact conditions, see note d.						

[a] A dry-cell battery shall be considered an inherently limited power source when the voltage is 30 volts or less and the capacity is equal to or less than that available from series connected No. 6 carbon zinc cells.

[b] V_{max}: Maximum output voltage regardless of load with rated input applied.

I_{max}: Maximum output current under any noncapacitive load, including short-circuit, and with overcurrent protection bypassed, when used. When a transformer limits the output current, I_{max} limits apply after 1 minute of operation. Where a current-limiting impedance, listed for the purpose or as part of a listed product, is used in combination with a nonpower-limited transformer or stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after 5 seconds.

VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed, when used. Current-limited impedance shall not be bypassed when determining I_{max} and VA_{max}.

[c] When the power source is a transformer, $(VA)_{max}$ is 350 or less where V_{max} is 15 or less.

[d] For dc interrupted at a rate of 120 – 20 Hz, V_{max} shall not be greater than 24.8 volts. Where wet contact (immersion not included) is probable, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 30 volts for continuous dc and 12.4 volts for dc that is interrupted at a rate of 10 – 200 Hz.

41.1.3 Means for current-limiting include:

a) Transformer winding impedance;

b) Thermal link embedded within the winding overwrap of a transformer;

c) Circuit components (resistors, regulators, transistors) which comply with the Temperature Test, Section 34, under I_{max} condition; and

d) Current-limiting impedances such as positive temperature coefficient varistors.

41.1.4 Relative to 41.1.2, the following examples are not means for current-limiting.

a) Circuit component burnout,

b) Permanent or replaceable fuses,

c) Opening of conductors on printed-circuit boards, or

d) Opening of internal wiring conductors.

41.1.5 The over-current protection device referred to in 41.1.2 shall be of the noninterchangeable type such that it is unable to be renewed in the field with an over-current device having a higher current rating.

41.1.6 When conducting I_{max} and V_{max},I_{max}, and VA_{max} measurements, all over-current protection devices of the product are to be short-circuited. Current-limiting devices shall not be bypassed and shall remain functional.

41.1.7 When the product contains a float battery charger, V_{max},I_{max}, and VA_{max} measurements shall be conducted with both ac and battery connected to the product. When the product contains a battery transfer relay, or contains a trickle charge battery circuit, measurements of V_{max},I_{max}, and VA_{max} shall be conducted with the product first energized only from the ac power source and then repeated with the product energized solely from the battery. The battery used during these measurements shall have the largest capacity as specified in the manufacturer's installation document.

41.2 Maximum voltage

41.2.1 With the product energized only from its rated primary power source, the output voltage of the circuit under test is to be measured while the circuit is connected to full rated load and under open circuit conditions. The maximum voltage recorded under these two conditions shall be V_{max}. Where the product also incorporates a secondary source of supply, this test is to be repeated with the product energized solely from the secondary power source and with the primary power source disconnected. The V_{max} value obtained from each power source shall be considered separately when applying the requirements of Tables 41.1 – 41.4.

Table 41.4
Power source limitations for direct-current
Class 2 and Class 3 circuits – not inherently limited power source

Circuit		Not inherently limited power source (overcurrent protection required)			
		Class 2			Class 3
Circuit voltage V_{max} (volts)[b]		**0 – 20**	**over 20 – 60**	**over 60 – 100**	**over 100 – 150**
Power limitations $(VA)_{max}$ (volt-amps)[b]		250[c]	250	250	NA
Current limitations I_{max} (amps)[b]		1000/ V_{max}	1000/ V_{max}	1000/ V_{max}	1.0
Maximum overcurrent protection (amps)		5.0	100/ V_{max}	100/ V_{max}	1.0
Power source maximum nameplate ratings	VA (volt-amps)	5.0 x V_{max}	100	100	100
	Current (amps)	5.0	100/ V_{max}	100/ V_{max}	100/ V_{max}

Voltage ranges shown are for continuous dc in indoor locations or where wet contact is not probable. For interrupted dc or wet-contact conditions, see note d.

[a] A dry-cell battery shall be considered an inherently limited power source, provided the voltage is 30 volts or less and the capacity is equal to or less than that available from series connected No. 6 carbon zinc cells.

[b] V_{max}: Maximum output voltage regardless of load with rated input applied.

I_{max}: Maximum output current under any noncapacitive load, including short-circuit, and with overcurrent protection bypassed, when used. When a transformer limits the output current, I_{max} limits apply after 1 minute of operation. Where a current-limiting impedance, listed for the purpose or as part of a listed product, is used in combination with a nonpower-limited transformer or stored energy source, e.g., storage battery, to limit the output current, I_{max} limits apply after 5 seconds.

VA_{max}: Maximum volt-ampere output after one minute of operation regardless of load and overcurrent protection bypassed, when used. Current-limited impedance shall not be bypassed when determining I_{max} and VA_{max}.

[c] When the power source is a transformer, $(VA)_{max}$ is 350 or less where V_{max} is 15 or less.

[d] For dc interrupted at a rate of 120 to 20 Hz, V_{max} shall not be greater than 24.8 volts. Where wet contact (immersion not included) is probable, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 30 volts for continuous dc and 12.4 volts for dc that is interrupted at a rate of 10 to 200 Hz.

41.3 Maximum current

41.3.1 In order to determine compliance with the I_{max} limitation, a variable load resistor is to be connected across the circuit. While monitoring the current through the load resistor, the load resistor is to be adjusted from open-circuit to short-circuit as quickly as is possible and the highest current reading noted. The load resistor is then to be readjusted to produce the highest current obtained and the current through the load resistor measured after 1 minute or after 5 seconds as determined from Tables 41.1 – 41.4.

41.3.2 The maximum current measurement is to be the rms value for circuits that are constantly energized and the peak value for circuits that pulse the output. The measurement of the time period referred to in 41.3.4, starts when the output is initially energized with the load specified in 41.3.3 and 41.3.4, and continues until the current is continuously below the I_{max} value of Tables 41.1 – 41.4. The time period is to include any momentary period where the output current temporarily drops below the required I_{max} limit.

41.3.3 Where a transformer limits the value of I and when I_{max} is unable to be maintained for 1 minute due to transformer burnout, a plot of current versus time shall be generated and the graph extrapolated to 1 minute. The results satisfy the requirement of the test when the extrapolated value of I_{max} at 1 minute does not exceed the I limitations as indicated in Tables 41.1 – 41.4.

41.3.4 When a transformer does not limit the value of I and the maximum current through the load resistor cannot be maintained for 5 seconds due to current limiting devices (such as opening of thermal link, power supply foldback, or PTC varistor effect), the circuit load resistor shall be adjusted to a value which produces a current just above the I value indicated in Tables 41.1 – 41.4. The results are in compliance when the I value stated in Tables 41.1 – 41.4 is unable to be maintained for more than 5 seconds.

41.3.5 In order to determine VA_{max}, the product shall be energized from a rated source of supply and the circuit under test open-circuited. A variable load resistor, initially set to draw rated circuit current, shall then be connected across the circuit, the circuit voltage and current recorded, and then the load is to be removed. The resistance of the load shall then be incrementally decreased, momentarily reconnected across the circuit while recording the voltage and current, and then removed. This procedure shall be repeated until the load resistance has been reduced to a short-circuit. Using the recorded voltage and current, the volt-ampere output under each load condition shall be calculated. The load resistor shall then be adjusted to that value which produced the maximum volt-ampere calculated and then connected to the circuit. After the time determined in Tables 41.1 – 41.4, the voltage and current are again to be measured. The results of this test are acceptable when the calculated volt-ampere output of the circuit does not exceed the values in Tables 41.1 – 41.4 as appropriate.

42 Dielectric Voltage-Withstand Tests

Effective date for 42 changed from November 5, 2006 to September 1, 2009

42.1 A product shall withstand for 1 minute, without breakdown, the application of a sinusoidal ac potential of a frequency within the range of 40 – 75 hertz, or a dc potential, between live parts and the enclosure, between live parts and exposed dead metal parts, and between live parts of circuits operating at different potential or frequencies. The test potential is to be as follows (see also 42.3):

a) For a unit rated 30 volts ac rms (42.4 volts dc or ac peak) or less – 500 volts ac (707 volts, when a dc potential is used);

b) For a unit rated between 31 and 150 volts ac rms – 1000 volts ac (1414 volts, when a dc potential is used);

c) For a unit rated more than 150 volts ac rms – 1000 volts ac plus twice the rated voltage (1414 volts plus 2.828 times the rated ac rms voltage when a dc potential is used).

42.2 Exposed dead metal parts are noncurrent-carrying metal parts that are capable of becoming energized and are accessible from outside of the enclosure of a product during operation with the door of the enclosure closed.

42.3 For the application of a potential between live parts of circuits operating at different potentials or frequencies, the voltage is to be the applicable value specified in 42.1 (a), (b), or (c), based on the highest voltage of the circuits under test instead of the rated voltage of the unit. Electrical connections between the circuits are to be disconnected before the test potential is applied.

42.4 When the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground is sufficient to prevent maintenance of the specified ac test potential, the capacitor or filter is to be tested using a dc test potential in accordance with 42.1.

42.5 The test potential shall be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. The method of applying the test voltage is to be such that there are no transient voltages that result in the instantaneous voltage applied to the appliance or circuit exceeding 105 percent of the peak value of the specified test voltage. The applied potential is to be:

a) Increased from 0 at a uniform rate so as to arrive at the specified test potential in approximately 5 seconds, then

b) Maintained at the test potential for 1 minute without an indication of a breakdown or leakage of greater than 0.5 mA. Control of the rate of rise shall be either manual or automatic.

42.6 A printed wiring assembly or other electric circuit component that would be damaged by, or would short-circuit, the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly is then to be tested instead of an entire unit. Where applicable, rectifier diodes in the power supply are to be individually shunted before the test to avoid destroying them in the case of a malfunction elsewhere in the secondary circuits.

43 Dielectric Voltage-Withstand Testing in lieu of measuring clearances

Effective date for 43 changed from November 5, 2006 to September 1, 2009

43.1 For printed wiring assemblies contained within metal enclosures, if one or more components would cause the indication of a breakdown because they complete the path between the points being tested, those components may have one termination disconnected, so long as the points in question are subjected to the same test voltage.

43.2 Clearance values for printed wiring assemblies contained within metal enclosures may be verified by conducting the impulse withstand voltage test described in 43.4. The equipment shall withstand the voltage impulse without breakdown or disruptive discharge. Breakdown is considered to have occurred when the leakage current exceeds 4 milliamperes or when the test voltage is interrupted prior to completion. Operation of an overvoltage protective device is not considered a breakdown.

43.3 If a disruptive discharge occurs through an overvoltage protective device or system, that device or system is to be removed from the circuit and the test voltage is to be reduced to the impulse withstand voltage of that device or system. The test voltage is then to be applied across the load side at the point where the overvoltage protection was connected.

43.4 With reference to 10.2.2 and 10.3.6, a previously untested product is to be used. The voltage is to be full lightning 1.2/50 microsecond impulses in accordance with Techniques for High-Voltage Testing, ANSI/IEEE 4-1978. Three positive and three negative impulses are to be applied. The minimum interval between pulses is to be 1 second. Other equivalent methods, as shown in Table 10.2 or 10.3, as appropriate, may be used. The test voltage is to be applied at the supply input to the product under consideration.

Table 43.1
Test methods to be used to test spacings

Type of test	Impulse	ac rms	ac peak or dc	ac peak 1/2 sine wave	ac peak ramp
Rate of rise	1.2/50	–	–	–	6000 V/sec.
Hertz	–	50 – 60	50 – 60	50 – 60	50 – 60
Duration of test	3 Pos. & 3 Neg.[a] cycles	3 Pos. & 3 Neg.[a] cycles	3 Pos. & 3 Neg.[a] cycles dc, min. 10 ms	3 Pos.& 3 Neg.[a]	4 – 5 mA leakage current detection[b]

[a] The available current is to be limited to 4 – 5 milliamperes. The test equipment can be power limited or designed to shut off by the detection of 4 – 5 milliampere leakage current.

[b] The measured voltage must exceed the values in Table 10.2 or 10.3 as appropriate when the leakage current of 4 – 5 milliamperes is measured.

44 Mechanical Strength Tests for Metal Enclosures and Guards

Effective date for 44 changed from November 5, 2006 to September 1, 2009

44.1 The enclosure or guard of a unit, when of metal, shall withstand a force of 100 lbs (45.4 kg) for 1 minute without:

a) Permanent distortion to the extent that spacings are reduced more than 50 percent of the values specified in Spacings, Section 10;

b) Transient distortion that results in contact with live parts; or

c) Developing openings that do not comply with the accessibility requirements in 9.11.1 –9.11.4. The force is to be applied by means of a metal sphere 12.7 mm (1/2 inch) in diameter.

44.2 The enclosure or guard of a unit, when of metal, shall withstand an impact of 5 ft-lbs (6.8 N·m) without:

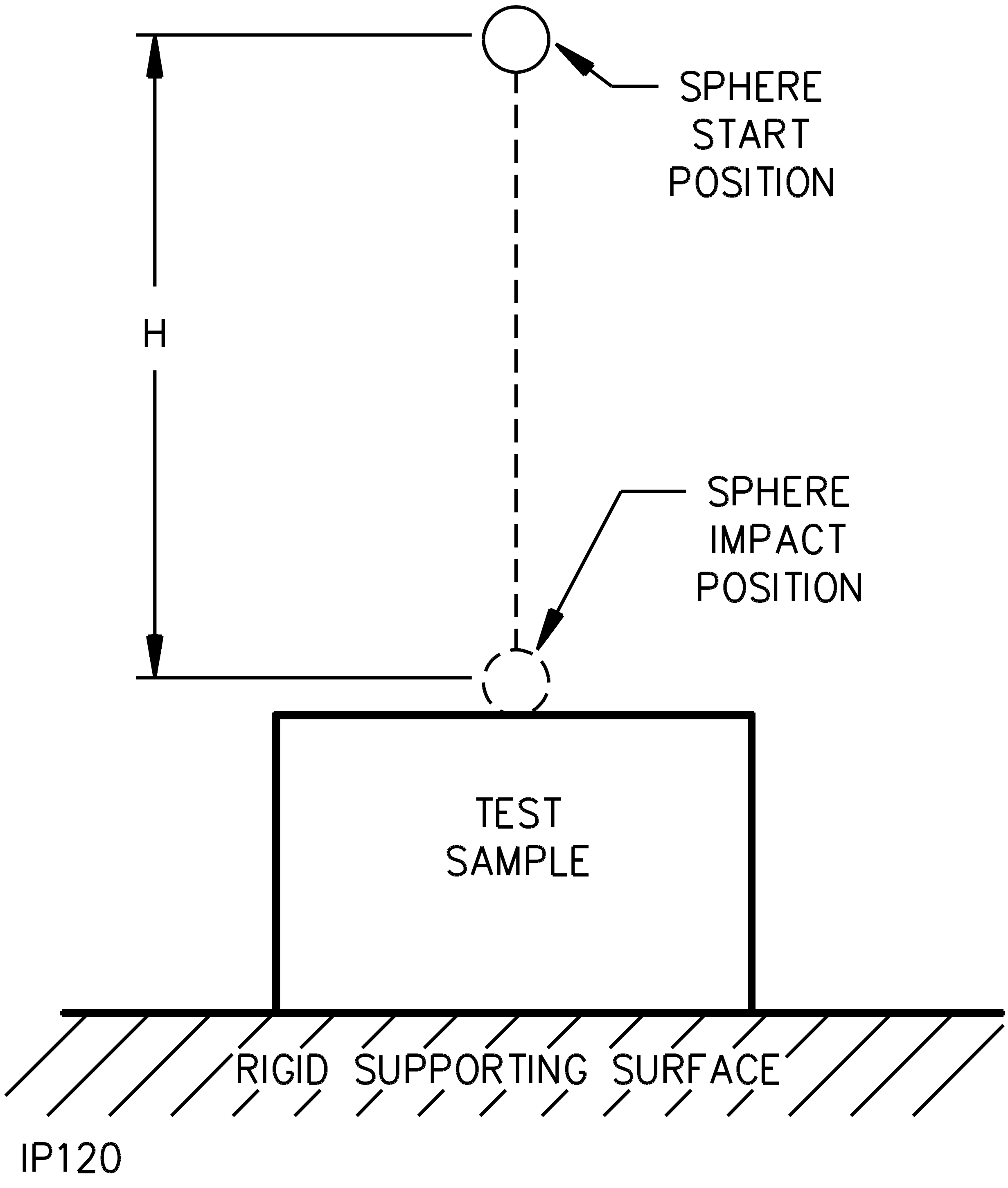
a) Permanent distortion to the extent that spacings are reduced below the values specified in Spacings, Section 10;

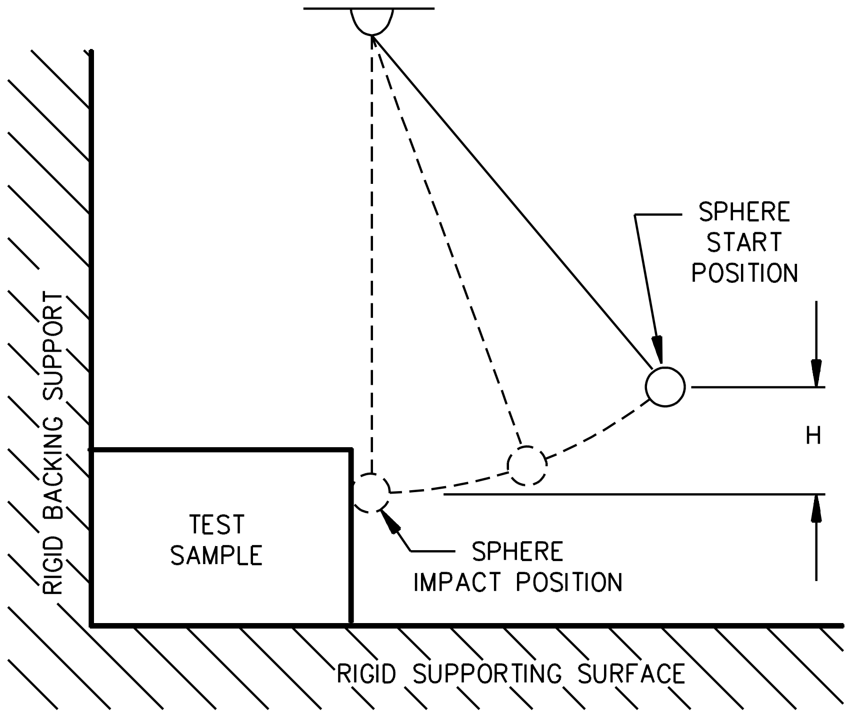
b) Transient distortion that results in contact with live parts; or

c) Developing openings that do not comply with the accessibility requirements in 9.11.1 –9.11.4.

The impact is to be applied by means of a smooth, solid, steel sphere 2 inches (50.8 mm) in diameter and having 1.18 lb (0.54 kg) mass. The sphere is to fall freely from rest through a vertical distance of 51 inches (1.30 m). See Figure 44.1.

Figure 44.1
Ball-pendulum impact test





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45 Corrosion Tests

Effective date for 45 changed from November 5, 2006 to September 1, 2009

45.1 Corrosion Test – 21 Day

45.1.1 Two samples, one at maximum and one at minimum sensitivity setting, are to be placed in a 200 liter or larger test chamber on a platform approximately 2 inches (50.8 mm) above the bottom of the chamber. The temperature in the chamber is to be maintained at 30 ±2°C (86 ±3°F) and the relative humidity at 70 ±2 percent (measured directly in the chamber). The temperature and humidity are to be checked daily. Because of the corrosive atmosphere a set of wet and dry bulb thermometers shall be used for measurement of relative humidity.

45.1.2 The following gas mixture in air is to be supplied to the chamber at a rate sufficient to achieve an air exchange in the chamber of about five times per hour, for a period of 3 weeks: 100±10 parts per billion (ppb) (parts per billion = parts per 109 by volume) hydrogen sulfide (H_2S) plus 20 ±5 ppb chlorine (Cl_2) plus 200 ±50 ppb nitrogen dioxide (NO_2). The air inside the chamber is to be circulated by a single fan, with flow upwards from the bottom.

45.1.3 Following this test, the alarms shall comply with the sensitivity requirements of 15.1 – 15.5.

45.2 Corrosion (Salt Spray) Test

45.2.1 An alarm, detector or control system (if applicable) intended for use in a limited outdoor environment shall operate as intended and shall not false alarm after exposure for 48 hours to a salt spray in accordance with the procedure specified in the Standard for Salt Spray (Fog) Testing, ASTM B117-85.

45.2.2 Two alarms or detectors and a control system, one at maximum and one at minimum sensitivity, are to be subjected to the salt spray while in a de-energized condition. Following the exposure, the samples are to be removed, dried for at least 24 hours in an air circulating oven or air dried for at least 48 hours, and then subjected to the Sensitivity requirements outlined in Sections 15.1 – 15.5.

45.2.3 Following this test, the alarms shall comply with the sensitivity requirements of 15.1 – 15.5.

45.3 Corrosion Test (10 day) (Alternative to the 21 Day Test, See 45.1)

45.3.1 In lieu of the test specified in 45.1, samples of the alarm, detector or control system (if applicable) shall operate as intended after being subjected to the corrosive atmosphere tests described in 45.3.2 – 45.4.1. The samples are to be placed in the test chambers that are located in an ambient room temperature of 23 ±2°C (73.4 ±3°F), maintained at 20 – 50 percent relative humidity, and are to be mounted in the intended position of use on a platform 2 inches (50.8 mm) above the bottom of the exposure chamber. The relative humidity inside the chamber during the test is to be 95 percent.

45.3.2 Moist Hydrogen Sulfide-Air Mixture Exposure – Two samples, one at maximum and one at minimum sensitivity setting, are to be exposed to a moist hydrogen sulfide-air mixture in a closed glass chamber for a period of 10 days. The amount of hydrogen sulfide is to be equivalent of 0.1 percent of the volume of the chamber. A small amount of water (10 ml/0.003 m of chamber volume) is to be maintained at the bottom of 3 the chamber for humidity.

45.3.3 Moist Carbon Dioxide-Sulfur Dioxide-Air Mixture Exposure – Two samples, one at maximum and one at minimum sensitivity setting, are to be exposed to a moist carbon dioxide-sulfur dioxide-air mixture in a closed glass chamber for a period of 10 days. The amount of carbon dioxide is to be the equivalent of 1.0 percent, and the amount of sulfur dioxide is to be the equivalent of 0.5 percent of the volume of the chamber. A small amount of water (10 ml/0.003 m of chamber volume) is to be maintained at the 3 bottom of the chamber for humidity.

45.4 10 Day Corrosion – Test equipment

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

a) Compressed Gas Cylinders (Commercial Grade SO_2, Dry Grade CO_2, C.P. Grade H S).

b) Needle Valves (to adjust flow).

c) Selector Valve (selects CO_2 or SO_2).

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

e) Gas inlets to exposure chamber.

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

g) Small motor and fan blade. [1550 rpm motor with aluminum fan blade, ten 3-1/2 inch (88.9 mm) wings providing air movement toward motor. Neoprene gasket used to seal shaft through-hole in glass cover.]

h) Support Platform (plastic ″egg-crate″ grid material).

i) Test Sample. Normally two employed.

Different type chambers shall not be used unless the equivalent gas concentrations and water are maintained.

45.4.2 The samples are to be tested for sensitivity prior to exposure. Following the corrosive exposures described in 45.3.2 and 45.3.3, the alarms are to be dried in a circulating air oven at a temperature of 40°C (104°F) for a period of at least 24 hours, after which the samples are to be tested again for sensitivity. The sensitivity of the samples shall not vary by more than the limits specified in 15.1 – 15.5. The activation of a trouble signal is also acceptable.

45.4.3 The samples are to be subjected to the corrosive atmospheres while de-energized so as not to produce an alarm signal. Battery operated alarms or detectors are to be tested with the batteries in place, and the leads to the clips disconnected for the same reason. After the exposure the leads are to be reconnected and the Sensitivity test outlined in section 15.1 – 15.5 is to be conducted.

46 Vibration Tests

Effective date for 46 changed from November 5, 2006 to September 1, 2009

46.1 An alarm or detector intended for residential applications shall withstand vibration without breakage or damage of parts. Following the vibration, the samples shall operate as intended.

46.2 To determine compliance with 46.1, sensitivity measurements following the vibration shall comply with 15.1 – 15.5.

46.3 Two samples, one at the maximum and one at the minimum sensitivity setting, are to be secured in their intended mounting position on a mounting board and the board, in turn, securely fastened to a variable speed vibration machine having an amplitude of 0.01 inch (0.25 mm). The frequency of vibration is to be varied from 10 to 35 cycles per second in increments of 5 cycles per second until a resonant frequency is obtained. The samples are then to be vibrated at the maximum resonant frequency for a period of 1/4 hour. If no resonant frequency is obtained, the samples are to be vibrated at 35 cycles per second for a period of 4 hours.

46.4 For this test, amplitude is defined as the maximum displacement of sinusoidal motion from a position of rest or one-half of the total table displacement. Resonance is defined as the maximum magnification of the applied vibration.

46.5 An alarm, detector, or control panel intended for use as a system or portable device shall withstand vibration without breakage or damage of parts. The vibration parameters shall be defined based on the intended application. If vibration operating parameters are not defined by the manufacturer, the sample shall be subject to the minimum vibration parameters as outlined in this standard or it’s normative references. Following the vibration, the samples shall operate as intended.

46.6 The samples are to be secured in their intended mounting position (including all applicable accessory equipment) on a mounting board and the board, in turn securely fastened to a variable speed vibration machine have an amplitude and frequency as follows:

a) 10 Hz to 30 Hz, 1.0 mm total excursion and

b) 31 Hz to 150 Hz, 2 g acceleration peak

46.7 The samples shall be vibrated over the specified frequency range, displacement and acceleration as specified for a period of 1 hour in each of the three mutually perpendicular planes. The frequency rate of change shall not exceed 10 Hz/min.

47 Battery Tests

Effective date for 47 changed from November 5, 2006 to September 1, 2009

47.1 If a battery is employed as the main source of power of a gas or vapor detector or sensor intended for permanent installation, it shall provide power to the unit under intended ambient conditions for at least 12 months in the standby condition, including random and weekly alarm testing, and then operate the alarm for a minimum of 4 minutes of alarm, followed by 7 days of trouble signal. Portable gas or vapor detectors or sensors shall be subject to the minimum requirements as outlined within the appropriate reference.

47.2 Six samples of the battery, or sets of batteries if more than one is used for primary power, are to be tested under each of the following conditions for a minimum of 12 months while connected to the alarm or a simulated load to which the battery is to supply power.

a) Room Ambient – 23 ±3°C (73.4 ±5°F), 30 – 50 percent relative humidity, 760 mm Hg.

b) High Temperature – 45°C (113°F).

c) Low Temperature – 0°C (32°F).

d) Humidity – 30 ±2°C (86 ±3°F), 85 ±5 percent relative humidity.

47.3 For the test either alarm samples or test loads simulating a maximum standby current drain are to be employed. The alarm load is to be the audible appliance intended to be used in the alarm or an appropriate load simulating maximum alarm conditions. The batteries are to be tested in the mounting clips employed in the alarm.

47.4 Terminals or jacks are to be provided on each test fixture to facilitate measurement of battery voltage, standby, and alarm currents. The measuring means is to be separated from the battery test means by a wiring harness or equivalent at least 3 feet (0.9 m) long.

47.5 Prior to placing the battery test setups in the various ambient conditions, each battery is to be subjected to 25 cycles of alarm representing random testing. Each cycle is to consist of 5 seconds of alarm and at least 5 minutes between each application.

47.6 During the course of the test, the battery voltage and current in standby and alarm condition are to be recorded periodically. The alarm voltage is to be recorded 3 seconds after energization. The standby voltage and current are to be recorded prior to the alarm measurements. The alarm is to be placed into an alarm condition weekly. The duration of the weekly alarm test signal is to be 3 seconds.

47.7 At the end of the 12 months, all batteries shall have sufficient capacity to operate the alarm signal for a minimum of 4 minutes followed by 7 days of trouble signal. To obtain the trouble signal level it may be necessary to continue the test with the standby current drain for longer than 12 months. The length of time that the batteries subjected to conditions in 47.2 (b), (c) and (d) are to operate the alarm signal may be less than 12 months, but not less than 6 months, if the alarm or detector is marked to indicate the battery limitations for the ambient condition involved.

47.8 Battery Replacement Test

47.8.1 The battery clips and holders of a battery operated alarm or detector shall withstand 50 cycles of battery removal and replacement at a rate not to exceed 6 cycles per minute without any reduction in contact or mounting integrity. During battery replacement, the alarm or detector shall not produce an alarm or alarm signal for more than 1 second. The test shall not have an adverse effect on the operation of the alarm or detector.

47.8.2 For this test an alarm or detector is to be installed as intended in service and the battery(s) removed and replaced as specified by the manufacturer. The alarm or detector shall then be tested for its intended operation.

47.9 Sensor Replacement Test

47.9.1 For alarms or detectors that contain replaceable sensors, the device shall withstand 50 cycles of sensor removal and replacement at a rate not to exceed 6 cycles per minute without any reduction in contact or mounting integrity. During sensor replacement, the alarm or detector shall not produce an alarm or alarm signal for more than 1 second. The test shall not have an adverse effect on the operation of the alarm or detector.

47.9.2 For this test an alarm or detector is to be installed as intended in service and the sensor removed and replaced as specified by the manufacturer. The alarm or detector shall then be tested for its intended operation. As specified by the manufacturer the alarm or detector may or may not be powered during this test.

48 Audibility Test

Effective date for 48 changed from November 5, 2006 to September 1, 2009

48.1 General

48.1.1 For an alarm or detector not intended to provide the primary alarm signal but consist of an alarm sounding device shall be tested in accordance with the parameters defined in 48.2. The samples shall be tested to comply with the sound pressure level and intended application as specified in the installation instructions.

48.1.2 Except as permitted in 48.4.1, the primary alarm sounding appliance, either integral with the alarm, detector or control panel or intended to be connected separately, shall be capable of providing for at least 4 minutes, a sound output equivalent to that of an omnidirectional source with an A-weighted sound pressure level of at least 85 decibels (db) at 10 feet (3.05 m) with two reflecting planes assumed. To determine compliance with this requirement, the method described in 48.2.1 – 48.3.2 is to be employed.

48.2 Sound output measurement

48.2.1 The sound power output of the sample shall be measured in a reverberation room using procedures outlined in ANSI Standards S12.31 (Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms) or S12.32 (Precision Methods for the determination of Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms). The sound power in each 1/3 octave band shall be determined using the comparison method. The A-weighting factor shall be added to each 1/3 octave band. The total power is to be determined on the basis of actual power. The total power is then to be converted to an equivalent sound pressure level for a radius of 10 feet (3.05 m). An additional 6 db is to be added to allow for two reflecting planes.

48.2.2 Each sample is to be mounted to a 3/4 inch (19.1 mm) plywood board measuring 2 by 2 feet (610 by 610 mm), supported in a vertical plane, and positioned at an angle of 45 degrees to the walls of the reverberation room.

48.2.3 For this test an ac powered sample is to be energized from a source of rated voltage and frequency. A battery powered sample is to be energized from batteries under each of the following conditions along the trouble signal level curve illustrated in Figure 19.1, or equivalent:

a) Nondischarged battery (a battery with some unknown shelf life, as is purchased at a retail outlet) with sufficient added resistance to obtain a trouble signal (Point D of Figure 19.2), or the maximum resistance for the particular battery based on documented data, whichever is less.

b) Battery depleted to the trouble signal level voltage, no added resistance.

c) Battery depleted to a voltage value between conditions in 48.2.3(a) and (b) which is evaluated to be the least favorable for sound output. For a straight-line curve it is the midpoint voltage. For a nonlinear curve it is to be selected.

48.2.4 The equivalent of a battery shall be considered to be a voltage source with a series resistance adjusted to a level at which a trouble signal is obtained during the normal standby condition. The resistances and voltages used are to be those that were determined during the Circuit Measurement Test, Section 19.

48.2.5 At least two samples shall be tested. Units intended for multiple-station connection shall also be tested interconnected as multiple-stations with the maximum line resistance as defined in 22.2. For ac powered units employing a nonrechargeable standby battery, the measurement shall be made with the sample connected to a rated ac voltage source, and then with the ac power de-energized and energy obtained from a standby battery depleted to 85 percent of rated battery voltage, or at the voltage level at which a trouble signal is obtained. For an ac unit employing a rechargeable standby battery, the measurement is to be made using a fully recharged battery.

48.3 Alarm duration test

48.3.1 An alarm sounding appliance of a sample powered by a primary battery that has been discharged to the trouble level condition shall produce a sound power output level per the intended application or the equivalent of 85 db at 10 feet (3.05 m) after 1 minute of continuous alarm operation and shall provide at least 82 db after 4 minutes.

48.3.2 To determine compliance with 48.3.1, a measurement shall be made under the following conditions. The ambient noise level is to be at least 10 db below the measured level produced by the signaling appliance. The sample is to be mounted 1 foot (302 mm) from the microphone placed in a direct line with the alarm. The sample is then to be energized in the alarm condition and the sound output is to be measured at 1 minute intervals, using a sound level meter[a] employing the A-weighting network. A maximum of 3 db decrease from the original 1 minute reading after 4 minutes shall determine compliance for a battery operated alarm that is providing a trouble signal.

48.4 Supplementary remote sounding appliances

48.4.1 The sound output of a supplementary remote sounding appliance, shall not be less 85 dbA for primary signaling or less than the sound output rating specified by the manufacturer.

MARKING AND INSTRUCTIONS

49 Marking

Effective date for 49 changed from November 5, 2006 to September 1, 2009

49.1 General

49.1.1 A product shall be plainly and permanently marked with the following information, where it shall be visible after installation. Portable instruments that are available with carrying cases shall be marked with the information necessary for the proper operation and understanding of all visual or audible signals. Sensors, sensor packaging or a combination of both shall include the marking information outlined in Section 49.1.1 a), b) and d).

a) Name or trademark (registered) of manufacturer;

b) Model number or other designation method determined to be equivalent;

c) Electrical rating, in volts, amperes, or watts, and frequency for a cord-connected appliance;

d) Date of manufacture by week, month, or quarter and year (abbreviations are not forbidden when an established or otherwise traceable code or serial number is employed);

e) Type of signaling device;

f) Each light, switch, meter, and similar component shall have a marking adjacent to the component to indicate the intended function;

g) Reference to an installation document, when not attached to the unit, by drawing number and issue date and/or revision level;

h) For cord-connected emergency signaling products the following, or other wording that has been determined to be equivalent, shall be marked on the product ″Do Not Connect To A Receptacle Controlled By A Switch″;

i) The identification of primary batteries by part number, manufacturer model number, or equivalent located adjacent to the component;

j) For a primary battery-operated product, the word ″WARNING″ and the equivalent shall be included on the unit ″Use Only Batteries Specified in Marking. Use Of A Different Battery May Have A Detrimental Effect On Product Operation″;

k) With regard to the requirement in 9.8, a warning flag, hinged cover (inside or outside), or equivalent, shall be marked with the word ″WARNING″ and the following or equivalent text: ″Unit is Non-Operational″. Letters shall be in a contrasting color and visible from 6 feet (1.83 m);

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l) With regard to the requirement in 9.9, a warning flag, hinged cover (inside or outside), or equivalent, shall be marked with the word ″WARNING″ and the following or equivalent text: ″Battery Has Been Removed″. Letters shall be in a contrasting color and visible from 6 feet (1.83 m);

m) The sensitivity setting for a device having a fixed setting. When the device is intended to be adjusted in the field, the range of sensitivity shall be indicated. The marked sensitivity shall be indicated in PPM, percent or percentage of LEL.

49.1.2 Unless the correct wiring connections are evident, installation wiring terminals or wire leads shall be marked to indicate the connections. When connections are not indicated on the unit the terminals or leads shall be numbered, colored, or otherwise indicated, and markings on the unit shall correlate with the installation instructions.

49.1.3 A unit intended for permanent connection to a wiring system other than a pre-wired metal-enclosed system, shall be marked to indicate the system(s) for which it is intended. The marking shall be located so that it shall be visible when power connections are being made to the unit.

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

49.1.5 A unit having Class 2 or Class 3 output circuits shall be marked to indicate the class of circuit.

Exception: When the product is of a modular construction and compliance with the above is not achieved, or would be inappropriate, marking on the product shall identify all modules and the class of circuit.

49.1.6 When, during the Temperature Test, Section 34, the temperature on a lead intended to be field installed, or on a surface of the wiring compartment which the lead might contact, is more than 60°C (140°F), the product shall be marked ″For Field Connections Use Wires Suitable for at Least ____°C (____°F)″ or the equivalent. The marking is to be at or near the points where field connections are to be made, and located so that it shall be readily visible during installation. The blanks are to be filled in with temperature values in accordance with Table 49.1.

Table 49.1
Temperature for marking

Temperature attained in terminal box or compartment,		Temperature in marking	
°C	(°F)	°C	(°F)
61 – 75	142 – 167	75	167
76 – 90	168 – 194	90	194

49.1.7 In accordance with the exception to 34.1, a cord-connected unit furnished with an electromagnetic radiation suppression filter, and having a leakage current in excess of 0.5 or 0.75 milliamperes (whichever applies) and less than 2.5 milliamperes, shall be marked with the word ″WARNING″ and the following or the equivalent: ″To reduce the risk of electric shock, this unit is provided with a grounding type power-supply cord. Connect unit to a grounded receptacle″.

49.1.8 A cautionary marking shall comply with all of the following requirements:

a) The marking shall be permanently attached;

b) The marking shall not be attached to parts that shall be replace during maintenance or servicing;

Exception: This requirement is not applicable when the marking is integral with the replacement part.

c) The marking shall not be attached to parts removable by hand; and

d) The marking shall have lettering that complies with the following requirements:

1) The cautionary signal word (such as ″DANGER″, ″WARNING″, or ″CAUTION″) shall be in letters no less than 7/64 inch (2.8 mm) high,

2) The other words shall be in letters no less than 3/32 inch (2.4 mm) high and in a contrasting color to the background, and

3) When molded or stamped in a material not having a contrasting background color, the letters shall have a height of no less than 7/64 inch (2.8 mm) and a raised or lowered depth of no less than 0.020 inch (0.51 mm).

49.1.9 When the construction of a unit is such that replacing lamps or fuses, or resetting circuit breakers, exposes persons to the risk of unintentional contact with normally enclosed high-voltage parts, the unit shall be marked to indicate plainly that such servicing is to be performed only while the unit is electrically disconnected from the branch-circuit supply. The marking shall be adjacent to every door or cover the opening of which exposes high voltage parts.

49.1.10 With reference to the requirement in 9.8.4, a cover shall be marked ″Circuit fuses inside only –contact service representative for replacement or repair,″ or wording determined to be equivalent. The marking shall be on or adjacent to the cover.

49.1.11 When the construction of a unit is such that improper routing of field wiring exposes wire insulation to rough or sharp edges, or subjects internal components to damage, a marking shall be provided in the wiring area to plainly indicate that wiring is to be routed away from sharp projections, corners, and internal components.

49.1.12 There shall be legible and durable marking for each replaceable fuse indicating the ampere rating (and voltage rating when more than 125 volts) of the fuse to be used for replacement. The marking shall be located so that it is obvious which fuse or fuseholder is referenced.

49.1.13 A product whose surface temperatures exceed the limit specified in Table 34.2 shall be marked with the word ″CAUTION″ and the following or wording determined to be equivalent: ″Hot Surface. Avoid Contact.″ The marking shall be located on or adjacent to the surface in question.

49.1.14 A product tested using the manufacturer's instructions for voltage adjustment shall be provided with a marking as follows:

a) Adjacent to the cord or supply compartment, to warn the user that internal adjustments must be made when the product is installed or moved and

b) Showing the adjustments that must be made for various voltages.

49.1.15 The marking shall either be on the outside or inside of the overall enclosure of the product and visible at the points of adjustment.

49.1.16 Field wiring terminal connection to which permanent leads are connected, such as those not intended to be removed for testing or servicing, shall be marked adjacent to the terminals.

49.1.17 When push-in terminals are used the following shall be marked adjacent to the terminals: ″Do Not Use Aluminum Conductors″.

49.2 Permanence of marking

49.2.1 Markings that are affixed to the outside of a unit, or cautionary and located inside a unit, shall be sufficiently durable so as to resist damaging effects due to handling, cleaning agents, or other occurrences anticipated in intended use.

49.2.2 A marking that is required to be permanent shall be molded, die-stamped, paint-stenciled, stamped or etched in metal that is permanently secured, or indelibly stamped lettering on a pressure-sensitive label secured by adhesive that, upon investigation, is found to be suitable for the application. Usage, storage and handling of a product are to be evaluated in the determination of the permanence of a marking.

49.2.3 Unless it has been investigated and approved for the application, a pressure-sensitive label, or a label that is secured by cement or adhesive, which is required to be permanent, shall comply with the requirements in the Standard for Marking and Labeling Systems, UL 969.

50 Installation Wiring Diagram

Effective date for 50 changed from November 5, 2006 to September 1, 2009

50.1 An installation wiring diagram shall be provided with each product illustrating the field connections to be made. The drawing shall either be attached to the unit or referenced in the marking on the unit by the name or trademark of the manufacturer, drawing number, and issue date and/or revision level.

50.2 The drawing shall show the installation terminals or leads to which field connections are to be made as they would appear when viewed during an installation. The terminal numbers on the unit shall agree with the numbers on the drawing.

50.3 The following information shall be marked on the installation wiring diagram for the applicable circuits to which field connections are made. In addition, each circuit of a product intended for emergency signaling shall be marked to indicate that the circuit is ″SUPERVISED″ or ″NOT SUPERVISED″.

a) MAIN SUPPLY CIRCUIT – Volts, frequency, and maximum current input or specific power supply with which it is intended to be used. A terminal for the connection of a grounding conductor shall be properly identified.

b) RECHARGEABLE BATTERY CIRCUIT – Voltage, maximum circuit current, maximum amp-hour capacity, type of suitable battery, and expected standby operating time(s).

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c) INITIATING DEVICE CIRCUIT – Reference to the type of devices to be used shall be indicated as well as their intended connection. The maximum line impedance shall be indicated.

d) ALARM DEVICE CIRCUIT – The type of signaling devices and their connection shall be indicated. When the circuit is intended for the connection of a polarized appliance, the field connections to which the appliance is to be wired shall be marked with plus (+) or minus (–) symbols, or equivalent, to indicate the proper field connection. The maximum line impedance or equivalent shall be indicated.

e) SUPPLEMENTARY SIGNALING CIRCUITS – Maximum current, voltage, and frequency. The maximum line impedance or equivalent shall be indicated.

f) SIGNALING LINE CIRCUIT – Maximum current, voltage, and frequency. The maximum line impedance or equivalent shall be indicated.

g) Where extra terminals are provided to which field connections are not intended, the marking ″NC″, or marking determined to be equivalent, shall be used.

50.4 The diagram shall contain a description of the intended use of the system consisting of a specific definition of the system type.

50.5 There shall be a description of the system operation including but not limited to:

a) Normal standby,

b) Alarm,

c) Alarm test,

d) Alarm silence,

e) Alarm reset,

f) Trouble, and

g) Trouble silence.

MANUFACTURING AND PRODUCTION TESTS

51 General

Effective date for 51 changed from November 5, 2006 to September 1, 2009

51.1 To verify compliance with these requirements in production, the manufacturer shall provide the necessary production control, inspection, and tests. The program shall include at least the tests specified in Sections 52 – 56 conducted on 100 percent of the production. See the Manufacturing and Production Tests, Appendix A.

52 Sensitivity Calibration Tests

Effective date for 52 changed from November 5, 2006 to September 1, 2009

52.1 The sensitivity of each device shall be checked, following the warm-up period specified by the manufacturer, using appropriate instruments to determine that the sensitivity levels are within the marked rating including tolerance, which is within the alarm's specified limits. The test equipment shall verify the value or range of sensitivities marked on the alarm. The value of indication shall be in the form of percent and/or ppm and time.

52.2 For the warm-up period, the devices are to be energized from a source of supply in accordance with 14.2. If the sensitivity of the device is not within the manufacturer's specifications, the device is to be corrected and retested. If a retested sample is still outside the specification, it is to be rejected.

52.3 A warm-up period is required for those alarms employing components whose characteristics are likely to vary during initial warm-up, such as solid-state devices operating at greater than 25 percent of rating, lamp filaments, resistors, and other components that affect sensitivity.

52.4 A warm-up period is not required if the alarm components are operated at not more than 25 percent of rating in the standby condition or if the individual components are burned-in prior to assembly.

53 Measurement of In-Service Reliability

Effective date for 53 changed from November 5, 2006 to September 1, 2009

53.1 In-service reliability

53.1.1 Reliability for Supervised Failures: For alarms, detectors or sensors that are not intended for field calibration, the device shall have a mean time between failure (MTBF) of no less than 100,000 hours when estimated at a 90 percent confidence level for Supervised Failures averaged over the devices' lifetime. At this failure rate the cumulative Supervised Failures over the devices' lifetime shall not exceed 23 percent at a 90 percent confidence level.

53.1.2 Reliability for Unsupervised Failures: the device shall have a mean time between failure (MTBF) of no less than 166,667 hours when estimated at a 90 percent confidence level for Unsupervised Failures averaged over the devices' lifetime. At this failure rate the cumulative Unsupervised Failures over the devices' lifetime shall not exceed 14.6 percent at a 90 percent confidence level.

53.2 Sample frequency and sample size

53.2.1 1 In-service reliability shall be estimated by subjecting a suitable sample of devices to the Sensitivity Test of Section 15. Gas concentrations shall be selected according to the intended application of the product or the requirements identified in the applicable Standard. Except for sensitivity type tests requiring the device to respond before a specified concentration is reached, a minimum of 3 sensitivity gas concentrations shall be selected.

53.2.2 Reliability information on devices shall be collected quarterly using any of the following methods:

a) Life cycle testing at the manufacturer's facility,

b) Testing of devices installed in the field, or

c) Laboratory testing of devices bought back from customers.

53.2.3 Prior to testing, devices shall be installed and operated in an actual or simulated residential environment for a period of sufficient duration to predict the average failure rate of the overall population over the devices' lifetime. During the installation period the devices shall be tested and an upper bound on their failure rate at a 90 percent confidence level shall be determined at quarterly intervals. It is not prohibited that installation times of less than the devices' lifetime, but not less than 3000 hours, be used in this analysis, taking into account any other measurements that might be available demonstrating the applicability of the shorter installation period for estimating failure rates averaged over the devices' lifetime. The data from the shorter installation period shall be replaced with data from progressively longer durations, up to the devices' lifetime, as it becomes available. When no data is available to demonstrate the applicability of the shorter duration data it is still usable.

53.2.4 The sample size for tests shall be determined according to widely accepted procedures for statistical quality control, as summarized in Supplement A. A statistically significant sample of representative devices shall be randomly chosen to estimate the required in-service reliability at the required confidence level.

53.3 Test results and record keeping

53.3.1 The manufacturer shall maintain data and records of all tests performed to evaluate the devices' conformance to the required in-service reliability.

54 Production Line Dielectric Voltage-Withstand Tests

Effective date for 54 changed from November 5, 2006 to September 1, 2009

54.1 Each alarm or detector rated at more than 30 volts ac (42.4 volts dc or ac peak) shall withstand, without breakdown, as a routine production-line test, the application of an essentially sinusoidal ac voltage of a frequency within the range of 40 to 70 hertz, or a dc voltage, between hazardous-voltage circuit live parts and the enclosure, high-voltage live parts and exposed dead (grounded) metal parts, and live parts of circuits operating at different voltages or frequencies. The test voltage is to be:

a) For an alarm or detector rated at 250 volts ac or less – either 1000 volts (1414 volts, if a dc voltage is used) applied for 60 seconds or 1200 volts (1697 volts, if a dc voltage is used) applied for 1 second.

b) For an alarm or detector rated at more than 250 volts – either 1000 volts plus twice the rated voltage (1414 volts plus 2.828 times the rated ac voltage, when a dc voltage is used) applied for 60 seconds or 1200 volts plus 2.4 times the rated voltage (1697 volts plus 3.394 times the rated ac voltage, if a dc voltage is used) applied for 1 second.

Exception: A product, consisting of an enclosure which is entirely comprised of polymeric materials, is not required to be subjected to this test if there are no exposed dead metal parts that may become energized under fault conditions.

54.2 If the alarm or detector employs hazardous-voltage and extra-low-voltage circuits, the test is to be conducted with the extra-low-voltage circuit connected to the cabinet, chassis, or other dead (grounded) metal parts so that the voltage that is applied between the hazardous-voltage live parts and dead (grounded) metal parts will be applied simultaneously between hazardous-voltage live parts and extra-low-voltage circuits.

54.3 In cases where the application of the test potential will either damage or short-circuit a printed-wiring assembly or other electronic-circuit component, the assembly or component shall be disconnected or otherwise rendered inoperative prior to the test. It is not prohibited that a representative subassembly be tested instead of an entire unit.

54.4 A 500 volt-amperes or larger transformer, the output voltage of which is variable, is to be used to determine compliance with 54.1. A 500 volt-amperes or larger transformer is not required if the high voltage testing equipment used is such that it maintains the specified high voltage at the equipment for the duration of the tests.

54.5 The test equipment used for this test is to include a visible indication of application of the test voltage and an audible or visible indication, or both, of breakdown. In the event of breakdown, manual reset of an external switch is to be required, or an automatic reject of the unit under test is to result. Other arrangements shall not be considered unless determined to achieve the results contemplated.

54.6 If the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is sufficient to prevent maintaining the specified ac test voltage, the alarm or detector is to be tested using a dc test voltage in accordance with 54.1.

55 Production Line Grounding Continuity Tests

Effective date for 55 changed from November 5, 2006 to September 1, 2009

55.1 The manufacturer shall test each alarm or detector that has a power-supply cord terminating in an attachment-plug employing a grounding pin to verify electrical continuity between the device and the grounding pin of the attachment-plug.

55.2 For this test, the manufacturer is to employ an acceptable resistance-indicating instrument with leads and terminals by which the grounding circuit continuity is determined.

55.3 If an investigation of the alarm or detector has shown all exposed dead metal parts that will become energized and all dead metal parts within the enclosure that are exposed to contact during servicing to be acceptably bonded to the frame and enclosure of the alarm, a test that determines the electrical continuity between the grounding pin and the frame or enclosure is sufficient.

56 Audibility Test

Effective date for 56 changed from November 5, 2006 to September 1, 2009

56.1 For alarms or detectors consisting of an integral audible signal device, the manufacturer shall test a minimum of two sample alarms per production lot or shift to verify that the sound output level of the representative production samples can produce the specified db sound pressure level. The db sound pressure level as measured in accordance with 48.2 or equivalent.

57 Audibility Test

Effective date for 57 changed from November 5, 2006 to September 1, 2009

57.1 The battery intended to be employed with the alarm or detector shall be shipped from the factory with the alarm in the same package. To prevent unnecessary drain during shipment and storage, the battery shall not be connected in the alarm.

57.2 A nonrechargeable standby battery of an ac operated accessory to a single- or multiple-station alarm or detector is not required to be shipped with the unit provided instructions on the unit specify the battery to be used by model number and manufacturer. A rechargeable standby battery shall be shipped with the unit in which it is to be employed.

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SUPPLEMENT SA - RELIABILITY AND FAILURE RATE DETERMINATION INFORMATION

GENERAL

SA1 Instructions for Determining a Reliability Prediction for Detectors, Sensors and/or Alarms

Effective date for SA1 changed from November 5, 2006 to September 1, 2009

SA1.1 Make a list of every component in the detector, sensor and/or alarm.

SA1.2 By circuit analysis or experimentation, determine the effect of any failure mode (short or open) of each component on the alarm or sensing operation and the rationale for the decision. This will determine if a component is to be considered critical, conditionally critical, or noncritical.

SA1.3 A component is considered noncritical if all failure modes of the component will result in a trouble signal, or have no effect on the intended operation of the detector, sensor or alarm for alarm and trouble signals, and will not affect the sensitivity of the device or system.

SA1.4 A component is considered critical if two or more failure modes of the component, which will affect the intended operation or the sensitivity of the detector, sensor or alarm, do not result in a trouble signal[a].

SA1.5 A component is considered conditionally critical if only one failure mode of the component will affect the intended operation or the sensitivity of the detector, sensor or alarm, and does not result in a trouble signal. [a]

SA1.6 Make a list of all critical and conditionally critical components in the alarm.

SA1.7 For each critical and conditionally critical component, the expected failure rate, based upon a minimum confidence factor of 60 percent, may be determined from the screening burn-in or published component reliability data method.

SA1.8 For each conditionally critical component, the expected failure rate may be determined by calculating only the failure rate for the mode meeting the conditions of SA1.5 or by applying a 0.75 multiplying factor to the value determined by the PARTS COUNT or PARTS STRESS ANALYSIS method described in MILITARY HANDBOOK 217F), or equivalent.

[a] A trouble signal may be indicated by energization of an audible signal, energization of a separate visual indication (amber or orange), or de-energization of a power-on light. If a visual indication is depended on to denote a trouble condition, it shall have a documented predicted failure rate of not greater than 2.5 failures per million hours.

SA2 Methods of Determining Failure Rate

Effective date for SA2 changed from November 5, 2006 to September 1, 2009

SA2.1 PARTS COUNT METHOD – When using this method the failure rate is to be determined as follows, using Appendix A of Military Handbook 217F):

a) Employ generic failure rate from Tables SA2.1 – SA2.6 which most closely approximates the component employed.

b) Determine the quality factor multiplier for each component from Tables SA2.7 – SA2.9.

c) Multiply each generic failure rate by its associated quality factor multiplier to obtain the final failure rate for the component. See example calculation, Table SA2.10.

d) Add all individual failure rates of critical and conditionally critical components to obtain the overall failure rate for the alarm.

NOTE – Mil-specification numbers in Tables SA2.4 and SA2.5 are provided for reference only to determine general component type.

Table SA2.1
Generic failure rate for standard bipolar digital devices (ttl and dtl) in failures per million hours

Circuit complexity	Failure rate
1 to 20 gates[a]	0.029
21 to 50 gates	0.062
51 to 100 gates	0.094
101 to 500 gates	0.38
Greater than 500 gates	6.0
Memories, less than or equal to 1000 bits	0.30
Memories 1001 to 4000 bits	0.70
Memories 4001 to 8000 bits	1.2
[a] Assume 1 gate is equivalent to four transistors.	

Table SA2.2
Generic failure rate for standard bipolar beam lead and ecl, bipolar and MOS linear, and all other MOS devices in failures per million hours

Circuit complexity	Failure rate
1 to 20 gates[a]	0.048
21 to 50 gates	0.19
51 to 100 gates	0.31
101 to 500 gates	1.4
Greater than 500 gates	23
Linear, less than or equal to 32 transistors	0.052
Linear, 33 to 100 transistors	0.12
Memories, less than or equal to 1000 bits	1.2
Memories 1001 to 4000 bits	2.7
Memories 4001 to 8000 bits	4.5
[a] Assume 1 gate is equivalent to four transistors.	

Table SA2.3
Generic failure rate for discrete semiconductors in failures per million hours

Part type	Failure rate
Transistors	
Silicon NPN	0.18
Silicon PNP	0.29
GePNP	0.41
GeNPN	1.1
FET	0.52
UJT, PUT[a]	1.7
Diodes	
Silicon, general-purpose	0.12
Germanium, general-purpose	0.26
Zener and avalanche	0.16
Thyristor	0.16
Silicon microwave detector	2.2
Ge microwave detector	5.6
Silicon microwave mixer	3.0
Ge microwave mixer	10.0
Varactor, step	1.5

[a] A lower failure rate (0.16 failures/106 hours) may be assigned when the construction of the device is comparable to that of a thyrister.

Table SA2.4
Generic failure rate for resistors in failures per million hours

Resistors, fixed			Failure rate
Construction	Style	Mil-R-Spec. (reference only)	
Resistors, fixed			
Composition	RCR	39008	0.002
Composition	RC	11	0.01
Film	RLR	39017	0.015
Film	RL	22684	0.075
Film	RNR	55182	0.017
Film	RN	10509	0.017
Film, power	RD	11804	0.96
Wire-wound, accurate	RBR	39005	0.056
Wire-wound, accurate	RB	93	0.28
Wire-wound, power	RWR	39007	0.033
Wire-wound, power	RW	26	0.17
Wire-wound, chassis mount	RER	39009	0.062
Wire-wound, chassis mount	RE	18546	0.31
Resistors, variable			
Wire-wound, trimmer	RTR	39015	0.066
Wire-wound, trimmer	RT	27208	0.33
Wire-wound, precision	RR	12934	2.7
Wire-wound, semi-precision	RA	19	2.3
Wire-wound, semi-precision	RK	39002	2.3
Wire-wound, power	RP	22	2.3
Nonwire-wound, trimmer	RJ	22097	4.6

Table SA2.4 Continued on Next Page

Table SA2.4 Continued

Resistors, fixed			Failure rate
Construction	Style	Mil-R-Spec. (reference only)	
Composition (common pot)	RV	94	
Factory preset and sealed			0.46
Field variable			3.7

Table SA2.5
Generic failure rate for capacitors in failures per million hours

Dielectric	Style	Mil-C-Spec. (reference only)	Failure rate
Paper/plastic	CHR	39022	0.0006
Paper/plastic	CPV	14157	0.0006
Paper/plastic	CQR	19978	0.0006
Paper/plastic	CQ	19978	0.006
Mica	CMR	39001	0.0032
Mica	CM	5	0.032
Mica	CB	10950	0.58
Glass	CYR	23269	0.011
Ceramic	CKR	39014	0.022
Ceramic	CK	11015	0.22
Tantalum, solid	CSR	39003	0.026
Tantalum, nonsolid	CLR	39006	0.034
Tantalum, nonsolid	CL	3965	0.34
Aluminum, oxide	CU	39018	0.23
Aluminum, dry electrolyte	CE	62	0.41
Ceramic, variable	CV	81	1.1
Piston, variable	PC	14409	0.11

Table SA2.6
Generic failure rate for miscellaneous parts in failures per million hours

Part type	Failure rate
Pulse transformer	0.0027
Audio transformer	0.0066
Power transformer and filters	0.021
RF transformer and coils	0.022
Connectors	0.45
Connections	
Solder, reflow lap to printed-wiring boards	0.00012
Solder, wave to printed-wiring boards	0.00044
Other hand solder connections	
(for example, wire to terminal board)	0.0044
Crimp	0.0073
Weld	0.002
Wirewrap	0.0000037
Coaxial connectors	0.63
Toggle switches	0.57
Push button switches	0.38

Table SA2.6 Continued on Next Page

Table SA2.6 Continued

Part type	Failure rate
Sensitive switches	0.90
Rotary switches	1.4
General-purpose relays	0.30
High-current relay	1.0
Latching relays	0.29
Reed relays	0.26
Meters and bimetal	5.7
Two-sided printed-wiring boards	0.0024
Multilayer printed-wiring boards	0.30
Quartz crystals	0.20
Thermistor	
Bead	0.10
Disc	0.31
Fuses	0.10
Neon lamps	0.20
Photocells	0.02
Light-emitting diodes (LED)	
General use (indicator light)	0.20
Light source of photoelectric detectors	2.50[a]

[a] This is the maximum value permitted and is based on the failure rate at half light output. Selected LED's having projected lower failure rates at half-light output are usually employed. The reliability is to be evaluated on data supplied by LED manufacturer.

Table SA2.7
Quality factors for tables SA2.1 and SA2.2

Quality level or screen class	Description	Quality factor
A	Mil-M-38510, Class A	0.5
B	Mil-M-38510, Class B	1
B-1	Mil-Std-883A, Method 5004, Class B	2.5
B-2	Supplier equivalent of Mil-Std-883A,	
	Method 5004, Class B	5
C	Mil-M-38510, Class C	8
D	Commercial (or non-mil standard) part with no screening beyond the manufacturer's regular quality assurance practices	75
E	Screening procedure per Table S5.1	8

Table SA2.8
Quality factor for table SA2.3

Part class	Quality factor
JANTXV	0.1
JANTX	0.2
JAN	1.0
Commercial grade	1.0

Table SA2.9
Quality factor for tables SA2.4 and SA2.5

Failure rate level (established reliability parts)	Quality factor
L	1.5
M	1.0
P	0.3
R	0.1
S	0.01
NOTE – For nonestablished reliability parts the quality factor is 1.5. The quality factor for all miscellaneous parts is 1.0.	

Table SA2.10
Alarm reliability prediction – parts count method sample calculation

Component	Generic failure rate (A)	Quality factor multiplier (B)	Failure rate failures/10^6 hrs (A) times (B)
Composition resistor	0.01	1	0.01
Composition resistor	0.01	1	0.01
Composition resistor	0.01	1	0.01
Film resistor	0.075	1	0.075
Film resistor	0.075	1	0.075
Wire wound resistor, power	0.17	1	0.17
Capacitor, plastic	0.006	1	0.006
Capacitor, plastic	0.006	1	0.006
Capacitor, tantalum, solid	0.026	1	0.026
Capacitor, dry electrolyte	0.41	1	0.41
Transistor, silicon NPN	0.18	0.3	0.06
Transistor, silicon NPN	0.18	0.3	0.06
Thyrister (SCR)	0.16	1	0.16
Diode, silicon	0.12	1	0.12
Diode, silicon	0.12	1	0.12
Relay, reed	0.26	1	0.26
Relay, general purpose	0.30	1	0.30
Connector	0.45	1	0.45
Printed-wiring board	0.0024	1	0.0024
Switch, push button	0.38	1	0.38
Potentiometer, factory preset	0.46	1	0.46
LED (indicator lamp)	0.20	1	0.20
Total alarm failure			3.371

SA2.2 [a]PARTS STRESS ANALYSIS METHOD – The failure rate is calculated using the procedure in Military Handbook 217F, Section 3.4 or equivalent. Calculations and supporting data on rating of components for the determination will be required for review. See also Table SA2.11 and Figure SA2.1 for equations and tabulation sheets.

[a] If a Mil-Spec component is required in an alarm but does not employ a specific marking to that effect, it will be necessary for the detector, alarm or sensor manufacturer to provide documentation to verify that the component is Mil-Spec graded. The documentation may be in the form of a shipping order, invoice, or equivalent, provided by the component vendor.

Table SA2.11
Parts stress analysis method references

Type device	Applicable equation	MIL-HDBK-217B 9/20/74 page reference
Monolithic bipolar and MOS digital SSI/MSI devices 100 gates or 400 transistors		2.1.1-1
Monolithic bipolar and MOS linear devices		2.1.2-1
Monolithic bipolar and MOS digital LSI devices 100 gates or 400 transistors		2.1.3-1
Monolithic MOS and bipolar memories		2.1.4-1
Hybrid devices		2.1.7-1
Transistors Group I, general purpose		2.2.1-1
Transistors Group II, field effect transistors		2.2.2-1
Transistors Group III, unijunction		2.2.3-1
Diodes, Group IV, general-purpose		2.2.4-1
Diodes, Group V, zeners		2.2.5-1
Diodes, Group VI, thyristers		2.2.6-1
Diodes, Group VII, microwave detectors and mixers		2.2.7-1
Diodes, Group VIII, varactor step recovery tunnel		2.2.8-1
RCR and RC insulated fixed composition		2.5.1-1
RLR, RL, RNR, RN, fixed film-insulated		2.5.2-1
RD/P power film		2.5.2-5
RBR and RB fixed wire wound		2.5.3-1
RWR and RW power-type fixed wire-wound		2.5.3-3
RER and RE power-type, chassis-mounted fixed wire-wound		2.5.3-5
RTH bead and disc-type thermistors	Read direct from table	2.5.4-1
RTR and RT variable lead screw-activated wire-wound		2.5.5-1
RR precision wire-wound potentiometers		2.5.5-3
RA and RK (Not ER) semi-precision wire-wound potentiometers		2.5.5-7
RP high-power wire-wound potentiometers		2.5.5-13
RJ nonwire-wound trimmers		2.5.6-1
RV composition potentiometers		2.5.6-5
CPV paper and plastic film, Est. Rel.		2.6.1-1
CHR metalized paper, Est. Rel.		2.6.1-1
CQ & CQR paper and plastic film, ER & NON-ER		2.6.1-1
CM mica-molded, CMR mica-dipped, Est. Rel.		2.6.2-1
CB button mica		2.6.2-3
CYR glass capacitors, Est. Rel.		2.6.3-1
CK ceramic, general-purpose, CKR ceramic, general-purpose, Est. Rel.		2.6.4-1
CC ceramic, temperature compensating		2.6.4-5
CSR solid tantalum electrolytic, Est. Rel.		2.6.5-1

Table SA2.11 Continued on Next Page

Table SA2.11 Continued

Type device	Applicable equation	MIL-HDBK-217B 9/20/74 page reference
CLR nonsolid tantalum, Est. Rel., CL nonsolid tantalum, NON Est. Rel.		2.6.5-3
CU aluminum oxide electrolytic		2.6.6-1
CE aluminum, dry electrolyte		2.6.6-3
CV variable ceramic capacitors		2.6.7-1
PC variable, piston-type tubular trimmer		2.6.8-1
Transformers		2.7-1
Motors, high-speed		2.8.1-1
Blowers		2.8.2-1
Relays		2.9-1
Switches, snap-action toggle or pushbutton		2.10-1
Basic sensitive switches		2.10-2
Rotary, ceramic or glass wafer silver alloy contacts		2.10-3
Connectors		2.11-1

NOTE– $_Q$ multiplier same as for JAN Class C if Table S5.1 screening is conducted.

Figure SA2.1
Tabulation sheet

DEVICE	EQUATION	λ_b	π_Q	π_E	π_A	π_{S2}	π_C	π_R	π_V	π_{TAPS}	π_{SR}	π_{CV}	π_F	π_N	π_{CYC}	π_L	π_P	λ_{CYC}	λ_P

Overall System Failure Rate Failures/10^6hours

λ_P = Failure rate for Component – Failures/10^6hours (Sum of numbers for that Component)

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SA2.3 SCREENING BURN-IN METHOD – This method is required for the evaluation of custom integrated circuit chips although it may also be applied to any other component of an detector and/or alarm, including generic chips. The evaluation shall consist of a burn-in test program to determine the numerical failure rate coupled with a minimum quality assurance screening program for all production units. Refer to Criteria for Acceptance of Microelectronic Devices, Sections SA4 – SA6.

SA2.4 ALTERNATE METHOD (GENERIC DEVICES ONLY) – An alternate for generic components only shall consist of the burn-in test program to determine the numerical failure rate coupled with the shall consist of the burn-in test program to determine the numerical failure rate coupled with the component manufacturer's standard screening program which is employed for the device family of the component. The condition of acceptance of the limited screening shall include the following:

a) A test sample lot shall be screened in accordance with the component manufacturer's standard program and then subjected to the Burn-In Test described in Sections SA4 – SA6.

b) The component manufacturer shall provide failure rate data on the particular device being tested or the device family [b] from a second source, such as field failure rate data or a separate burn-in test.

c) A comparison of the burn-in test data from SA2.4(a) and SA2.4(b) shall be made and results from SA2.4(a) shall not be worse than those in SA2.4(b) by one order of magnitude (10:1).

[b]Similar devices manufactured under same process and design rules.

SA2.5 PUBLISHED RELIABILITY DATA – This method may be employed for the evaluation of generic integrated circuit chips as well as any component or components of a detector and/or alarm, except for a custom chip. The evaluation is derived by the use of generic failure rate data from industry and military recognized publications on component reliability based on field accumulated data. Examples of such publications include Micro-Circuit Device Reliability, Linear/Interface Data and Micro-Circuit Device Reliability, Digital Generic Data. Devices evaluated by this method shall conform to the identification program in SA4.3, and the minimum screening program of Table SA5.1or equivalent.

SA2.6 The overall failure rate of the components of an alarm may be evaluated by combination of two or more of the failure rate determination methods described in SA2.1, SA2.2, SA2.3, SA2.4, and SA2.5.

SA3 Maximum Alarm Failure Rates

Effective date for SA3 changed from November 5, 2006 to September 1, 2009

SA3.1 The overall failure rates for the alarm shall not be greater than indicated in Table SA3.1.

Table SA3.1
Maximum alarm failure rate

Method of failure rate computation	Maximum alarm failure rate (failures per million hours)
Parts count	3.5
Parts stress analysis	4.0
Screening burn-in	4.0
Published reliability data	4.0
Any combination of above	Lower failure rate number

Table SA3.2
Minimum screening programs

A. HERMETIC PACKAGES	
1. Internal visual (Method 2010.1, Condition B modified)	100 percent[a]
2. Bond strength (Method 2011)	Sample Basis[a]
3. Stabilization bake (Method 1008C, 150°C, 24 hours)	100 percent[b]
4. Temperature cycling (Method 1010C, minus 55°C to 150°C, 10 cycles)	100 percent[e]
5. Seal (Fine leak, Method 1014B 5×10^{-8} CC/Sec)	100 percent[c]
6. Seal (Gross leak, Method 1014B fluorocarbon)	100 percent
7. Functional electrical, 25°C	100 percent
8. External visual, Method 2009	100 percent
9. Quality conformance	AQL 1.5% per MIL-STD 105 Level II
a) Functional electrical, 25°C	
b) Temperature cycling (Method 1010C, minus 55°C to 125°C, 10 cycles)	
c) Seal (Fine leak, Method 1014B, 5×10^{-8} CC/Sec)[d]	
d) External Visual, Method 2009	
B. PLASTIC PACKAGES	
1. Internal visual (Method 2010.1, Condition B modified)	100 percent[a]
2. Bond strength (Method 2011)	Sample Basis[a]
3. Temperature cycling (Method 1010C, minus 55°C to 125°C, 10 cycles)	100 percent[e,f]
4. Functional electrical test, 25°C	100 percent
5. External visual, Method 2009	100 percent
6. Quality conformance	AQL 1.5% per MIL-STD 105 Level II
a) Functional electrical test, 25°C	
b) Temperature cycling (Method 1010C, minus 55°C to 125°C, 10 cycles)	
c) External visual, Method 2009	

[a] Modified procedures or sample lot sizes are to be submitted for review.
[b] Stabilization bake may be waived if production process includes equivalent conditioning.
[c] May be reduced to 1.5 percent AQL when vendor's first lot of 25,000 units shows statistical justification.
[d] May be waived if justified by the reject rate in Item A5.
[e] Thermal shock Method 1011.1, Condition B or C, may be substituted.

Table SA3.2 Continued on Next Page

Table SA3.2 Continued

[f] May be waived if the sample lot used in the burn-in test is subjected to 100 cycles of the temperature cycling and no devices fail as a result of the temperature cycling. The manufacturer shall then perform an annual audit of the device package type. This audit may be in the form of selecting samples from the same package type and subjecting them to the Temperature Cycling or Thermal Shock (Methods 1010C or 1011.1, Conditions B or C, Military Handbook 883D, April 9, 1979). Records shall be maintained for inspection.

CRITERIA FOR ACCEPTANCE OF MICROELECTRONIC DEVICES

SA4 General

Effective date for SA4 changed from November 5, 2006 to September 1, 2009

SA4.1 The evaluation and criteria for acceptance of microelectronic devices consists of a two part procedure:

a) Part I consists of a quality assurance screening program either by the component vendor or alarm manufacturer, to assure uniformity of production.

b) Part II includes a determination of a failure rate for the device supplemented by a one time burn-in test.

SA4.2 Although this program is oriented primarily to custom integrated circuit chips, it can also be applied for other microelectronic devices.

SA4.3 Components that meet the requirements of this program shall be distinctively marked for identification purposes. The alarm manufacturer shall maintain on file, accessible to an inspector, copies of the purchase and shipping orders for all alarms and chips so that a tally of alarms shipped can be compared to the quantity of screened devices procured from the component vendor.

SA5 Quality Assurance Screening Program

Effective date for SA5 changed from November 5, 2006 to September 1, 2009

SA5.1 The following minimum screening program (see Table SA5.1) is to be established by either the component manufacturer (vendor) or the detector or alarm manufacturer. If the screening program is conducted by the component manufacturer, each lot or shipment to the alarm manufacturer is to be accompanied by a certificate of compliance with the Quality Assurance Screening Program.

SA5.2 The test methods and conditions referenced in Table SA3.1 are based on MIL-STD-883B dated July 31, 1977 and its most current revisions.

SA6 Determination of Failure Rate Number Supplemented by Burn-In Test

Effective date for SA6 changed from November 5, 2006 to September 1, 2009

SA6.1 General

SA6.1.1 The objective of this part is to determine a numerical failure rate for the device to be employed in the overall reliability calculation of the detector or alarm. The method employs Arrehenius calculations and activation energy tables to correlate elevated temperature operation to a failure rate of 38°C (100°F) (maximum installation ambient temperature of the alarm).

SA6.2 Determination sequence

SA6.2.1 The following step-by-step procedure is to be employed in determining the failure rate number.

a) Estimate numerical failure rate desired.

b) Select desired test temperature for acceptance test.

c) Using selected test temperature, refer to curves in Figure SA6.1 to determine related test time for initial conditional acceptance and final acceptance.

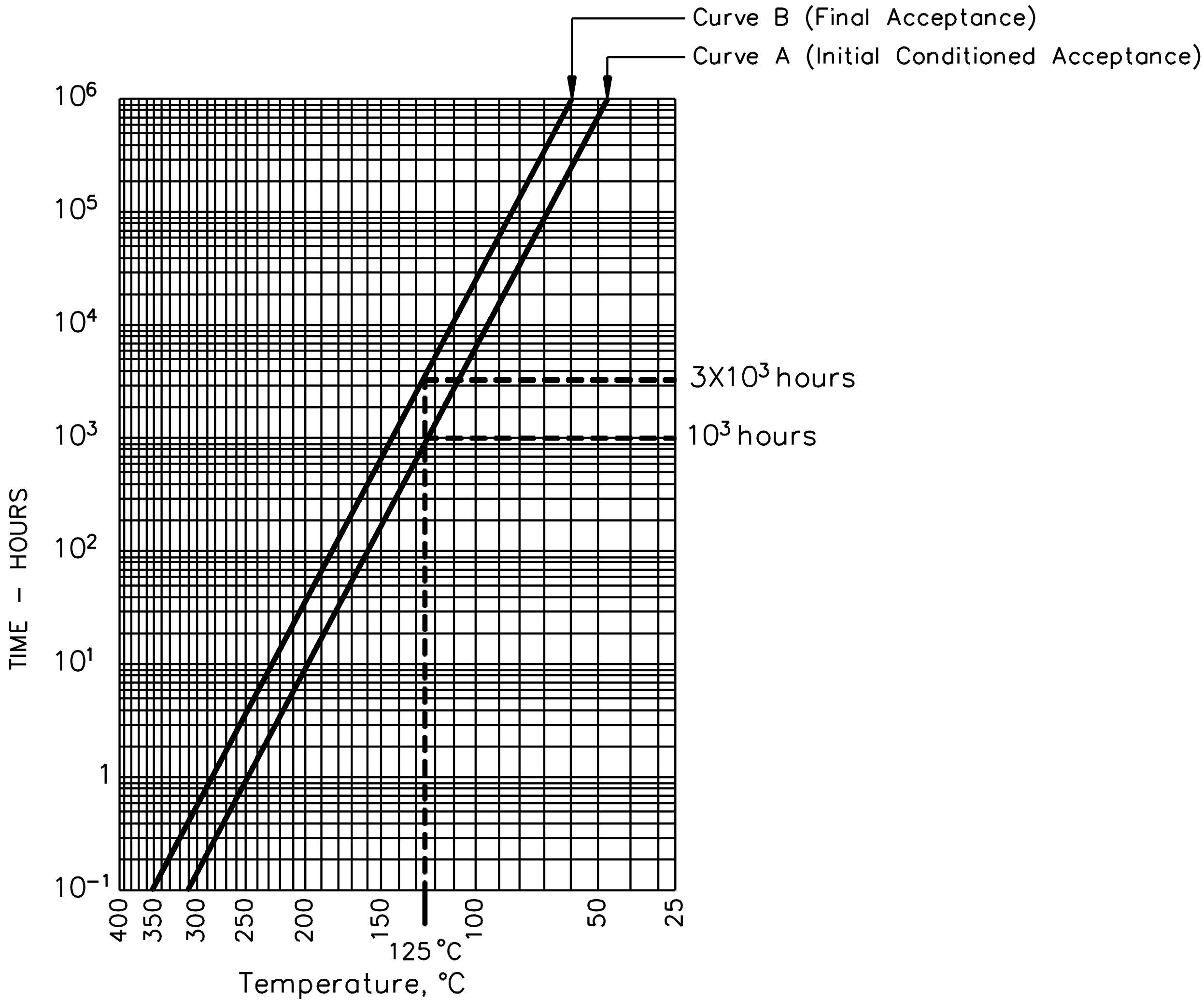
d) Using the equation in SA6.5.1 and the initial conditioning test time determined in SA6.2.1(c)

e) Sample lot size to be used in temperature test is determined from Table SA6.1. This table lists initial sample lot sizes based on expected failure rates in percent per 1000 hours at a 60 percent confidence level and number of devices that fail during the test, the latter listed as accept numbers. If a different temperature is employed, lot sizes can be derived from a table of Summation of Terms of Poisson's Exponential Binomial Limit [d] at a 60 percent confidence level.

f) Using the Arrehenius equation and the final test time determined in SA6.2.1(c), calculate the failure rate of the device for final acceptance.

[d] Reliability Handbook by W. Grant Ireson

Figure SA6.1
Time-temperature regression and allowable time limits for test condition



S2486

Table SA6.1 part 1
Sample lot size for burn-in test

Accept number (c)	Failure lot size for burn-in test									
	20.00	18.00	15.00	12.00	10.00	8.00	7.00	6.00	5.00	4.00
0	5	5	6	8	9	12	13	16	19	23
1	11	12	15	18	22	27	31	36	44	54
2	15	17	21	26	31	39	44	52	62	77
3	20	22	27	34	40	50	58	67	81	101
4	27	30	36	45	54	67	77	89	107	134
5	32	35	42	53	63	79	90	105	126	158
6	36	40	48	60	73	91	104	121	145	181
7	41	45	54	68	81	101	116	135	162	203
8	45	50	60	76	91	113	129	151	181	227
9	50	56	67	84	100	125	143	167	200	251
10	60	67	80	100	120	150	171	200	240	300
11	65	72	86	108	129	162	185	216	259	324
12	70	77	93	116	139	174	199	232	278	348
13	74	83	99	124	149	186	212	248	297	372
14	77	85	102	128	153	192	219	255	307	383
15	82	91	109	136	163	204	233	272	326	408

Table SA6.1 part 2
Sample lot size for burn-in test

Accept number (c)	Failure lot size for burn-in test								
	3.00	2.00	1.50	1.00	0.70	0.30	0.20	0.15	0.10
0	31	47	62	93	133	311	466	622	933
1	73	109	145	218	311	725	1088	1451	2176
2	103	155	206	309	442	1031	1547	2062	3093
3	134	201	268	403	575	1342	2013	2684	4026
4	179	268	358	536	766	1788	2682	3576	5364
5	210	315	420	631	901	2102	3153	4204	6307
6	242	363	484	726	1037	2419	3629	4838	7257
7	270	405	540	810	1158	2701	4052	5403	8104
8	302	453	604	906	1295	3021	4531	6042	9063
9	334	501	668	1002	1432	3342	5012	6683	10025
10	399	599	799	1198	1712	3994	5991	7988	11982
11	431	647	863	1294	1849	4314	6472	8629	12943
12	464	696	927	1391	1987	4637	6956	9275	13912
13	496	744	991	1487	2124	4957	7435	9913	14870
14	511	766	1022	1533	2190	5109	7663	10218	15327
15	543	815	1087	1630	2329	5434	8151	10868	16302

SA6.3 Test calculations and procedures

SA6.3.1 Figure SA6.1SA6.1 illustrates basic curves which represent burn-in test conditions of a device of 1000 hours for initial conditional acceptance and is continued to 3000 hours for final acceptance when tested at an elevated temperature of 125°C (251°F).

SA6.3.2 The elevated test temperature and related time periods (using the illustrated curves) may be increased or decreased except the minimum selected temperature for the burn-in test shall not be less than 100°C (212°F).

SA6.3.3 The following examples illustrate the use of the curves in Figure SA6.1 for calculations of final and initial conditional acceptance at temperatures other than 125°C (251°F).

a) Example 1 – Assuming a test temperature of 150°C (302°F):

   1) Time for Initial Conditional Acceptance – 167 hours (using Curve A).

   2) Time for Final Acceptance – 650 hours (using Curve B).

b) Example 2 – Assuming a test temperature of 100°C (212°F):

   1) Time for Initial Conditional Acceptance – 5700 hours (using Curve A).

   2) Time for Final Acceptance – 25,000 hours (using Curve B).

SA6.4 Test conditions

SA6.4.1 Suitable sockets or other mounting means shall be provided to make firm electrical contact to the terminals of devices under test in the specified circuit configuration. The mounting means shall be so designed that they will not remove internally dissipated heat from the device by conduction, other than that removed through the device terminals and the necessary electrical contacts, which shall be maintained at or above the specified ambient temperature. The apparatus shall provide for maintaining the specified biases at the terminal of the device under test and, when specified, monitoring of the input excitation. If the device incorporates on board elements which directly drive such things as the alarm horn, battery pulse test or beacon LED of a photoelectric carbon monoxide alarm, these shall be pulsed during the test for a number of cycles equivalent to the operation life of the intersection of curve B, Figure SA6.1 with the 38°C (100°F) line.

SA6.4.2 Power supplies and current-setting resistors shall be capable of maintaining the specified operating conditions, as minimal throughout the testing period with normal variations in their source voltages, ambient temperatures, and the like. The test equipment shall preferably be so arranged that only natural convection cooling of the devices occurs. When test conditions result in significant power dissipation, the test apparatus shall be arranged so as to result in the average power dissipation for each device whether devices are tested individually or in a group. The test circuits need not compensate for normal variations in individual device characteristics but shall be arranged so that the existence of failed or abnormal (that is, open, short, or the like) devices in a group does not negate the effect of the test for other devices in the group.

SA6.5 Failure rate number calculation

SA6.5.1 The following equation is to be used in determining the initial conditional and final failure rates for the device in concert with the burn-in test. Extrapolations are made from the selected elevated test temperature to the 38°C carbon monoxide alarm operating condition by use of the Arrehenius Equation in which:

$$\lambda = Ae^{\left(-\frac{E}{KT}\right)}$$

in which:

λ is the failure rate per million hours;

A is constant;

e is the base of natural logarithm = 2.7183;

E is the Activation energy in electron volts (ev) (varies between 0.65 ev to 1.1 ev for a large number of integrated circuits). Documentation shall be provided to support value employed. If documentation is not provided, value of 0.65 ev is to be used;

K is Boltzman's constant (8.62×10^{-5} ev/°K); and

T is absolute temperature in degrees Kelvin.

Example:

a) Desired numerical failure rate λ_2 = 0.1 failure per 10^6 hours.

b) Desired test ambient temperature is 125°C.

c) Required test time from FigureSA6.1 for conditional acceptance is 1000 hours and for final acceptance is 3000 hours.

d) Using the equation in SA6.5.1 and assuming an Activation Energy (E) of 0.65 ev, the following calculations are performed:

$$\lambda_1 = Ae^{\left(-\frac{E}{KT}\right)} \quad for\ 125°C$$

$$\lambda_2 = Ae^{\left(-\frac{E}{KT}\right)} \quad for\ 38°C$$

Then

$$\frac{\lambda_1}{\lambda_2} = \left[-\frac{E}{K}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right]$$

in which:

λ_2 *is 0.1 failure per* 10^6 *hours,*

e is 2.7183,

E is 0.65 ev,

T_1 *is 398°K,*

T_2 *is 311°K, and*

K is 8.62×10^{-5} *ev/°K*

Then

$$\lambda_1 = \lambda_2\ \ln^{-1}\left[\frac{-0.65}{8.62} x 10^{-5}\left(\frac{1}{348} - \frac{1}{311}\right)\right]$$

in which:

λ_1 *is* 20×10^{-6} *failures/hour,*

λ_1 *is 20 failures/*10^6 *hours,*

λ_1 *is 0.02 failures/1000 hours, and*

λ_1 *is 2.0 percent/1000 hours.*

e) Referring to Table SA6.1, the following sample lot size for the appropriate accept number (C – the number of failures or less) can be used at the conditional acceptance point (1000 hours). For 2.0%/1000 hours:

Appendix – MANUFACTURING AND PRODUCTION TESTS

A1 Glossary

Effective date for A1 changed from November 5, 2006 to September 1, 2009

For the purpose of this document, the following definitions apply:

RECOGNIZED COMPONENT – A part of subassembly covered under UL’s Recognition Service and intended for use in Listed, Classified, or Recognized products. A Recognized component is incomplete in construction features or restricted in performance capability so that determination by UL of its acceptability in a complete product is necessary.

VARIATION NOTICE (VN) – A document used to record observed differences between a product or manufacturing process and the description of the product or process in the Procedure and/or standard.

A2 UL REPRESENTATIVE’S DUTIES

Effective date for A2 changed from November 5, 2006 to September 1, 2009

General

a) Examine the construction of the product intended to bear the UL Mark or Marking to determine compliance with the description of the product and other requirements expressed in the Procedure.

b) Where so specified by Instructions for Tests and/or Inspection at the Factory, inspect the test records and facilities of the manufacturer to insure that:

1) The proper number of samples are undergoing the required tests, and

2) The required tests are being performed correctly, and

3) The proper information is being recorded and is up-to-date, and

4) The instruments being used for the tests have been calibrated at the prescribed interval and are in good working order.

c) Report to the manufacturer and Follow-Up Services by means of a Variation Notice (VN) if:

1) Variations in construction are found, or

2) The manufacturer’s method and/or frequency of required tests is not as described, or

3) The records required to be maintained by the manufacturer are not as described, or

4) The instruments being used are not the same as described, or

5) Nonconforming test results are witnessed during tests conducted specifically for the UL Representative.

d) Explain to the manufacturer that a VN is a means of communication with the manufacturer and forms a record of those items where nonconformance to the Procedure has been found.

e) When a product does not comply with the Follow-Up Services Procedure, require that the manufacturer shall either:

1) Remove any markings referencing UL from the product, or

2) Suitably modify all products that do not comply with the Follow-Up Services Procedure, or

3) Hold shipment pending further inspections from Follow-Up Services.

f) In the event of a disagreement between the manufacturer and the UL Representative as to whether a product is acceptable, the manufacturer shall hold production at the factory pending resolution of the variations. The manufacturer has the right to appeal a decision with which he disagrees and the UL Representative shall provide the name of the Follow-Up Services' Engineer to whom the appeal is to be made. Should Follow-Up Services grant temporary authorization for the continued use of the UL Mark, such temporary authorization shall only be for the time needed to review and/or process the Procedure revision, or as otherwise specified to cover a particular lot or production run.

Instructions for Inspection of Test Equipment

Operation check

During every inspection visit, the dielectric voltage withstand test equipment should be checked to make certain it is operating properly. This is normally done by having the operator touch the probes together.

Sensitivity test

The sensitivity of the dielectric equipment is to be checked quarterly. When dielectric test equipment is adjusted to produce the required test voltage and a resistance of 120,000 ohms is connected across the output terminals, the equipment shall indicate a ″breakdown″ (an unacceptable performance indication by the tester) within 0.5 second.

a) Observe the resistance measurement of the manufacturer's 120,000 ohm resistor using an ohmmeter or equivalent instrument.

b) Observe the resistance measurement of the UL 120,000 ohm resistor. If the resistance of the manufacturer's resistor is equal to or greater than the UL resistor, it is suitable for use. If it is less than the UL resistor, it is not suitable for the sensitivity test. Report this fact on a VN, but DO NOT STOP THE USE OF THE LISTING MARK.

c) When the manufacturer's resistor is suitable it shall be used to check the sensitivity of the dielectric voltage withstand test equipment as follows. DO NOT USE THE UL RESISTOR FOR THE SENSITIVITY TEST.

<u>U S E E X T R E M E C A U T I O N</u>

d) Have the dielectric test voltage checked using the manufacturer's voltmeter across the high potential probes or terminals. It should indicate:

1) Minimum: The required test voltage.

2) Maximum: 120 percent of the required test voltage.

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Note: The required test voltage varies based on whether the production line test time is 1 second or 1 minute (see Instructions for Tests and/or Inspection at the Factory).

e) With the voltage adjusted to the normal test voltage, have the probes of the dielectric voltage withstand test equipment applied across the manufacturer’s test resistor (NOT THE UL RESISTOR). The voltmeter may or may not be removed but the test voltage must be as indicated in (d).

f) If the dielectric test equipment indicates ″breakdown″ in 0.5 second or less after application of the required test voltage, the results are acceptable.

g) If the dielectric test equipment does not indicate ″breakdown,″ the results are not acceptable. The manufacturer may adjust the sensitivity of the test equipment (if possible). A retest shall then be conducted. If the equipment cannot be adjusted to indicate a breakdown with the manufacturer’s resistor, report the information on a VN on which you have indicated that the equipment does not meet the sensitivity requirements. DO NOT STOP THE USE OF THE LISTING MARK unless the dielectric equipment will not indicate ″breakdown″ even with the high voltage leads connected together.

Instructions for Inspection of the Product

General instructions

At each inspection samples of current production and/or stock shall be examined for compliance with the applicable description and requirements contained in the Procedure. In making this determination, consideration shall also be given to the following general requirements applying to the products covered by the Procedure.

a) Electrical Spacings – Measure minimum through air and over surface spacings when specified.

b) Internal Wiring – Conductors shall be routed away or protected from sharp edges and moving parts.

c) Connectors – Connectors shall be applied to insure the insulation and containment of all bare wiring strands.

d) Markings – Information required shall be legibly marked on the product, in the manner and minimum height specified.

e) Security of Parts – Parts shall be secured to prevent any rotation or shifting which could result in a reduction of electrical spacings.

Special requirements which may also apply to some or all of the products covered by the Procedure include the following:

a) Parts and Accessories – Such items packaged with the product shall be specifically described in the Procedure.

b) Adapters – 3- to 2-wire grounding type adaptors shall not be furnished with the product unless specifically authorized by the Procedure.

c) Multiple Voltage – Cord connected multiple voltage products shall be provided with an attachment plug that is suitable for the voltage for which the product is set.

d) Packaging – There shall be no marking on the carton or package that is, or could be construed to be, in conflict with or an extension of the use covered in the instruction manual or Procedure.

e) Printed Wiring Boards – Printed wiring boards shall show no burning, bubbling, or other visible evidence of damage to their conductors or substrate material as a result of the fabrication process.

Instructions to the UL Representative for Sample Pick-Up

UL representative

Once each quarter, the UL Representative shall randomly select two units of the same model from each family of alarms described in the Sample Selection Index of Instructions for Tests and/or Inspection at the Factory. These samples shall be subjected to the Sensitivity test as specified in the Procedure at the rated voltage only. The test method is described in Instructions for Follow-Up Tests at UL. Selection of the samples should be such that all families of alarms are tested annually. To accomplish this, the following guidelines are to be used:

a) For manufacturers with four or more families of alarms, select samples from one or more families each quarter such that all families are sampled once annually. Mark the sample tag identifying the gas type associated with the Sensitivity test, example ″Carbon Monoxide Sensitivity Test.″

b) For manufacturers with three or less families of alarms, select samples from one family each quarter until all families have been selected.

c) A log indicating which models have been selected shall be maintained by the UL Representative.

The two samples shall be labeled ″1″ and ″2.″ These samples should first be subjected to the Production Line Sensitivity Calibration Test, in Instructions for Tests and/or Inspection at the Factory. The samples shall be forwarded, along with the required data specified in Instructions for Tests and/or Inspection at the Factory, to Follow-Up Services Reviewing Office. Only samples that acceptably pass the Production Line Sensitivity Calibration Test shall be sent to the Reviewing Office.

A3 INSTRUCTIONS FOR FOLLOW-UP TESTS AT UL

Effective date for A3 changed from November 5, 2006 to September 1, 2009

Engineering services department

The samples forwarded to the Follow-Up Services Department shall be subjected to the Sensitivity test. The test method is described in the Standard.

Sensitivity Test

Method

The units shall be tested in accordance with the Electrical Supervision Test, Section 17, in the Standard. The response times of samples 1 and 2 (as indicated by the instructions in Instructions to the UL Representative for Sample Pick-Up) shall be recorded and compared to the tolerance specifications and/or the maximum allowable time and concentration for the target gas.

Results

All the samples shall respond within the manufacturers tolerances as outlined within this Standard and as specified within the manufacturers Instruction Manual.

A4 INSTRUCTIONS FOR TESTS AND/OR INSPECTION AT THE FACTORY

Effective date for A4 changed from November 5, 2006 to September 1, 2009

Manufacturer's Responsibilities

The manufacturer's responsibilities include, but are not limited to:

a) Control of the UL Mark – Restrict the use of markings that reference UL (either directly by the use of the name or abbreviation thereof, or the UL symbol, Classification Mark, or Recognized Component Mark, or indirectly by means of agreed upon marking that are understood to indicate acceptance by UL) to those products that are found by the manufacturer's own inspection to comply with the Follow-Up Service Procedure description. Use of such markings is further limited by the agreement that has been executed by the subscriber and UL.

b) Packaging – There shall be no marking on the carton or package that is, or could be construed to be, in conflict with or an extension of the use covered in the instruction manual or Procedure.

c) Substitution of Nonspecified Printed Wiring Boards – Before a printed wiring board can be used, check the current edition of the Recognized Component Directory, the Supplement, a copy of the printed wiring board company's Recognition Report or a copy of the Component Recognition Card Text to insure that the printed wiring board has a flammability and operating temperature rating as specified in the individual section description, and that the solder temperature and dwell time are as indicated.

d) Production Line Tests – Conduct the factory tests detailed in Instructions for Tests and/or Inspection at the Factory.

e) Test Equipment Calibration – Determine that the test equipment is functioning properly and have it calibrated annually, or whenever it has been subject to abuse (such as being dropped or struck with an object) or its accuracy is questionable. Calibration may be by the manufacturer or an outside laboratory. In either case, it shall be by comparison with a standard that is traceable to the applicable U.S. or Foreign National Standard. Certification of Calibration shall be maintained by the manufacturer until the next succeeding certification, and shall be readily available for review by a UL Representative. A letter from the outside laboratory or manufacturer's off site calibration lab stating that their lab standards are directly traceable to their country's national standard and outlining their traceability pathway is considered adequate proof of traceability.

f) Required Records – Maintain records of test performance. The record shall include the model or catalog designation of the product, the date of production, the test(s) performed, number of units tested, test results, and action taken on rejections. Records for test performance shall be retained for six months and shall be readily available for review by the UL Representative.

Exception: Records of test results need not be maintained for 100 percent production line tests.

Requirements for Factory Tests

General

The following constitutes the minimum test program to be implemented by the manufacturer. The tests can be conducted in any sequence, unless a particular order is indicated in the Procedure. The specific gas detectors or alarms have been arranged into families based on ratings, enclosure construction, and electrical or mechanical attributes. These families are described in the Sample Selection Index found in Instructions for Tests and/or Inspection at the Factory of this Supplement. The production line tests shall be conducted on samples from each family of alarms as noted in the individual test descriptions.

Table 1
Sample selection index

Family	Product Designation (Cat. No. or Model No.)	Rating	Procedure Section

Production Line Dielectric Voltage Withstand Test

General

The manufacturer shall conduct a dielectric voltage withstand test on 100 percent of production (of units rated more than 30 V ac (42.4 V dc), that are provided with housings or enclosures of exposed conductive surfaces.

Method

A sinusoidal ac voltage of a frequency within the range of 40 – 70 Hz, or a dc voltage, shall be applied between live parts and accessible dead-metal parts for a period of 60 seconds or 1 second as follows:

a) For an alarm rated at 250 volts ac or less – either 1000 volts ac (1414 volts dc) applied for 60 seconds or 1200 volts ac (1697 volts dc) applied for 1 second.

b) For an alarm rated at more than 250 volts ac – either 1000 volts ac plus twice the rated voltage (1414 volts dc plus 2.828 times the rated ac voltage, if a dc voltage is used) applied for 60 seconds or 1200 volts ac plus 2.4 times the rated voltage (1697 volts dc plus 3.394 times the rated ac voltage, if a dc voltage is used) applied for 1 second.

Test equipment

No Text on This Page

The test equipment shall be as described in the white pages of Instructions for Tests and/or Inspection at the Factory.

Basis for acceptability

All products shall withstand the applied potential without electrical breakdown. For the purpose of these requirements, nonconforming performance for the dielectric voltage withstand test is defined as an abrupt decrease or nonlinear advance of voltage as the test voltage is increased or similarly, an abrupt increase in current.

Production Line Dielectric Voltage-Withstand Test Equipment

The equipment specified below has been evaluated and found to be acceptable for conducting the production line dielectric voltage-withstand test.

Manufacturer	Model/Catalog No. Designation

Exception: The following devices employ constructions that are exempt from the Production Line Dielectric Voltage Withstand Test.

Model Number	Procedure Section

Production Line Grounding Continuity Test

General

The manufacturer shall test each alarm which employs a power supply cord terminating in an attachment plug cap employing a grounding pin.

Test equipment

For this test, the manufacturer is to employ any of the following types of equipment (with leads and terminals) by which grounding circuit continuity may be determined:

a) An ohmmeter set on lowest impedance scale which is not to exceed 10 ohm maximum or

b) A source of voltage (maximum 120 V) in series with a visual or audible indicator which would energize if the circuit under test is continuous.

Method

Electrical continuity shall be determined between the grounding pin of the attachment plug and any user accessible dead-metal parts.

Basis for acceptability

Electrical continuity shall be ensured between the grounding pin of the attachment plug and the dead-metal parts.

Electrical Function and Calibration

General

The following tests shall be performed on 100 percent of production except the audibility of signaling device [see below, Method, Part (c)] which is performed on two samples per shift. (A shift is defined as a complete change of assembly personnel.)

Test equipment

The test equipment used by the manufacturer shall be as specified in Instructions for Tests and/or Inspection at the Factory of this Appendix.

Method

Each alarm shall be subjected to a complete functional electrical test which shall verify the following:

a) Operation of alarm relays.

b) Operation of trouble relays.

c) Audibility of signaling device.

Alarm annunciation shall be verified by operation of the sensitivity test feature, or the electrical and/or mechanical equivalent. The sensitivity of each alarm or detector shall be calibrated to the sensitivity level indicated in Instructions for Tests and/or Inspection at the Factory of this Supplement. The audibility level shall be determined by the test method specified in Instructions for Tests and/or Inspection at the Factory of this Appendix.

Basis for acceptability

Each alarm and/or trouble relay shall operate. The sound level meter reading should be equal to or greater than the decibel level indicated in Instructions for Tests and/or Inspection at the Factory of this Appendix.

Electrical function and calibration

Family designation –

Audibility test

Test equipment –

Method –

Results –

Production Line Sensitivity Calibration Test (Quarterly)

General

Two samples shall be subjected to this test each quarter. The samples shall be labeled ″1″ and ″2″ and selected by the UL Representative for Follow-Up testing at UL (See Instructions to the UL Representative for Sample Pick-Up).

The following data shall be recorded and forwarded to UL with the samples. The manufacturer shall also retain a copy of the recorded data, so that a comparison can be made after the testing is completed at UL.

Record the following for each sample:

a) Ambient temperature.

b) Relative humidity.

c) Barometric pressure.

d) Time of operation of alarm at designated concentration of gas.

e) Display reading of the sample at the time of alarm or specified gas concentration.

Test equipment

The test equipment used by the manufacturer shall be as specified in the Instructions for Tests and/or Inspection at the Factory of this Appendix.

Method

The sensitivity test method shall be as specified in Instructions for Tests and/or Inspection at the Factory of this Appendix.

Basis for acceptability

The selected samples shall respond to the specified gas concentration, time limit and tolerance as specified in the manufacturers instruction manual.

Sensitivity calibration test

Test equipment –

Method –

Production Line Sensitivity Calibration Test (Per Shift)

General

This test is performed by the manufacturer to assure that the electrical calibration of the alarms relates correctly to the alarm’s actual response characteristics to carbon monoxide. This test is to be conducted daily for a single shift production or on a per shift basis if more than one shift is used in a 24 hour period. A shift is defined as a complete change of assembly personnel. A minimum of two complete end product samples shall be randomly selected per shift and subjected to this test.

Test equipment –

The test equipment used by the manufacturer shall be as specified in the Instructions for Tests and/or Inspection at the Factory of this Appendix.

Method –

The test method shall be as specified in the Instructions for Tests and/or Inspection at the Factory of this Appendix.

Basis for acceptability

The selected samples shall respond to the specified gas concentration, time limit and tolerance as specified in the manufacturers instruction manual.

Sensitivity calibration test (per shift)

Family designation –

Test equipment –

Method