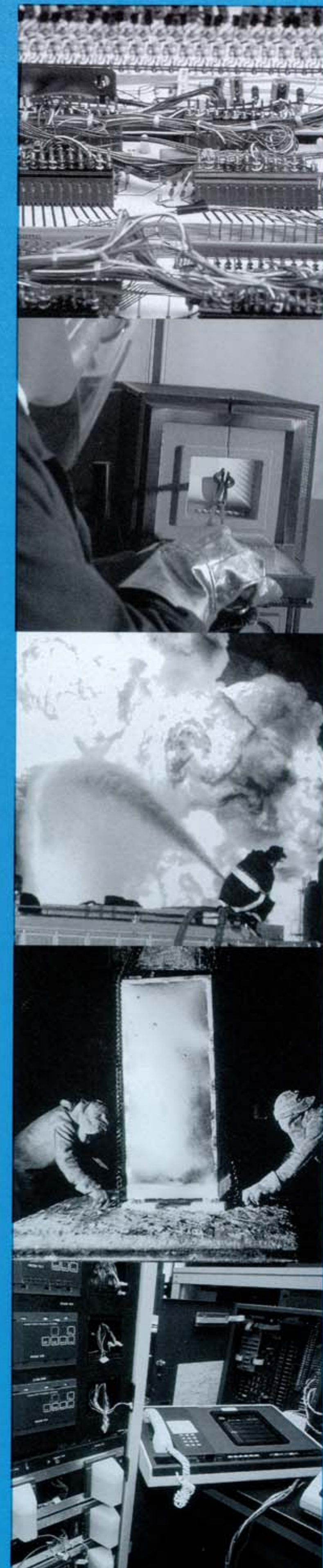
UL 2034

Underwriters Laboratories Inc.

Standard for Safety

Single and Multiple Station Carbon Monoxide Alarms



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UL Standard for Safety for Single and Multiple Station Carbon Monoxide Alarms, UL 2034

Third Edition, Dated February 28, 2008

Revisions: This Standard contains revisions through and including February 20, 2009.

Summary of Topics

In addition to some minor formatting changes, the following revisions have been incorporated into the Third Edition of the Standard for Single and Multiple Station Carbon Monoxide Alarms, UL 2034:

1. Marking Requirements for RV and Unconditioned Area CO Alarms

2. Marine Battery Temperature Requirements

3. RV Unconditioned Area Battery Temperature Requirements

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

Future Effective Date	References
August 1, 2009	3.7, 8.1, 38.1.1, 38.1.6, 39.3.5, 75.2.1, 75.7.1, 78.1.1, 78.1.2, 78.2.3, 83.1, 84.1, 84.3
February 20, 2015	70.2, 70.2.1, 71.3, 71.4, 75.1.7, 75.1.8

The new and revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated August 1, 2008.

The revisions dated February 20, 2009 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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1	February 20, 2009
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6-7	February 20, 2009
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E1	February 20, 2009
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SR1-SR2	February 20, 2009
SR3-SR8	February 28, 2008

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UL 2034

Standard for Single and Multiple Station Carbon Monoxide Alarms

First Edition – April, 1992
Second Edition – October, 1996

Third Edition

February 28, 2008

This ANSI/UL Standard for Safety consists of the Third Edition including revisions through February 20, 2009.

The most recent designation of ANSI/UL 2034 as an American National Standard (ANSI) occurred on February 18, 2009. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or effective date information. Any other portions of this ANSI/UL standard that were not processed in accordance with ANSI/UL requirements are noted at the beginning of the impacted sections.

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

1.1 These requirements cover electrically operated single and multiple station carbon monoxide (CO) alarms intended for protection in ordinary indoor locations of dwelling units, including recreational vehicles, mobile homes, and recreational boats with enclosed accommodation spaces and cockpit areas.

1.2 Carbon monoxide alarms covered by these requirements are intended to respond to the presence of carbon monoxide from sources such as, but not limited to, exhaust from internal-combustion engines, abnormal operation of fuel-fired appliances, and fireplaces. Carbon monoxide alarms are intended to alarm at carbon monoxide levels below those that cause a loss of ability to react to the dangers of carbon monoxide exposure. See Table 39.1, Part A, Alarm – carbon monoxide concentration and response time.

1.3 Carbon monoxide alarms covered by this standard are not intended to alarm when exposed to long-term, low-level carbon monoxide exposures or slightly higher short-term transient carbon monoxide exposures, possibly caused by air pollution and/or properly installed/maintained fuel-fired appliances and fireplaces. See Table 39.1, Part B, False alarm resistance specifications.

1.4 These requirements, where applicable, also cover all remote accessories that may be connected to or are intended to be employed with a single or multiple station carbon monoxide alarm. See 35.2.1.

1.5 This standard does not cover the following:

a) Single and multiple station smoke alarms that are covered by the Standard for Single and Multiple Station Smoke Alarms, UL 217, or the Standard for Smoke Alarms, ULC-S531.

b) Smoke alarms of the nonself-contained type that are intended for connection to a household or industrial system control unit. These are included in the Standard for Smoke Detectors for Fire Alarm Signaling Systems, UL 268, or the Standard for Smoke Detectors, Fire Alarm, ULC-S529.

c) Mechanically operated single and multiple station fire alarm devices that are specified in the Standard for Single and Multiple Station Heat Detectors, UL 539, or the Standard for Heat Actuated Fire Detectors, Fire Alarm, ULC-S530.

d) Heat alarms whose requirements are covered in the Standard for Heat Detectors for Fire Protective Signaling Systems, UL 521, or the Standard for Lined Building Protection Fire Hose, ULC-530.

e) Carbon monoxide gas detectors intended for use in hazardous locations as defined in the U.S. Coast Guard Electrical Engineering Regulations.

1.6 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

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. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

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.

3 Glossary

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

3.2 ALARM, MULTIPLE STATION – A single station alarm that is able to be interconnected with one or more other alarms for common alarm annunciation.

3.3 ALARM SIGNAL – An audible and visual signal intended to indicate a gas concentration in excess of 30 ppm carbon monoxide for thirty days or 70 ppm carbon monoxide for 1 hour. The audible portion of the alarm signal shall be 4 cycles of 100 milliseconds ″on″/100 milliseconds ″off,″ then 5 seconds ″off.″ After the initial 4 minutes of the alarm signal, the 5 second ″off″ period may be changed to 60 seconds±10 percent. This signal shall be repeated until the alarm resets after dissipation of CO or the alarm signal is manually silenced. The visual indicator for alarm shall be located on the face of the unit.

3.4 ALARM, SINGLE STATION – An alarm device consisting of an assembly of electrical and mechanical components including a sensor or sensors, an audible alarm, and an optional visual alarm constructed to detect the presence of carbon monoxide gas. It is powered either from an external source by means of splice leads or a cord and plug arrangement or from an integral battery or batteries. Some devices have terminals for connection to remote audible signaling appliances or accessories. Some also contain an integral transmitter for energizing a remote audible signaling appliance.

3.5 CARBON MONOXIDE (CO) – A colorless, odorless, toxic gas.

3.6 CARBOXYHEMOGLOBIN OR CARBONMONOXYHEMOGLOBIN (COHb) – A stable combination of carbon monoxide and hemoglobin formed in the blood when carbon monoxide is inhaled. Percent carboxyhemoglobin indicates the degree to which the oxygen-carrying capacity of the blood is impeded by the uptake of carbon monoxide by the hemoglobin.

3.7 COMPONENT, LIMITED LIFE – A component that provides a minimum of one year of service but is expected to periodically fail and be replaced and that is supervised for failure that affects normal operation or sensitivity. Typical examples of such components include incandescent lamps, electronic tube heaters, functional heating elements, and batteries. See also 38.4.1.

Revised 3.7 effective August 1, 2009

3.8 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 rated of 2.5 or less failures per million hours.

3.9 DRIP-PROOF – A product that is constructed, or so protected, so that falling drops of liquid or solid particle striking the enclosure, from 0 – 15 degrees downward from the vertical, do not interfere with the intended operation of the equipment.

3.10 DWELLING UNIT – That structure, area, room, or combination of rooms in which a family (or individual) lives. This is intended to cover the living area only and not common usage areas in multifamily buildings such as corridors, lobbies, and basements.

3.11 END-OF-LIFE SIGNAL – An audible signal, differing from the alarm signal, intended to indicate that the device has reached the end of its useful life and should be replaced. It is permitted for the audible component of the signal to be of the same format as a trouble signal, provided a visual indicator is employed to differentiate between the end-of-life and other trouble conditions. The end-of-life signal shall repeat once every 30 – 60 seconds ±10 percent.

3.12 LONG-TERM, LOW-LEVEL CARBON MONOXIDE EXPOSURES – Situations resulting in a carbon monoxide concentration not exceeding 30 ppm for less than 30 days.

3.13 PPM – Gas concentration in parts per million.

3.14 QUALIFIED APPLIANCE TECHNICIAN – A person, firm, corporation, or company that either in person, or through a representative, is engaged in and responsible for the installation, testing, servicing, or replacement of heating, ventilation, and air-conditioning (HVAC) equipment, combustion appliances and equipment, and/or gas fireplaces or other decorative combustion equipment.

3.15 SELF-CONTAINED UNIT – An alarm containing an internal battery or batteries.

3.16 SENSITIVITY – The gas concentration versus time at or above which the alarm must initiate or remain in alarm.

3.17 SENSOR – The component or combination of components of the alarm that responds to and in turn provides a usable output signal in the presence of carbon monoxide.

3.18 SHORT-TERM CARBON MONOXIDE EXPOSURE – Situations resulting in a carbon monoxide concentration not exceeding 70 ppm for less than 60 minutes.

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

3.20 SWITCHING DEVICE – A device designed to close and/or open one or more electrical circuits.

3.21 TROUBLE LEVEL – Any combination of battery voltage and series resistance that results in an audible trouble signal from a battery-operated alarm.

3.22 TROUBLE SIGNAL – A visual or audible signal, differing from the alarm signal, intended to indicate a fault or trouble condition, such as an open or shorted condition of a component in the device, an open or ground in the connecting wiring, loss of AC power, or the need for replacement of a limited life component. In a product that includes more than one limited life component, other than the battery, the trouble signal shall be identified by both an audible and visual signal. The audible portion of the trouble signal shall be a single tone pattern consisting of a short ″beep″ of not more than 0.5 second repeating once every 30 – 60 seconds ±10 percent. This signal shall be repeated until the trouble condition is corrected.

3.23 UNCONDITIONED AREAS – Enclosed spaces without continuous climate controls where an individual spends time and where there is a potential for carbon monoxide buildup. (Examples include attached garages, crawl spaces and attics associated with a family living unit, cottages and cabins with combustible fuel appliances and/or fireplaces, barns, etc.)

3.24 WARNING SIGNAL – Except for alarm and trouble signals, no other audible and visual signals shall be used (i.e. warning signals that indicate the presence of CO less than 30 ppm).

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

4 Alarm Reliability Prediction

4.1 Alarm units shall be constructed to a maximum failure rate of 4.0 failures per million hours as calculated by a full part stress analysis prediction as described in Section 2.0 of the Military Standard 217F or 3.5 failures per million hours as calculated by a simplified parts count reliability prediction as described in Section 3.0 of the Military Standard 217B, or equivalent. A ″Ground Fixed″ (GF) environment is to be used for all calculations. If actual equivalent data is available from the manufacturer, it is usable in lieu of the projected data for the purpose of determining acceptable reliability.

4.2 Any component whose failure results in any of the following is not required to be included in the failure rate calculations:

a) Energization of either an audible trouble signal or energization of a separate visual indication (orange or yellow),

b) De-energization of a power-on light,

c) Does not affect the normal operation, or

d) Is evaluated by specific performance tests included in this standard. Examples include the sensor, audible signal appliance, test switch, and battery contacts.

4.3 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 alarm.

4.4 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.)

4.5 A sensor, or a sensing component supervision system, of a CO alarming device 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 CO sensor unresponsive to the CO concentrations given in Table 39.1 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 38. All predicted failure modes shall result in a trouble signal.

5 Battery Removal Indicator

5.1 Removal of a battery from a battery-operated carbon monoxide 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.

5.2 If a warning flag, or equivalent, is employed to comply with the requirement of 5.1, it shall be marked as required in 83.6.

6 Alarm Reset/Silence Button

6.1 Each single and multiple station carbon monoxide alarm shall be provided with a manually operated alarm reset/silence button. The operation of the button shall silence the alarm signal and restore the alarm to its normal condition resulting in the alarm once again being able to sense carbon monoxide and alarm within the limits of the Sensitivity Test, Section 39. The alarm signal shall be reenergized within 6 minutes from the time the reset button is operated if the concentration of carbon monoxide surrounding the alarm remains at 70 ppm or greater.

7 Voltage Classification

7.1 Unless otherwise indicated, all voltage and current values contained in this standard are rms.

a) Extra-Low-Voltage Circuit – A circuit that has an AC voltage of not more than 30 volts AC (42.4 volts peak) and maximum power of 100 volt-amperes, such as supplied by a Class 2 transformer; or a circuit of not more than 30 volts DC supplied by a primary battery; or a circuit supplied by a combination of a transformer and fixed impedance, that as a unit, complies with all the performance requirements of a Class 2 transformer. A circuit that is derived from a supply circuit of more than 30 volts by connecting resistance or impedance, or both, in series with the supply circuit to limit the voltage and current, is not considered to be an extra-low-voltage circuit.

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

8 Lifetime

8.1 The unit (including the sensor) shall have a specified lifetime of at least 3 years from the date of manufacture, or from the date the unit is placed into service. The unit reliability shall be estimated with an in-service reliability measurement, see 78(a). If the manufacturer bases the specified lifetime on the date that the unit is placed into service, this specification shall be substantiated with technical data documenting that performance degradation is not likely to occur prior to the unit being placed into service if the unit is placed into service within 18 months after manufacture. The selection of which basis is employed to define the beginning of specified lifetime may be contingent upon the technology of the sensor used in the unit.

Added 8.1 effective August 1, 2009

CONSTRUCTION

9 General

9.1 Accessories

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

9.2 Sensitivity adjustment

9.2.1 A field sensitivity adjustment, if provided, shall be accessible with the 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 allowable, if no hazardous voltage parts are able to be contacted by the user. Adjustment extremes shall not exceed the values given in Table 39.1.

9.3 Supplementary signaling feature

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

10 Service and Maintenance Protection

10.1 General

10.1.1 An uninsulated live part of a hazardous-voltage circuit within the enclosure shall be located, guarded, or enclosed so as to reduce the risk of unintentional contact by persons performing service functions with the equipment energized.

10.1.2 An electrical component which may require examination, replacement, adjustment, servicing, or maintenance with the alarm energized shall be located and mounted with respect to other components and with respect to grounded metal so that it is accessible for such service without subjecting the user to an electric shock from adjacent uninsulated hazardous-voltage live parts.

10.1.3 The following are not considered to be uninsulated live parts:

a) Coils of relays, solenoids, and transformer windings, if the coils and windings are provided with insulating overwraps,

b) Terminals and splices with insulation rated for the intended application, and

c) Insulated wire.

10.2 Sharp edges

10.2.1 An edge, projection or corner of an enclosure, opening, frame, guard, knob, handle, or the like, of a carbon monoxide alarm shall be smooth and rounded, so as not to cause a cut-type injury when contacted during use or user maintenance.

11 Enclosure

11.1 General

11.1.1 The enclosure of an alarm shall be constructed to resist the abuses encountered in service. The degree of resistance to abuse inherent in the alarm shall preclude total or partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other defects that, alone or in combination, results in a risk of fire, electrical shock, or injury to persons.

11.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two are to be considered in determining compliance with the requirement of 11.1.1.

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

11.1.4 There shall not be rear openings in a carbon monoxide alarm which are permeable to debris or air currents that affect alarm response.

11.1.5 There shall not be openings between the mounting surface to which an alarm is intended to be installed and the rear of the alarm which are permeable to air that affects alarm response.

11.1.6 To comply with 11.1.4 and 11.1.5, one of the following methods, or method determined to be equivalent, shall be used:

a) An elastomeric rubber or neoprene gasket, or the equivalent, may be placed between the rear of the alarm and the mounting surface to seal the rear openings or

b) Instructions in the installation manual may be provided to describe the location and method(s) of applying a sealing compound that has been determined to be acceptable for the intended use.

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

11.1.8 If the unit is intended for permanent connection in a hazardous voltage circuit, the enclosure shall either have provision for the connection of metal-clad cable, conduit, or nonmetallic sheathed cable, or have provision for mounting on an outlet box.

11.1.9 A mounting bracket, or other means provided to secure a detector system to a boat, shall be of a type and located so the installation maintains a fixed relationship to the boat when subjected to the vibration and shock loads of marine service. See 75.2.5– 75.2.13.

11.1.10 Among the factors taken into consideration when a frame or enclosure for a detector system intended for a boat is judged are:

a) Mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Combustibility,

e) Resistance to ignition from electrical sources,

f) Resistance to corrosion, and

g) Resistance to distortion at temperatures to which the enclosure is subjected under conditions of normal or abnormal use.

11.1.11 Materials which are to be exposed to moist environments shall not be adversely affected when subjected to the humidity conditioning specified in 75.2.14 and 75.2.15.

11.2 Cast metal enclosures

11.2.1 The thickness of cast metal for an enclosure shall be as indicated in Table 11.1. Cast metal having a thickness 1/32 inch (0.8 mm) less than that indicated in Table 11.1 shall be employed only if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape and/or size of the surface is such that equivalent mechanical strength is provided.

Table 11.1
Cast metal enclosures

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

11.2.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, there shall not be less than 3-1/2 nor more than five threads in the metal, and the construction shall be such that a standard conduit bushing is able to be attached.

11.2.3 If 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 3-1/2 full threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

11.3 Sheet metal enclosures

11.3.1 The thickness of sheet metal employed for the enclosure of an alarm shall not be less than that indicated in Table 11.2 unless the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape or size of the surface is such that equivalent mechanical strength is provided.

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

Table 11.2
Sheet metal enclosures

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

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

11.3.4 A closure for a hole larger than 1-3/8 inch (34.9 mm) diameter shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used.

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

11.3.6 A knockout shall be provided with a surrounding surface for seating of a conduit bushing, and shall be so located that installation of a bushing at any knockout used during installation will not result in spacings between uninsulated live parts and the bushing of less than those indicated in Spacings, Section 34.

11.4 Nonmetallic enclosures

11.4.1 An enclosure or parts of an enclosure of nonmetallic material shall have the mechanical strength and durability and be so formed that operating parts are protected against damage. The mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 11.2. See also the Tests of Thermoplastic Materials, Section 62.

11.4.2 The continuity of any grounding system to which an alarm is able to be connected shall not rely on the dimensional integrity of the nonmetallic material.

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

a) Enclosure containing parts presenting risk of fire – Minimum flammability rating of V-0, and complies with the performance requirements of the Flammability – 5 Inch Flame Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

b) Enclosures containing Class 2 and Class 3 circuits with a voltage not exceeding 30 V AC, 42.4 V-peak, or 60 V DC – Minimum flammability rating of HB, and complies with the performance requirements of the Flammability – 3/4 Inch Flame Test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

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

11.5 Ventilating openings

11.5.1 Ventilating openings in an enclosure for hazardous-voltage circuits including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening permits passage of a rod having a diameter of 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 that are used to clean internal parts, shall be constructed to reduce the risk of damage to functional internal components during such cleaning operations.

11.5.2 Except as noted in 11.5.3, 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) if zinc coated.

11.5.3 If the indentation of the guard or enclosure does not alter the clearance between uninsulated live parts and grounded metal so as to reduce spacings below the minimum values required, 0.021 inch (0.53 mm) expanded metal mesh or perforated sheet metal, 0.024 inch (0.61 mm) if zinc coated, is able to be employed under the following conditions:

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

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

11.5.4 The wires 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) in.

11.6 Covers

11.6.1 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, the intended protective functioning of which requires renewal or

b) It is necessary to open the cover periodically in connection with the intended operation of the alarm. 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 an alarm that requires such action in connection with its intended performance. This requirement does not apply to the battery replacement aspect of an alarm employing a battery as the main or standby supply.

11.6.2 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.

11.6.3 If an alarm cover is not intended to be removed for cleaning, maintenance, or both, and the alarm is intended to be returned to the factory for servicing, the cover shall be secured so that it cannot be readily removed. Exposed screw slots or nuts, other than a tamperproof type, shall be sealed or covered. See 83.1(s) for supplementary marking.

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.

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

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

11.7 Transparent panels

11.7.1 Glass covering an enclosure opening shall be held securely in place so that it cannot be displaced in service and shall provide mechanical protection of the enclosed parts. The thickness of a glass cover shall not be less than that indicated in Table 11.3.

Table 11.3
Thickness of glass covers

Maximum size of opening				Minimum thickness,	
Length or width,		Area,			
inches	(mm)	$inches^2$	(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] 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.

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

a) Be mechanically equivalent to that of glass,

b) Not distort, or

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

11.7.3 A lens, light filter, or similar part of a carbon monoxide alarm 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 (see Sections 36 – 69) of this standard.

12 Corrosion Protection

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

12.2 The requirement of 12.1 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, if 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 alarm. Parts made of stainless steel, polished or treated if necessary, do not require additional protection. Bearing surfaces shall be of materials that will prevent binding due to corrosion.

12.3 Metal shall not be used in combinations such as to cause galvanic action which will adversely affect cabinets or enclosures.

12.4 Hinges and other attachments shall be resistant to corrosion.

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

POWER SUPPLY

13 Primary Power Supply

13.1 The primary power supply of a single or multiple station carbon monoxide alarm shall be either an electrical power source or a battery or batteries. Connection to the electrical power source, if used, shall be in the form of permanent wiring to terminals or leads in a separate wiring compartment (see also 11.1.8) having provision for the connection of conduit, metal-clad or nonmetallic sheathed cable, or by means of a power-supply cord and a two or three prong attachment plug.

13.2 If a separate power supply is provided, it shall have limited output energy consisting of an open circuit voltage not in excess of 30 volts rms, 42.4 volts peak or direct current (DC), and its output capacity shall be limited to a maximum of 100 volt-amperes. The energy shall be limited by an energy limited transformer having an output rating of 100 volt-amperes or less, or by a transformer plus additional circuitry having characteristics equivalent to those of a Class 2 transformer.

14 Secondary Power Supply

14.1 The use of a secondary power supply is optional. If a secondary power supply, such as a battery, is provided, it shall have the capacity to supply the maximum intended power to the alarm for 8 hours in the standby condition and thereafter be able to operate the alarm for an alarm signal for at least 12 hours continuously, followed by not less than 7 consecutive days of trouble signal.

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

14.3 If a battery is employed as a secondary power supply, the marking on the unit shall include the manufacturer's specified periodic battery replacement instructions.

14.4 If the discharge condition of a nonrechargeable type battery cannot be discerned visually, some form of test means, or equivalent, shall be provided to determine battery capacity. Any of the following are suitable means:

a) Battery test switch with related meter or equivalent means to indicate battery capacity.

b) Monitored battery where a trouble indication, as described in 38.1.3, is obtained.

15 Batteries

15.1 General

15.1.1 If a battery or set of batteries is employed as the main source of power of a single or multiple station carbon monoxide alarm, it shall meet the requirements of the Battery Tests, Section 60.

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

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

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

15.1.5 Connections of external wiring to a battery-operated single- or multiple-station carbon monoxide alarm, or to a portable accessory, shall not be subjected to stress or motion during battery replacement and/or servicing. Removal of the alarm or accessory from the mounting support to replace a battery or to service the unit is not allowed unless the connected wiring is not subjected to flexing or stress.

15.2 Battery connections

15.2.1 Lead or terminal connections to batteries shall be identified with the proper polarity (plus or minus signs), and provided with strain relief. Indicating polarity on the unit adjacent to the battery terminals or leads is not prohibited.

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

15.2.3 Each lead of a clip-lead assembly employed as part of a battery operated alarm shall be a minimum of 26 AWG (0.21 mm^2) stranded wire with a minimum 1/64-inch (0.4-mm) insulation.

16 Supplementary Signaling Circuits

16.1 For a cord-connected or battery operated single station alarm employing a supplementary signaling circuit which is energized from a separate source of supply, the source of energy shall not exceed the energy limits defined in 68.2.1 and 68.2.2.

16.2 For an alarm intended to be connected to a fixed wiring system and employing a separately energized signaling circuit, the source of energy shall not exceed the limits in 68.2.1 unless the connections are made as a Class 1 wiring system as defined in the National Electrical Code, ANSI/NFPA 70-1996, or in the Canadian Electrical Code, Part 1 (CSA Standard C22.1).

FIELD WIRING

17 Permanent Connection

17.1 General

17.1.1 A single station or multiple station carbon monoxide alarm 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.

17.2 Field-wiring compartment for hazardous voltage connection

17.2.1 The field-wiring compartment area is to 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 if a bushing is required for installation.

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

17.3 Field-wiring terminals

17.3.1 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 not be provided unless determined to be equivalent.

17.3.2 If 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).

17.3.3 Except as noted in 17.3.4, 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.

17.3.4 A terminal plate shall have the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Other constructions shall be employed only if they provide equivalent security.

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

17.4 Field-wiring leads

17.4.1 Power supply leads provided for field connection shall not be less than 6 inches (152 mm) long, provided with strain relief, and shall not be smaller than 18 AWG (0.82 mm^2); and the insulation, if thermoplastic, shall not be less than 1/32 inch (0.8 mm) in thickness.

Exception No. 1: The lead may be less than 6 inches long if it is evident that the use of a longer lead may result in damage to the insulation.

Exception No. 2: Solid copper leads as small as 26 AWG (0.13 mm^2) may be used if:

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 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;

c) The assembled conductors comply with the requirements of the Strain Relief Test, Section 67; and

d) The installation instructions indicate that the lead cannot be spliced to a conductor larger than 18 AWG.

17.4.2 Leads provided for field connection to power limited signaling circuits, such as employed for multiple station interconnection or 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, may be employed only for 18 AWG (0.82 mm^2) and larger conductors.

17.5 Grounded supply terminals and leads

17.5.1 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 and 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 some other manner, such as on an attached wiring diagram.

17.5.2 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.

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

18 Power Supply Cord

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

Exception: The cord may be less than 6 feet in length if it is evident that the use of a longer cord:

a) May result in a risk of fire or electric shock;

b) May result in unintentional contact with moving parts that may cause a risk of injury to persons; and

c) Is not required for the intended operation of the product.

18.2 The flexible cord shall be of Type SP-1, SPT-1, SP-2, SPT-2, SV, SVT, SJ, SJT, SPE, SVE, or equivalent, minimum 18 AWG (0.82 mm^2). It shall be rated for use at the voltage and ampacity rating of the alarm, in accordance with the National Electrical Code, ANSI/NFPA 70, or the Canadian Electrical Code, Part 1 (CSA Standard C22.1).

18.3 Means shall be provided to prevent the flexible cord from being pushed into the enclosure through the cord-entry hole if such displacement:

a) Subjects the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is rated,

b) Reduces spacings below the minimum acceptable values, or

c) Results in damage in internal components.

18.4 A smoothly rounded restraining means shall be provided for securing the attachment plug to the receptacle. See the Strain Relief Test, Section 67.

18.5 The power supply cord shall be provided with strain relief means so that a stress on the cord will not be transmitted to terminals, splices, or internal wiring. See the Strain Relief Test, Section 67.

18.6 If a knot in a flexible cord serves as strain relief, a surface against which the knot may bear or with which it may come in contact shall be free from projections, sharp edges, burrs, and fins that may cause abrasion of the insulation on the conductors.

18.7 Clamps of any material (metal or otherwise) are acceptable for use on cords and supply leads without varnished-cloth insulating tubing or the equivalent under the clamp unless the tubing or the equivalent is necessary to prevent the clamp from damaging the cord or supply leads.

19 Equipment Grounding

19.1 General

19.1.1 An equipment grounding terminal or lead, or equivalent, is required for a hazardous-voltage alarm that is intended to be serviced internally and employs internal dead metal parts that become energized under a fault condition.

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

a) An extra-low-voltage alarm;

b) A hazardous-voltage alarm provided with an overall nonmetallic enclosure and cover, and that is not intended to be internally serviced; or

c) A hazardous-voltage alarm provided with an overall nonmetallic enclosure and cover, that does not employ internal dead metal parts that become energized under a fault condition and is able to be contacted during servicing.

19.2 Permanently-connected units

19.2.1 The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green, with or without one or more yellow stripes. No other leads visible to the installer, other than grounding conductors, shall be so identified. A field-wiring terminal intended for connection of an equipment-grounding conductor shall be plainly identified, such as being marked ″G,″ ″GR,″ ″Ground,″ ″Grounding,″ or a means determined to be equivalent, or by a marking on a wiring diagram provided on the alarm. The field-wiring terminal shall be so located that it cannot be removed during servicing of the alarm.

19.3 Cord-connected units

19.3.1 The grounding means for a cord-connected alarm that is intended to be serviced internally shall consist of a separate grounding lead integral with the supply cord and terminating in the grounding pin of a parallel blade attachment plug.

20 Remote Power Supply Leads

20.1 For an alarm that is intended to be connected to a separate remote power supply such as a transformer, the supply cord is not required to be factory wired to the alarm, or to the transformer terminals or leads, if the installation instructions provided with the unit are explicit regarding the method of connection. The minimum size conductors between the alarm and remote power supply shall not be less than 18 AWG (0.82 mm^2) and shall not be longer than 20 feet (6.1 m). The interconnecting wiring is to be provided by the manufacturer.

20.2 Where longer runs of interconnecting wiring are used in an installation, such as in a multiple station configuration, or where several alarms are supplied by a common power supply, the manufacturer is not required to provide the wiring. However, the installation wiring diagram or instructions shall be marked to specify that the wiring to be used shall be in accordance with the provisions of Article 725 of the National Electrical Code, ANSI/NFPA 70, or Section 33 of the Canadian Electrical Code, Part 1 (CSA Standard C22.1). In addition, the resistance of the interconnecting wiring shall be a maximum of 10 ohms, unless otherwise specified by the manufacturer.

INTERNAL WIRING

21 General

21.1 The internal wiring of an alarm shall consist of conductors having insulation rated for the voltage involved and the temperatures to which it shall be subjected, and shall have the mechanical strength and current-carrying capacity for the service. The wiring shall be routed away from moving parts and sharp projections and held in place with clamps, string, ties, or equivalent, unless of sufficient rigidity to retain a shaped form.

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

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

21.4 Internal wiring of circuits operating 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 equivalent to that required for the highest voltage involved. Segregation of insulated conductors shall be accomplished by clamping, routing, or equivalent means that provides permanent separation.

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

22 Wireways

22.1 Wireways shall be smooth and free from sharp edges, burrs, fins, and moving parts that cause abrasion of the conductor insulation.

23 Splices

23.1 All splices and connections shall be mechanically secured to preclude shorting to adjacent uninsulated current carrying parts in the event that an improper connection, such as a cold solder joint, is made. Tack soldering is not to be used unless the design precludes mechanical security and five samples resist a pull force of 2 pounds (8.9 N) applied for 3 seconds and the connection is subjected to 100 percent inspection and testing with the same pull force by the manufacturer.

23.2 A splice shall be provided with insulation equivalent to that of the wires involved, if permanence of electrical spacing between the splice and uninsulated metal parts is not assured.

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

24 Barriers

24.1 A metal barrier shall have a thickness at least equal to that required by Table 11.2, as determined by the size of the barrier. A barrier of insulating material shall not be less than 0.028 inch (0.71 mm) thick and shall be thicker 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 than 1/16 inch (1.6 mm).

25 Grounding and Bonding

25.1 An exposed dead metal part that becomes energized by hazardous voltage shall be bonded to the point of connection of the alarm grounding terminal or lead, and to the metal surrounding the knockout, hole, or bushing provided for field power supply connections.

25.2 Except as indicated in 25.3, uninsulated metal parts of electrical enclosures, transformer cores, mounting brackets, capacitors, and other electrical components shall be bonded for grounding if they may be contacted by the user or by a service person servicing or operating the equipment.

25.3 Metal parts as described below, are not required to comply with the requirement of 25.1 and 25.2:

a) Adhesive attached parts, such as a metal foil markings, screws, or handles that are located on the outside of the enclosure and isolated by grounded metal parts from electrical components or wiring by grounded metal parts so that they cannot become energized.

b) Isolated metal parts, such as small assembly screws, that cannot come in contact with wiring and uninsulated live parts.

c) Panels or covers that do not enclose uninsulated live parts when they cannot come in contact with wiring which causes them to become energized.

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

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

25.5 A bolted or screwed connection that incorporates a star washer or serration under the screwhead is acceptable for penetrating nonconductive coatings as required by 25.4.

25.6 The use of two or more screws, or two full threads engagement of a single screw in metal, complies with 25.4 if the bonding means depends upon screw threads.

25.7 Metal-to-metal hinge bearing members for doors or covers shall not be used as means of bonding the door or cover for grounding unless a multiple bearing-pin type (piano type) hinge is used.

25.8 The size of a copper or aluminum conductor employed to bond an electrical enclosure shall be based on the rating of the branch circuit overcurrent device by which the alarm will be protected. Except as noted below, the size of the conductor shall comply with the applicable requirements for connection of an equipment grounding conductor as specified in Table 250-95 of the National Electrical Code, ANSI/NFPA 70, and Table 16 of the Canadian Electrical Code, Part 1, CSA Standard C22.1, except that such a conductor need be not larger than one of the power supply conductors.

25.9 A bonding conductor to an electrical component need not be larger than the conductor supplying the component.

25.10 A bonding conductor in an alarm shall have insulation equivalent to that of live conductors, if there is any possibility of accidental contact between the bonding conductor and uninsulated live parts.

25.11 Splices shall not be employed in wire conductors used for bonding.

ELECTRICAL COMPONENTS

26 General

26.1 Mounting of components

26.1.1 A switch, lampholder, attachment-plug receptacle, plug connector, or similar electrical component, and uninsulated live parts shall be mounted securely and shall be prevented from turning.

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

a) The switch is a plunger or other type that does not rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during operation of the switch.

b) The means for mounting the switch makes it unlikely that the operation of the switch will loosen it.

c) The spacings are not reduced below the minimum required values if the switch rotates.

d) The operation of the switch is by mechanical means rather than by direct contact by persons.

Exception No. 2: A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, is not required to be prevented from turning if rotation cannot reduce spacings below the minimum values required. See Spacings, Section 34.

26.1.2 Uninsulated live parts shall be so secured to the base or mounting surface that they will be prevented from turning or shifting in position, if such motion may result in a reduction of spacings. Friction between surfaces is not acceptable as a means to prevent shifting or turning of live parts, but a properly applied lock washer may be accepted.

26.1.3 Uninsulated live parts, for example field-wiring terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they will be prevented from turning or shifting in position if such motion results in reduction of spacings below the minimum values required. This shall be accomplished by two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other equivalent method.

26.2 Operating components

26.2.1 Operating components and assemblies, such as switches, relays, and similar devices, shall be protected by individual dust covers or dust tight cabinets, against fouling by dust or by other material that impairs their operation.

26.2.2 Adjusting screws and similar adjustable parts shall be prevented from loosening under the conditions of actual use. A properly applied lock washer is one method of preventing loosening.

26.3 Current-carrying parts

26.3.1 Bearings, hinges, and similar items shall not be used for current carrying parts.

26.4 Electrical insulating material

26.4.1 Material for the mounting of uninsulated live parts shall be porcelain, phenolic composition, cold-molded composition, or equivalent material.

26.4.2 Vulcanized fiber is suitable for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts of other than extra-low-voltage circuits.

26.4.3 Polymeric materials shall not be used for the sole support of uninsulated live parts unless they are determined to be equivalent to the materials indicated in 26.4.1.

26.4.4 A flat sheet of insulating material, such as phenolic composition employed for panel-mounting of parts, shall not be less than 1/16 inch (1.6 mm) thick. Material less than 1/16 inch in thickness shall not be employed unless the panel is supported or reinforced to provide equivalent rigidity.

26.4.5 When a terminal block mounted on a metal surface is grounded it shall be provided with an insulating barrier between the mounting surface and all uninsulated live parts on the underside of the base unless the parts are staked, upset, sealed, or equivalently prevented from loosening so as to prevent the parts and the ends of replaceable terminal screws from coming in contact with the supporting surface or reducing spacings below the minimum values required.

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

27 Bushings

27.1 If a lead or wire harness passes through an opening in a wall, barrier, or enclosing case, there shall be a metal or insulating type bushing, or a means determined to be equivalent, which shall be substantial, secured in place, and have a smooth rounded surface.

27.2 If the opening is in a phenolic composition or other nonconducting material, or in metal of thickness greater than 0.042 inch (1.07 mm), a smooth surface having rounded edges is considered to be the equivalent of a bushing.

27.3 Ceramic materials and some molded compositions are suitable for insulating bushings, but separate bushings of wood and hot-molded shellac shall not be used.

27.4 Fiber shall be employed only where:

a) It is not subjected to a temperature higher than 90°C (194°F) under normal operating conditions,

b) The bushing is not less than 1/16 inch (1.6 mm) in thickness, with a minus tolerance of 1/64 inch (0.4 mm) for manufacturing variations, and

c) It is not affected adversely by ordinary ambient humidity conditions.

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

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

28 Lampholders and Lamps

28.1 A single and/or multiple station carbon monoxide alarm intended to be connected to an alternating current (ac) power source shall be provided with a ″power-on″ lamp to indicate energization of the unit.

28.2 If more than one lamp is provided on the alarm, the ″power-on″ lamp shall be white or green, an alarm indicating lamp shall be red, and a trouble lamp shall be amber or yellow.

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

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

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

28.6 A lamp or equivalent means, such as a distinctive audible signal indication, shall be provided on an alarm intended for multiple-station interconnection to identify the unit from which the alarm was initiated.

29 Protective Devices

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

30 Printed-Wiring Boards

30.1 The components of a printed-wiring board shall be secured in place and the spacings between circuits shall comply with the spacings requirements for rigidly clamped assemblies (Table 34.1). The board shall be mounted so that deflection of the board during servicing shall not result in damage to the board or risk of fire or electric shock.

30.2 A printed-wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796, and shall be mounted so that moisture does not accumulate on the board.

31 Switches

31.1 A switch shall have a current and voltage rating not less than that of the circuit which it controls. There shall be no power switches provided with an alarm.

31.2 If a reset switch is provided, it shall be of a self-restoring (momentary) type.

32 Transformers and Coils

32.1 A transformer shall be of the two-coil or isolated-winding type.

Exception: It is not prohibited that an autotransformer be employed in an alarm intended for permanent connection only, when the terminal or lead connected to the autotransformer winding which is common to both input and output circuits is identified, and that the output circuits are located only within the enclosure containing the autotransformer. See 17.5.1 and 17.5.2.

32.2 The insulation of coil windings of relays, transformers and the like shall be such as to resist the absorption of moisture.

32.3 Film-coated or equivalently insulated wire is not required to be given additional treatment to prevent moisture absorption.

33 Dropping Resistors

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

34 Spacings

34.1 Spacings shall be maintained between uninsulated live parts and dead metal parts, and between uninsulated live parts of opposite polarity. The spacings shall not be less than those indicated in Table 34.1.

34.2 The spacings between an uninsulated live part and a wall or cover of a metal enclosure; fitting for conduit or metal-clad cable; and any dead metal part shall not be less than that indicated in Table 34.1.

34.3 The ″Through air″ and ″Over surface″ spacings of Table 34.1 measured at an individual component part are to be judged on the basis of the volt-amperes used and controlled by the individual component. However, the spacings from one component to another, and from any component to the enclosure or to other uninsulated dead metal parts, excluding the component mounting surface, shall be judged on the basis of the maximum voltage and total volt-amperes rating of all components in the enclosure.

34.4 The spacing requirements in Table 34.1 do not apply to the inherent spacings inside motors, except at wiring terminals, or to the inherent spacings of a component provided as part of the alarm. Such spacings are judged on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete device, including clearances to dead metal or enclosures, shall be those indicated in Table 34.1.

34.5 The ″To wall of enclosure″ spacings of Table 34.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

34.6 Enameled or equivalently insulated wire is to be considered an uninsulated live part, but enamel is acceptable as turn-to-turn insulation in coils.

Table 34.1
Minimum spacings

Point of application	Voltage range	Minimum spacings[a,b]			
		Through air,		Over surface,	
		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 – 300	1/2	12.7	1/2	12.7
Installation wiring terminals:					
With barriers	0 – 30	1/8	3.2	3/16	4.8
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5
Without barriers	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
Rigidly clamped assemblies:[c]					
100 volt-amperes maximum[d]	0 – 30	1/32	0.8	1/32	0.8
Over 100 volt-amperes	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	1/8	3.2
	31 – 150	1/8	3.2	1/4	6.4
	151 – 300	1/4	6.4	3/8	9.5

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

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

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

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

PERFORMANCE

35 General

35.1 Test units and data

35.1.1 Alarms that are fully representative of production units are to be used for all tests. The range of sensitivities (ppm CO), regardless of time, which can lead to an alarm signal shall be provided for the samples. This range will define the production sensitivity.

35.1.2 The following samples are to be provided for testing:

a) At least 15 assembled alarms.

b) One additional unassembled alarm.

c) Installation and operating instructions (see 85.1 and 85.2 and Section 84).

d) For alarms employing a battery as the main operating supply, 24 additional battery operated alarms for long term battery tests or equivalent test circuit set-ups with appropriate measuring facilities to monitor the battery voltage, standby current, and alarm current. Each set-up, if provided, is to be representative of six alarms and is to include test terminals and switches, limiting resistors, the alarm horn, and batteries. The value of resistors is to represent the normal standby current which is obtained from a complete alarm.

35.1.3 The batteries are to be connected in the test circuit with the same terminal arrangement employed in the alarm. Provision for connection of the actual sounding appliance used in the alarm for random and weekly testing is also to be made. (See the Battery Tests, Section 60.)

35.1.4 Before, during, and after the tests specified in Sections 39, 40, 42, 46, and 47 of this Standard, all alarm samples shall remain operational without the need to replace any component or portion of the alarm. These same alarms may be used in subsequent tests.

35.1.5 The accessory devices such as horns or lights employed for testing are to be those specified by the wiring diagram of the alarm. Substitute devices shall be used only if they produce functions and load conditions equivalent to those obtained with the devices intended to be used with the alarm in service.

35.2 Accessories

35.2.1 Accessories for use with single and multiple station carbon monoxide alarms are to be subjected – but not necessarily limited– to the following tests as applicable:

a) Normal Operation Test, Section 36;

b) Circuit Measurement Test, Section 37;

c) Temperature Test, Section 43;

d) Overload Test, Section 44;

e) Endurance Test, Section 45;

f) Variable Ambient Temperature Test, Section 46;

g) Humidity Test, Section 47;

h) Leakage Current Test, Section 48;

i) Transient Tests, Section 49;

j) Dielectric Voltage-Withstand Test, Section 50;

k) Overvoltage Test, Section 52;

l) Undervoltage Test, Section 53;

m) Jarring Test, Section 58;

n) Audibility Test, Section 61;

o) Tests of Thermoplastic Materials, Section 62; and

p) Drop Test, Section 69 (portable appliance only).

35.3 Test voltages

35.3.1 Unless otherwise specified, the test voltage at rated frequency for each test is to be as follows:

Voltage, nameplate	Alarm rated test voltage
110 to 120	120
220 to 240	240
Other	Marked rating

35.3.2 The following samples are to be provided for testing:

a) At least 15 assembled alarms,

b) One additional unassembled alarm,

c) Installation and Operating Instructions (see 85.1 and 85.2 and Section 84).

d) For alarms employing a battery as the main operating supply, 24 additional battery operated alarms for long term battery tests or equivalent test circuit set ups with appropriate measuring facilities to monitor the battery voltage, standby current, and alarm current. Each set up, if provided, shall be representative of six alarms and shall include test terminals and switches, limiting resistors, the alarm horn, and batteries. The value of resistors shall represent the normal standby current which would be obtained from a complete alarm.

35.3.3 The batteries shall be connected in the test circuit with the same terminal arrangement employed in the alarm. Provision for connection of the actual sounding appliance used in the alarm for random and weekly testing shall also be made. (See the Battery Tests, Section 60.)

35.4 Component reliability data

35.4.1 Data on alarm components, such as capacitors, resistors, solid state devices, and the like, shall be provided for evaluation of the reliability of the components for the intended application. If a Military Standard is referenced, a copy of the specification is to be provided for review.

35.4.2 The data required by 35.4.1 shall include the following or equivalent information:

a) Component and overall alarm reliability analysis per Military Standard 217F, described in 4.1.

b) Component vendor’s reliability and life expectancy data. This includes failure rate data at rated values and derated values. The latter data is required only where the derating values form the basis of reliability.

c) General description of the alarm manufacturer’s quality assurance (QA) program. This information shall include incoming inspection, in-process QA, burn-in data and testing. This applies to complete and partial assemblies as well as individual components.

d) Component Fault Analysis – Effect of failure, open and short, of capacitors and limited-life components on operation of an alarm.

e) Maximum vendor’s ratings for each component as well as the actual maximum operating values (voltage and current) in the alarms.

f) A description of component screening and burn-in test data for solid-state devices or integrated circuits which operate at greater than the limits described in note (b) of Table 43.1.

g) General calibration procedure of test instruments employed by the manufacturer in the calibration of an alarm.

h) A general description of the circuit operation under standby, alarm, and trouble conditions.

i) A description of the carbon monoxide test chamber, including drawings and operation procedure, to be used by a manufacturer in conducting the factory calibration tests.

36 Normal Operation Test

36.1 An alarm 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.

36.2 The test voltage is to be in accordance with 35.3.1. The alarm is to be in the standby condition and prepared for its intended signaling operation when it is connected to related devices and circuits.

36.3 The maintenance of approximately 600 ppm of carbon monoxide in the alarm chamber shall result in the operation of the alarm in its intended manner for at least 12 hours.

36.4 A single station carbon monoxide alarm that employs a secondary power supply shall meet the requirements of this standard with the main power de-energized.

36.5 For multiple station configurations, the operation of one alarm shall result in the alarm signal of all connected alarms being energized and the alarm that initiated the alarm signal shall be identified. See 28.6.

36.6 Operation for alarm of a single-station carbon monoxide alarm with integral transmitter that is energized by an initial pulse(s) shall result in an alarm signal with a duration of at least 12 hours at a compatible receiving unit located at the maximum distance specified by the manufacturer, when tested under free-field conditions with no obstructions between the alarm transmitter and receiver units. Refer to 84.1(l) for instructions to be provided. A manual reset of the receiver is not required if the receiving unit audible alarm signal is energized in time sequence and duration with the alarm.

36.7 When a manual test switch is operated it shall cause all visual and audible indicators to be operated.

36.8 Any indicator of CO concentration shall be accurate to within plus or minus 30% of the indicated amount. No indication shall be given for CO concentrations less than 30 ppm. The indicator shall comply with the in-service reliability requirements of 78.1.2. Testing of this shall be performed at 70, 150, and 400 ppm and the test data shall be part of the in-service reliability measurement program.

37 Circuit Measurement Test

37.1 Current input

37.1.1 Except for a battery operated alarm, the input current of a single or multiple station carbon monoxide alarm shall not exceed the marked rating by more than 10 percent when the alarm is connected to a source of supply in accordance with 35.3.1 and operated under the conditions of intended use (standby and alarm).

37.2 Battery trouble voltage determination

37.2.1 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 for 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 measured over a 12 month period in the room ambient condition of the Battery Tests, Section 60.

37.2.2 The trouble level of a battery operated carbon monoxide alarm shall be determined (using the test circuit in Figure 37.1 and the voltage-resistance curves of Figure 37.2) for each of the following voltages:

a) Rated battery voltage,

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

c) Voltages between rated and trouble level voltage.

Figure 37.1
Test circuit

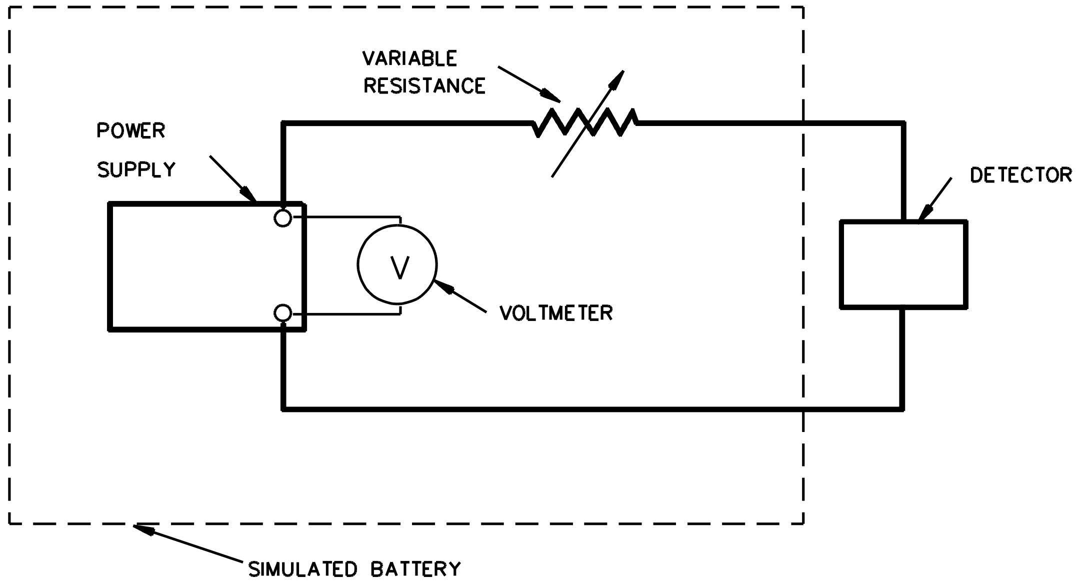

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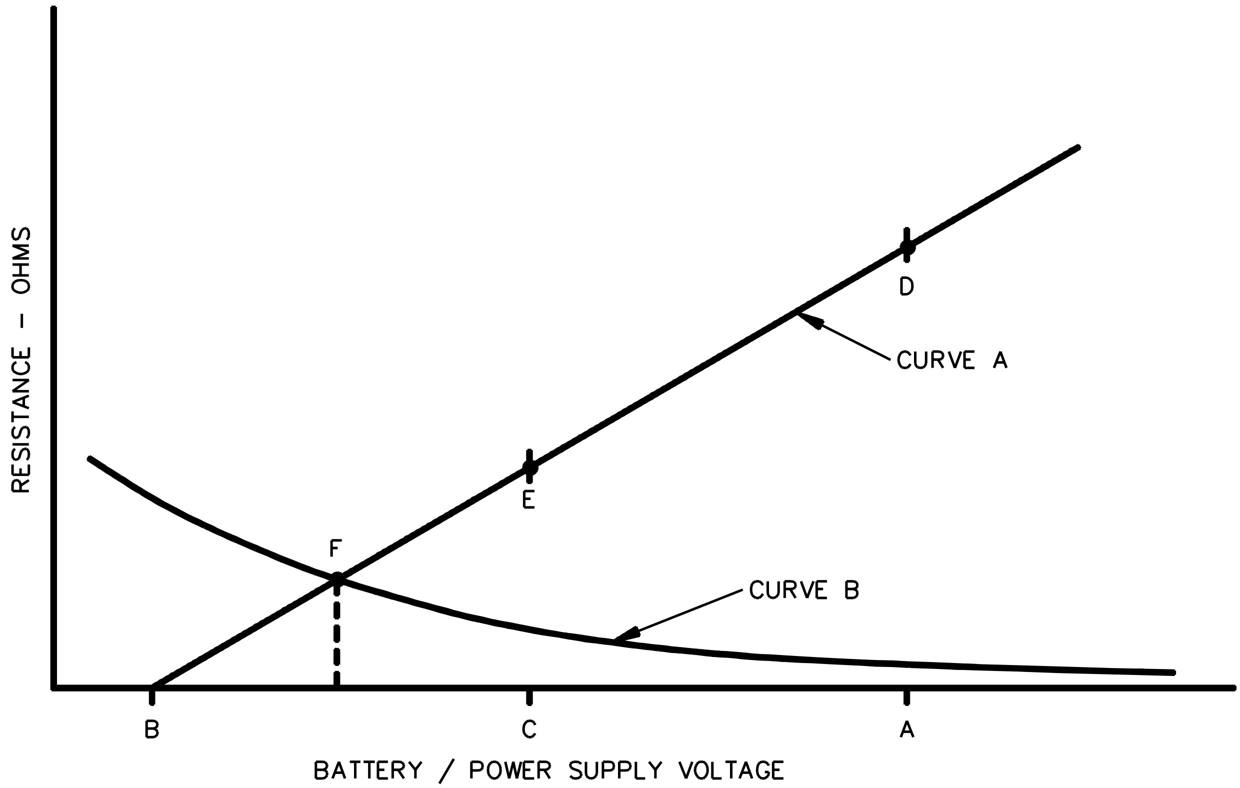
Figure 37.2
Trouble level determination graph



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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 (minimum 6 months) battery test. Shape and slope of curve, as well as point of intersection with Curve A, will vary depending on battery used.

37.2.3 To determine compliance with 37.2.1 each of three alarms is to be connected in series with a variable regulated direct current power supply and a variable resistor as illustrated in Figure 37.1. The trouble level is to be determined by the following steps:

a) Rated Battery Voltage – The voltage of the power supply is to be set at the rated battery voltage and the series resistor at 0 ohms. The resistance is to be increased in increments of 0.1 – 10 ohms, at a rate of not more than one increment per minute, until a trouble signal is obtained. The alarm is to be tested for alarm operation at each resistance level and at the trouble signal level.

b) Trouble Level Voltage – With the variable resistor set at 0 ohms, the voltage of the power supply connected to the alarm is to be reduced in increments of 1/10 volt per minute to the level where the trouble signal is obtained. The alarm is to be tested for alarm operation at each voltage level and at the trouble signal level.

c) Voltage Values Between Rated and Trouble Level Voltages – The voltage of the power supply is to be set at preselected voltages between the rated battery voltage and the trouble level voltage. The series resistance is then to be increased in increments of 0.1 – 10 ohms, at a rate of not more than one increment per minute, until a trouble signal is obtained. The alarm is to be tested for alarm operation at each resistance and voltage level and at the trouble voltage level. A sufficient number of voltage values shall be selected to determine the shape of the trouble level curve.

37.2.4 To determine that a battery is capable of supplying alarm and trouble signal power to the alarm for at least 12 months under the room ambient condition described in the Battery Tests, Section 60, Curve A of Figure 37.2 is to be plotted from the data obtained in the measurements described in 37.2.3 and compared to Curve B of Figure 37.2, which is plotted from data generated in the 6 months battery test. The intersection of Curves A and B shall not occur before 12 months and all points of Curve B to the right of point F (extended to the base line), shall be below Curve A.

38 Electrical Supervision Test

38.1 General

38.1.1 A carbon monoxide alarm 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 or a sensor,

Exception: The power source of a battery operated alarm.

b) An ″open″ in an externally connected alarm circuit, or

c) A ground fault in any externally connected wiring.

Revised 38.1.1 effective August 1, 2009

38.1.2 The wiring extending between alarms wired in a multiple station configuration 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.

38.1.3 If an audible trouble signal is required to indicate a fault condition, it shall be produced every 30 – 60 seconds ±10 percent for a minimum of seven consecutive days. The trouble signal shall be distinctive from the alarm signal.

38.1.4 To determine if an alarm unit complies with the requirements for electrical supervision, the alarm 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 alarm is then to be restored to the standby condition prior to establishing the next fault.

38.1.5 A fault condition (open, ground, or short), of other than the carbon monoxide alarm circuit of a carbon monoxide alarm with a noncarbon monoxide-alarm feature shall not prevent alarm signal operation as a carbon monoxide alarm. For this test the alarm 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 is then to be subjected to a carbon monoxide level of approximately 600 ppm which shall result in an audible alarm.

38.1.6 The unit shall indicate end-of-life, based on the manufacturer's specified lifetime, with an end-of-life signal (see 3.11). This signal shall be triggered either by an internal timer or by a self-diagnostic test(s).

a) For a unit that employs a signal generated by an internal timer, once maximum specified lifetime is reached the end-of-life signal shall be initiated. The timer can be reset repeatedly, for a period not exceeding 72 hours for each period of reset, if self-diagnostic test(s) indicate that the unit still meets the requirements of this standard. The timer shall not be able to be reset after 30 days following the initial end-of-life signal.

b) For a unit that employs a signal generated by a self-diagnostic test, once this test has determined the device no longer meets the requirements of this standard, the end-of-life signal shall be initiated.

c) If the sensor is automatically and periodically tested for response to CO (or an equivalent gas), then the unit's specified lifetime calculations can exclude the sensor component.

Added 38.1.6 effective August 1, 2009

38.2 AC powered units

38.2.1 Failure of an AC power source to an alarm shall be indicated by de-energization of a ″power-on″ lamp.

38.2.2 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.

38.2.3 Loss of power to a single unit of a multiple station alarm configuration, while energized in the standby condition, shall not result in a false alarm and shall not prevent the operation of the remaining units for alarm.

38.3 Battery powered units

38.3.1 An 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.

38.3.2 To determine compliance with 38.3.1, 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.

38.3.3 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.

38.3.4 To determine compliance with 38.3.3, 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.

38.4 Component failure

38.4.1 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 3.7 and 3.8.

38.5 External wiring

38.5.1 An open or ground fault in the loop wiring connected from a single station carbon monoxide 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.

38.5.2 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.

38.5.3 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.

39 Sensitivity Test

39.1 General

39.1.1 A carbon monoxide alarm shall operate (alarm signal) at or below the test points specified in Part A of Table 39.1 when using the test equipment described in 39.2.1. These test points are based on plotted limits for the 10 percent COHb curve Figure 39.1. If the alarm employs a variable sensitivity setting, test measurements are to be made at maximum and minimum settings. For this test, three carbon monoxide concentrations (70, 150, and 400 ppm) are to be used as specified in Part A of Table 39.1.

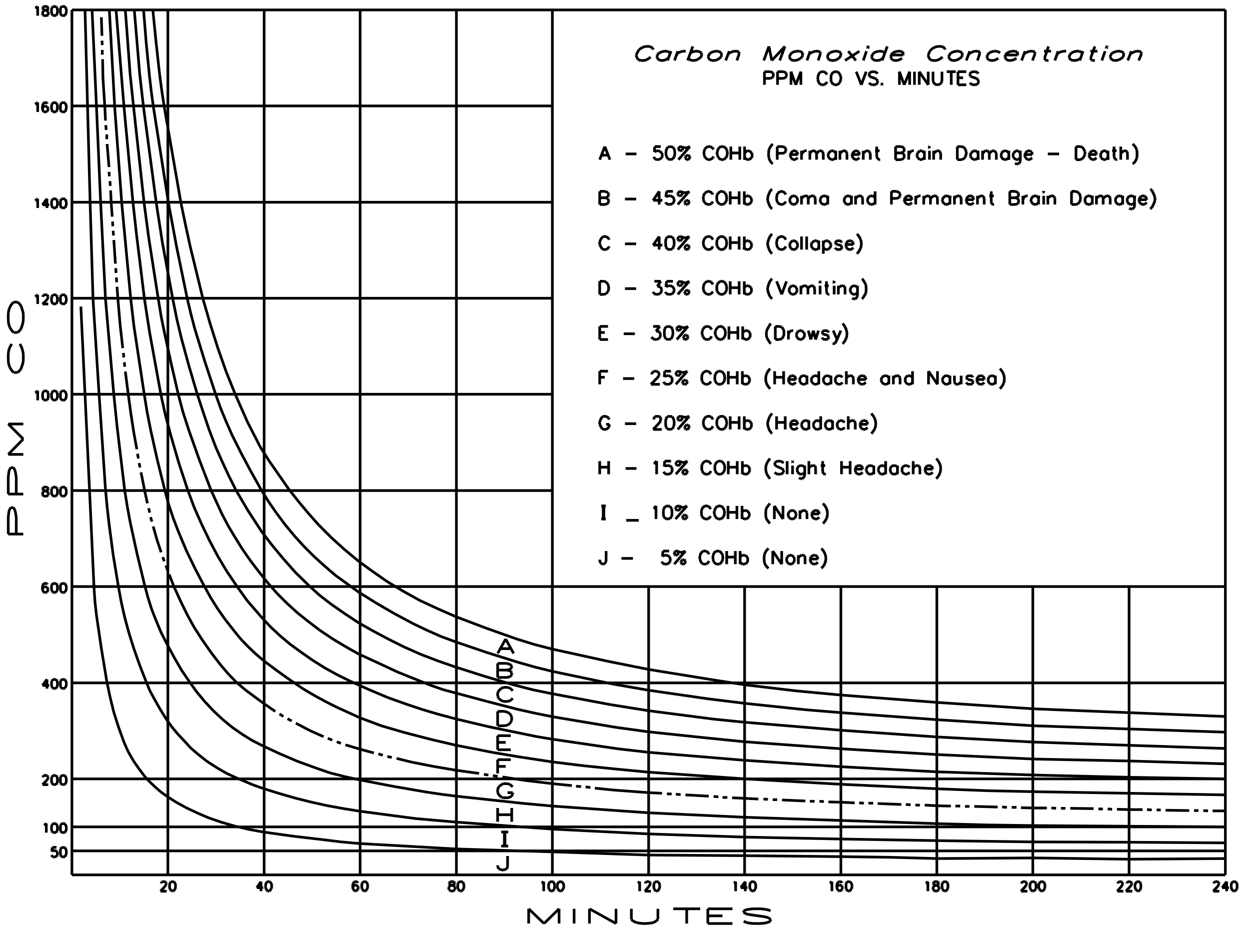
39.1.2 A carbon monoxide alarm shall not operate (alarm signal) below the test points specified in Part B of Table 39.1, when using the test equipment described in 39.2.1. If the alarm employs a variable sensitivity setting, test measurements are to be made at maximum and minimum settings. For this test, at least two carbon monoxide concentrations (70 and 30 ppm) are to be used as specified in Part B of Table 39.1.

39.1.3 A single station carbon monoxide alarm employing a secondary power supply shall operate within the limits specified in 39.1.1 when operating from the secondary power supply.

Table 39.1
Carbon monoxide concentration versus time for alarm test points based on 10 percent Carboxyhemoglobin (COHb)

A. Carbon monoxide concentration and response time	
Concentration, ppm	**Response time, minutes**
70 ±5	60 – 240
150 ±5	10 – 50
400 ±10	4 – 15
B. False alarm – carbon monoxide concentration resistance specifications	
Concentration, ppm	**Exposure time, (no alarm)**
30 ±3	30 days
70 ±5	60 minutes

Figure 39.1
Carbon monoxide concentration (ppm CO) versus time (minutes)



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Equation For determining estimated percent COHb in blood[a]

$$\%COHb_t = \%COHb_0[e^{-(t/2398B)}] + 218[1-e^{-(t/2398B)}]\ [0.0003 + (\text{ppm CO}/1316)]$$

in which:

$\%COHb_t$ is the percentage of COHb at time t,

$\%COHb_0$ is the percentage of COHb in the blood at time 0,

t is the time in minutes, and

B is 0.0404 (heavy work effort).

[a] A proposal for evaluating human exposure to carbon monoxide contamination in military vehicles, Steinberg, Nielson, March 1977, AMCMS Code 672716.H700011; Coburn, R.F., Forster, R.E., & Kane, P.G. Considerations for the physiological variables that determine the blood carboxyhemoglobin concentration in man. Journal of Clinical Investigation, 1965, 44 1899-1910.

39.2 Test equipment

39.2.1 The carbon monoxide alarm shall 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 carbon monoxide concentrations. The following conditions shall be established within the test chamber and maintained throughout the test:

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.

39.3 Test method

39.3.1 Twelve alarms shall be conditioned for 48 hours under the ambient conditions specified in 39.2.1.

39.3.2 The alarms shall then be placed in a test chamber, either individually or in a group, and operated for 15 ±5 minutes. The test chamber shall then be sealed. Carbon monoxide shall be introduced into the test chamber and slowly circulated in the chamber to produce a uniform concentration of 70 ±5 ppm. This level of carbon monoxide shall be established within 3 minutes after sealing the chamber and shall be maintained throughout the remainder of the test. Once the specified carbon monoxide level has been established, the alarms shall actuate within the time range specified in Table 39.1 (see 39.1.1), but not to exceed 240 minutes.

39.3.3 The test chamber shall be purged with fresh air to remove all carbon monoxide. The carbon monoxide alarms shall be reset according to the manufacturer’s instructions, and the test described in 39.3.2 shall be repeated with the carbon monoxide concentration maintained at 150 ±5 ppm. The alarms shall actuate within the time range specified in Table 39.1 (see 39.1), but not to exceed 50 minutes.

39.3.4 The test chamber shall be purged with fresh air to remove all carbon monoxide. The carbon monoxide alarms shall be reset according to the manufacturer’s instructions, and the test described in 39.3.2 shall be repeated with the carbon monoxide concentration maintained at 400 ±10 ppm. The alarms shall actuate within the time range specified in Table 39.1 (see 39.1), but not to exceed 15 minutes.

39.3.5 The test chamber shall be purged with fresh air to remove all carbon monoxide. The carbon monoxide alarms shall be reset according to the manufacturer’s instructions. The test chamber shall be sealed. Conditions within the chamber shall be 23 ±3C, 50 ±20 percent RH. The atmosphere within the chamber shall be mixed in a manner that ensures uniformity of gas concentration, temperature and humidity. Carbon monoxide shall be injected into the chamber at a constant rate for 30 ±0.3 min. The rate of CO injection shall be determined by the operator through calculation or from previous test experience to attain a concentration increase of 16 ppm CO per minute. The CO injection rate shall not vary from the initial injection rate by more than 10 percent for the 30 ±0.3 min injection period. After injecting CO into the chamber for 30 ±0.3 min., CO gas introduction shall stop and carbon monoxide concentration in the chamber shall be monitored for a period of 3 ±0.3 min. to assure a stable CO concentration of 480 ±15 ppm. Alarms during this test shall activate after 19.0 min and before 30.0 min.

Added 39.3.5 effective August 1, 2009

39.3.6 After each exposure to 70, 150, and 400 ppm CO as outlined in 39.3.2 – 39.3.4, the signal produced by the sensing portion of the alarm shall reset or refresh to a value corresponding to the initial clean air value (less than 2 ppm CO) within 16 hours, or less as specified by the manufacturer, before proceeding with the next test. In no case shall recovery time exceed 16 hours.

39.4 Uniformity of operation

39.4.1 The alarm shall be uniform in operation so that the readings of the response time/concentration for one alarm shall be within 50 percent of the overall average of all 12 alarms tested in 39.3.2, 39.3.3, and 39.3.4. If an alarm has a variable sensitivity setting, the requirement applies to each setting tested. All alarms must respond within the limits as specified in 39.1.1.

40 Selectivity Test

40.1 The alarm shall not sound when an alarm is exposed sequentially, as described in 40.3 – 40.6, to the concentrations of gases and vapors shown in Table 40.1. These substances are intended to represent air contaminants found in the vicinity of an installed alarm.

Table 40.1
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

40.2 Calculate the interior volume of the test chamber used in 39.2.1. From this volume, calculate the amount of each test substance necessary to supply the concentrations given in Table 40.1.

40.3 Ensure that the chamber has been well ventilated with fresh air. Place the alarm in operation inside the chamber and allow it to run for 15 ±5 minutes. Close and seal the chamber to prevent air infiltration.

40.4 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.

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

40.6 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 40.1 until the alarm has been exposed to all substances. It is not required that exposure to the substances be in any particular order.

40.7 Following this test, the Sensitivity Test, Section 39, using carbon monoxide is to be performed on the alarms. The sensitivity values used are to comply with those outlined in Table 39.1, Part A – Alarm, and Table 39.1, Part B – False alarm, except the 30 day test is to be conducted for 8 hours. All alarm samples used for and tested to the requirements of the Selectivity Test, Section 40, shall comply with these requirements.

41 Sensitivity Test Feature

41.1 A sensitivity test feature shall be provided on a carbon monoxide alarm, to simulate either mechanically or electrically a specified level of carbon monoxide in the sensing chamber. The test feature shall be accessible from outside the alarm, with the alarm installed as intended. The maximum permissible measured level shall not exceed 400 ppm. The test feature when operated shall result in an audible alarm signal of at least two full cycles to allow the user of the alarm device to become familiar with the sound of the alarm.

41.2 Four samples, two at maximum and two at minimum sensitivity, are to be subjected to this test. Each sample is to be connected to a rated supply voltage, except that an alarm employing a battery as the main supply shall be tested at the test voltage level (rated or trouble level voltage) that results in the lowest sensitivity measurement.

42 Stability Tests

42.1 There shall not be false alarms of an alarm set at the maximum sensitivity setting when two representative samples are placed in the test chamber as specified in 39.2.1. Two additional samples are to be tested as described in 42.2. 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 39.2.1.

a) Place two representative carbon monoxide alarm samples in a test chamber and provide power to the alarms for 15 ±5 minutes. The test chamber is then to be sealed. Carbon monoxide is then to be introduced into the test chamber and slowly circulated in the chamber to produce a uniform concentration of 70 ±5 ppm. This level of carbon monoxide is to be established within 3 minutes after sealing the chamber and is to be maintained throughout the remainder of the test. Once the specified carbon monoxide level has been established, the alarms shall not operate for alarm before 60 minutes has expired.

b) False alarm tests are to be conducted using the procedure specified in (a) except at a carbon monoxide concentration of 30 ±3 ppm for 30 days. Under this test condition, no actuation of the alarm shall occur.

c) 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.

d) 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 64.

42.2 Four sets (five sets for testing to the requirements in 70) of two representative alarm samples shall be subjected to a series of tests as outlined in 39, 40, 42.1, 46, and 47.

a) Two alarm samples are to be tested sequentially, to the tests referenced above, in the following order: 39, 42.1(a), 42.1(c), 40, and 46.1. The sensitivity reading shall not, in any case, exceed the limits specified in Table 39.1, Part A-Alarm, and Table 39.1, Part B-False Alarm, except the 30 days test is to be conducted for 8 hours.

b) Two alarm samples are to be tested according to 42.1(a), Stability Testing, in 30 ppm CO for 30 days.

c) Two alarm samples are to be tested according to 46.2, Effect of Shipping and Storage.

d) Two alarm samples are to be tested according to 47.1, High Humidity (52°C/95 percent RH) and 47.2 Low Humidity 23°C/15 percent RH).

42.3 For recreational approval (see 70), the following substitutions are to be made:

a) 71.1(a), 66°C, replaces 46.1, 49°C;

b) 71.1(b), minus 40°C, replaces 46.1, 0°C; and

c) 71.1(c), 61°C/93 percent RH, replaces 47.1, 52°C/95 percent RH.

Two additional alarm samples can be used for testing to the requirements of 71.1(a).

42.4 For either a residential or a recreational evaluation, a CO alarm manufacturer may choose to have its samples run through any of the tests in 42.2 or 42.3 sequentially, due to shortage of test chambers and equipment.

42.5 A total of four 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 35.3.1, and subjected to the tests in 42.1 and 42.2.

43 Temperature Test

43.1 The materials or components employed in an alarm shall not be subjected to a temperature rise greater than that indicated in Table 43.1, under any condition of operation.

Exception: If failure of a component results in an audible trouble signal, the temperature rise of the component in the standby condition is not bound by the limits in Table 43.1, but in no case shall it be greater than the temperature permitted under an alarm condition.

Table 43.1
Maximum temperature rises

Device or material	Normal standby, °C	(°F)	Alarm condition, °C	(°F)
A. COMPONENTS				
1. Capacitors	25	45	40	72
2. Fuses	25	45	65	117
3.Rectifiers – At any point				
a) Germanium	25	45	50	90
b) Selenium	25	45	50	90
c) Silicon				
Maximum 60 percent or rated volts	50	90	75	135
60 percent rated volts	25	45	75	135
4. Relays and other coils with:				
a) Class 105 insulated windings				
Thermocouple method	25	45	65	117
Resistance method	35	63	75	135
b) Class 130 insulated windings				
Thermocouple method	45	81	85	153
Resistance method	55	99	95	171
5. Resistors[a]				
a) Carbon	25	45	50	90
b) Wire wound	50	90	125	225
c) Other	25	45	50	90
6. Sealing compounds	15°C (27°F) less than its melting point			
7. Solid-state devices	See note[b]			
B. INSULATED CONDUCTORS[c]				
1. Appliance wiring material	25°C (45°F) less than the temperature limit of the wire			
2. Flexible cord	35	63	35	63
C. ELECTRICAL INSULATION – GENERAL				
1. Fiber used as electrical insulation or cord bushings	25	45	65	117
2. Phenolic composition used as electric insulation or as parts where deterioration will result in a risk of fire or electric shock	25	45	125	225
3. Varnished cloth	25	45	60	108
D. GENERAL				
1. Mounting surfaces	25	45	65	117
2. Wood for other combustible material	25	45	65	117

[a] The temperature rise of a resistor other than a line voltage dropping resistor may exceed the value shown if the power dissipation is 50 percent or less of the resistor manufacturer's rating.

Table 43.1 Continued on Next Page

Table 43.1 Continued

Device or material	Normal standby,		Alarm condition,	
	°C	(°F)	°C	(°F)
[b] The temperature of a solid-state device (for example, transistor, SCR, integrated circuits), shall not exceed 50 percent of its rating during the normal standby condition. The temperature of a solid-state device shall not exceed 75 percent of its rated temperature under the alarm condition or any other condition of operation which produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) is to 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 Military Standard 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 a recalibration of the sensitivity and retested. [c] For standard insulated conductors other than those mentioned, reference should be made to the National Electrical Code, NFPA 70, or the Canadian Electrical Code, Part 1, (CSA C22.1); the maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.				

43.2 Except as noted in 43.3, all values for temperature rises apply to equipment intended for use in prevailing ambient temperatures, usually not higher than 23 ±3°C (73.4 ±5°F).

43.3 If equipment is intended specifically for use with a prevailing ambient temperature constantly more than 23 ±3°C (73.4 ±5°F), the test of the equipment is to be made at the higher ambient temperature, and allowable temperature rises specified in Table 43.1 are to be reduced by the amount of the difference between that higher ambient temperature and 23 ±3°C (73.4 ±5°F).

43.4 Temperature measurements on equipment intended for recessed mounting are to be made with the unit installed in an enclosure of nominal 3/4 inch (19.1 mm) wood having clearance of 2 inches (50.8 mm) on the top, sides and rear, and the front extended to be flush with the alarm cover.

43.5 A temperature is considered to be constant when three successive readings, taken at not less than 5 minute intervals, indicate no change.

43.6 Temperatures are to be measured by means of thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2). The preferred method of measuring the temperature of a coil is the thermocouple method, but a temperature measurement by either the thermocouple or change-in-resistance method is acceptable, except that the thermocouple method is not to be employed for a temperature measurement at any point where supplementary thermal insulation is employed.

43.7 Thermocouples consisting of 30 AWG (0.06 mm^2) iron and constantan wires and a potentiometer-type indicating instrument are to be used whenever reference temperature measurements by thermocouples are necessary.

43.8 The thermocouple wire is to conform with the requirements the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

43.9 The temperature of a copper coil winding is determined by the change-in-resistance method by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature by means of the equation:

$$T = \frac{R}{r}(234.5 + t) - 234.5$$

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.

43.10 As it is generally necessary to de-energize the winding before measuring R, the value of R at shutdown may be 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 the time is plotted and extrapolated to give the value of R at shutdown.

43.11 To determine compliance with this test, an alarm is to be connected to a source of supply in accordance with 35.3.1 and operated under the following conditions:

a) Standby – (16 hours minimum). Constant temperatures,

b) Alarm – (1 hour), and

c) Alarm – (7 hours or to battery depletion). Abnormal test.

43.12 For test condition 43.11(c), the temperature limits shall be exceeded only when there is no manifestation of a fire or approaching failure, and the alarm operates as intended following the test.

43.13 The alarm is to be subjected to the Dielectric Voltage-Withstand Test, Section 50, following tests specified in 43.11(b) and 43.11(c).

44 Overload Test

44.1 Alarm

44.1.1 An alarm other than that operating from a primary battery shall be capable of operating 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 alarm energized in the standby condition, initiation of an alarm by carbon monoxide or equivalent means, and restoration of the alarm to standby.

44.1.2 Rated test loads are to be connected to those output circuits of the alarm which are energized from the 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 35.3.1 followed by increasing the voltage to 115 percent of rating.

44.1.3 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.

44.2 Separately energized circuits

44.2.1 Separately energized circuits of an alarm 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 35.3.1, 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.

44.2.2 The test loads shall be set at 150 percent of rated current while connected to a separate power source of supply in accordance with 35.3.1.

45 Endurance Test

45.1 Alarm

45.1.1 An alarm shall operate as intended after being subjected to 6000 cycles of 5 second signal operation, at a rate of not more than 10 cycles per minute, with the alarm connected to a source of supply in accordance with 35.3.1 and with related devices or equivalent loads connected to the output circuits. There shall not be electrical or mechanical failure or evidence of failure of the alarm components. It is not prohibited that battery operated units be connected to an equivalent filtered DC power supply source for this test.

45.1.2 Sensitivity measurements, using carbon monoxide, shall be recorded before and after the Endurance Test using the CO values listed in Table 39.1, Part A – Alarm, and Table 39.1, Part B – False alarm, except the 30 day test is to be conducted for 8 hours. All alarm samples tested as part of the Endurance Test, Section 45, shall comply with these requirements.

45.2 Separately energized circuits

45.2.1 Separately energized circuits of an alarm shall operate as intended, when operated for 6000 cycles at a rate of not more than 10 cycles per minute at a 50 percent duty cycle. When an electrical load is involved, the contacts of the device shall be caused to make and break the normal current at the voltage specified by 35.3.1. The load is to represent that which the device is intended control. The Endurance Tests of the separately energized circuits may be conducted in conjunction with the Endurance Test of the alarm. There shall not be electrical or mechanical malfunction of the alarm nor malfunction or welding of any relay contacts.

Exception: If the contact rating is at least twice that of the load controlled, this test is not required.

45.3 Audible signaling appliance

45.3.1 The audible signaling appliance of each of two alarms shall operate as intended when the alarm is operated for 8 hours of alternate 5-minute periods of energization and de-energization in the standby and alarm conditions, followed by 72 hours of continuous energization in an alarm condition. For this test, the alarms are to be connected to a source of rated voltage and frequency. For a battery operated alarm, a filtered DC supply is to be employed that has an output voltage equivalent to the fresh battery voltage.

45.4 Test means

45.4.1 A sensitivity adjustment switch, test means, or reset switch provided on an alarm shall operate as intended after being operated for 1500 cycles at the rate of not more than 10 cycles per minute. The time of actuation of a test means is to be sufficient to obtain at least 1 second of alarm. For this test one alarm is to be connected to a rated source of supply voltage and frequency. This test is to be conducted either alone or in conjunction with the endurance test of the alarm (See 45.1.1 and 45.1.2).

46 Variable Ambient Temperature Test

46.1 Operation in high and low ambient

46.1.1 An alarm shall operate for its intended signaling performance when tested at ambient temperatures of 0°C and 49°C (32°F and 120°F) at a relative humidity as indicated below. Two alarms, 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 units then are to be tested for sensitivity while connected to a source of supply that is in accordance with 35.3.1.

46.1.2 Sensitivity measurements are to be recorded before and during the Variable Ambient Temperature Test, Section 46, using the CO values listed in Table 39.1, Part A – Alarm, and Table 39.1, Part B – False alarm, except the 30 day test is to be conducted for 8 hours. Sensitivity tests are to be performed at each of the two ambient conditions as follows:

49°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.

46.1.3 Both units shall operate as intended in both ambient conditions. The sensitivity readings shall not, in any case, exceed the limits specified in Table 39.1, Part A – Alarm, and Table 39.1, Part B – False alarm, except the 30 day test is to be conducted for 8 hours.

46.2 Effect of shipping and storage

46.2.1 The sensitivity of an alarm 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.

46.2.2 Two alarms, 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 50 ±30 percent RH at 50°C for 45 days, or at 55°C for 30 days, or at 60°C for 20 days as selected by the manufacturer. The alarms then are to be tested for sensitivity while connected to a source of supply in accordance with 35.3.1.

46.2.3 Sensitivity measurements shall be recorded, before and after the Effect of Shipping and Storage Test in 46.2 using the CO values listed in Table 39.1, Part A – Alarm, and Table 39.1, Part B – False alarm, except the 30 day test is to be conducted for 8 hours. All alarm samples tested as part of the Effect of Shipping and Storage Test in 46.2 shall comply with these requirements.

47 Humidity Test

47.1 High humidity (non-condensing)

47.1.1 Two alarms, 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) while energized from a source of supply in accordance with 35.3.1.

47.2 Low humidity

47.2.1 Two alarms, 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 10 ±3 percent at a temperature of 22 ±3°C (72 ±5°F) while energized from a source of supply in accordance with 35.3.1.

47.3 Sensitivity measurements

47.3.1 Sensitivity measurements are to be recorded before and during exposure to the humidity condition in accordance with the Sensitivity Test, Section 39.

47.3..2 The sensitivity values using carbon monoxide shall not exceed the limits listed in Table 39.1, Part A – Alarm, and Table 39.1, Part B – False alarm, except the 30 day test is to be conducted for 8 hours. All alarm samples tested as part of the Humidity Test, Section 47, shall comply with these requirements.

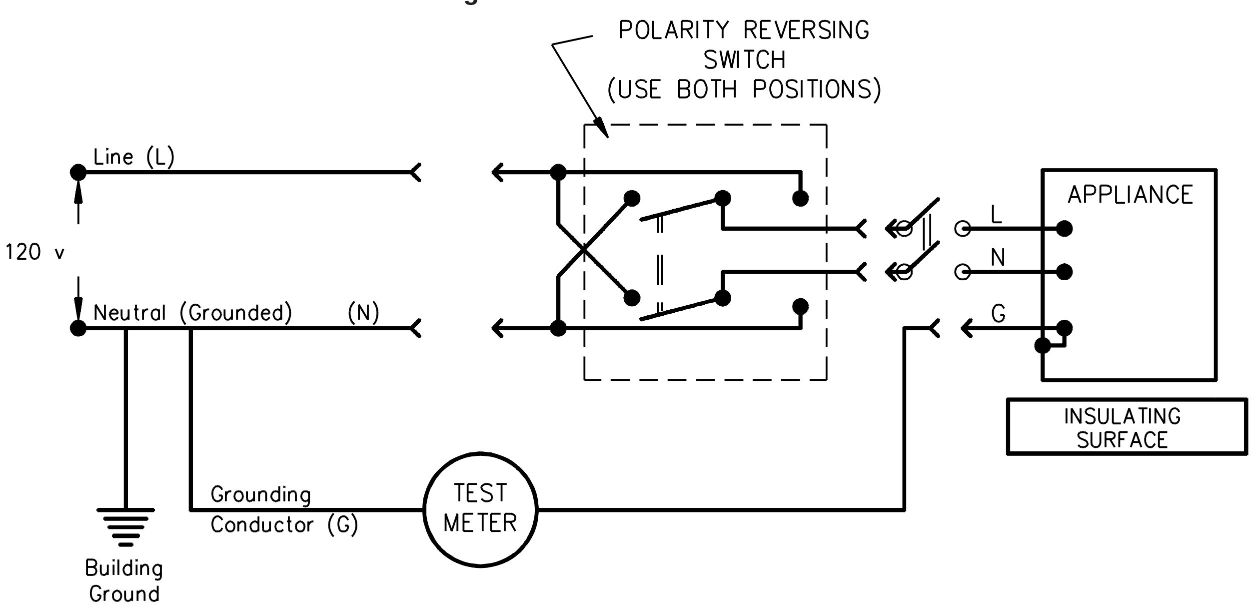
48 Leakage Current Test

48.1 Following the Humidity Test in Section 47, an alarm other than that operating from a primary battery, shall be subjected to this test, and shall not have leakage current in excess of 0.5 milliampere, AC or DC. All grounding connections to the unit being tested shall be disconnected prior to making the measurement. The leakage current measurement of a permanently installed alarm is to be made with the supply connection polarity as indicated on the installation wiring diagram supplied with the alarm. If a connection polarity is not indicated, the measurement is to be made with both polarities. See Figure 48.1. Measurement shall be made:

a) Between any exposed surface of an alarm that may be contacted by a person, and earth ground and

b) Between any interior parts of an alarm exposed to contact by a person during servicing, and earth ground.

Figure 48.1
Leakage current measurement circuit



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48.2 For this test the alarm is to be de-energized, removed from the humidity environment, placed on a dry insulating surface, and immediately reenergized from a rated source of supply. The leakage measurement then is to be made within 5 minutes of energization while in the standby and alarm conditions. The leakage current value is to be rms values for essentially DC (nonfiltered rectified AC) and sinusoidal waveforms up to 1 kilohertz. For frequencies above 1 kilohertz the leakage current limit is to be the value given multiplied by the frequency in kilohertz up to a maximum multiplier of 100.

48.3 The test meter employed to measure the leakage current is to be an average responding AC milliammeter that indicates the rms value of a pure sine wave, having an error of not greater than 5 percent, and a maximum input impedance of 1000 ohms. For AC measurements, a DC milliammeter, with a maximum impedance of 1000 ohms in the test circuit, is to be employed.

48.4 If 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 metal foil with an area of 10 by 20 centimeters (4 by 8 inches) placed in contact with the surface. Where the surface is less than 10 by 20 centimeters (4 by 8 inches), the metal foil is to be the same size as the surface. The metal foil is not to be pressed into openings and is not to remain in place long enough to affect the temperature of the sample.

48.5 If an alarm is intended for multiple station connection, leakage currents are to be measured with the maximum number of alarms intended to be interconnected, unless it is established by circuit analysis that the leakage current is independent of interconnection.

49 Transient Tests

49.1 General

49.1.1 An alarm 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 35.3.1 and connected to the device(s) intended to be used with the alarm.

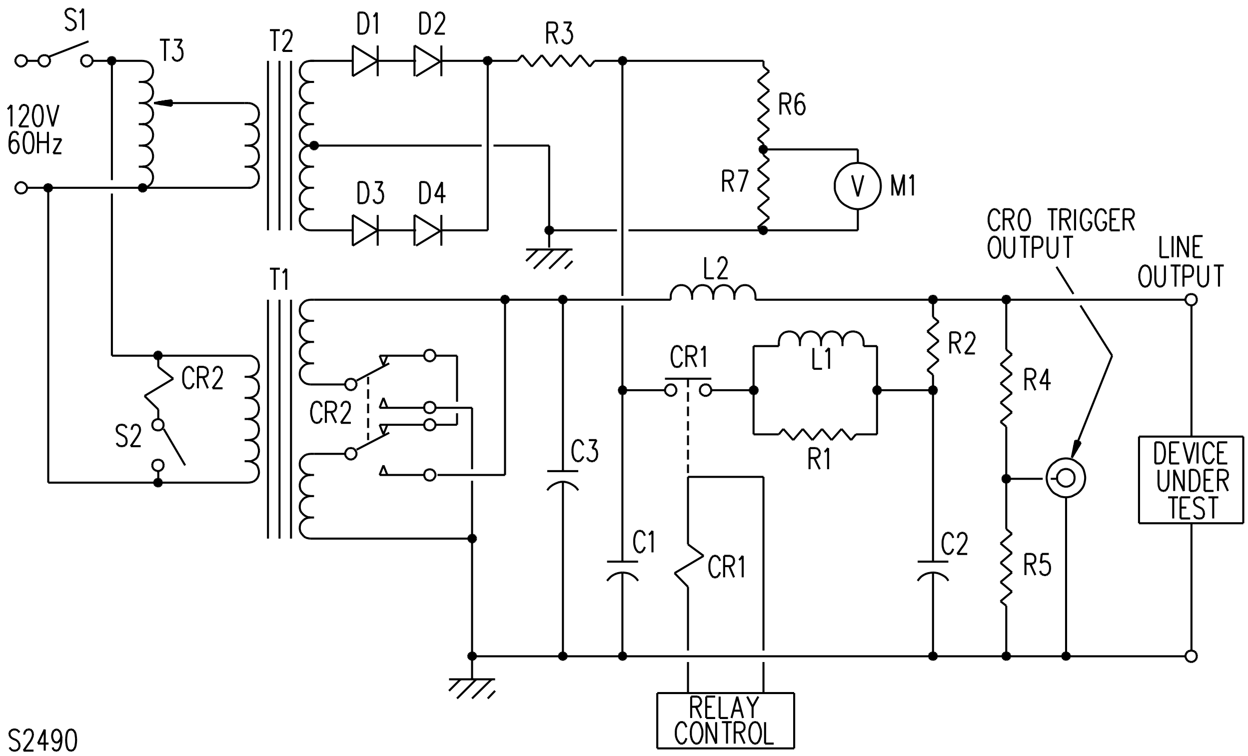
49.1.2 Different alarms are to be used for each of the four tests in 49.1.1. The alarms shall not false alarm for more than 1 second. Alarms using a primary battery as a power supply are to be subjected to the extraneous transients test only. If an alarm is intended for multiple-station connection, the transient tests are to be conducted with the maximum number of alarms intended to be connected.

49.1.3 Sensitivity measurements shall not exceed the limits specified in 39.1.1.

49.2 Supply line (hazardous-voltage) transients

49.2.1 For this test, the alarm 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 49.2.2. See Figure 49.1. The output impedance of the transient generator is to be 50 ohms.

Figure 49.1
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

49.2.2 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.

49.2.3 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.

49.3 Internally induced transients

49.3.1 The alarm is to be energized in the standby condition while connected to a source of supply in accordance with 35.3.1. 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 is operated for its intended signaling performance.

49.4 Extraneous transients

49.4.1 Single or multiple station carbon monoxide alarms shall not false alarm and their intended operation shall not be impaired when subjected to extraneous transients generated by the devices and appliances described in 49.4.2. In addition, the alarm shall respond to carbon monoxide during application of the transient condition.

49.4.2 Two single and two sets of multiple station carbon monoxide alarms 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 49.4.2(a) is to be at least 2 minutes. The conditions specified in 49.4.2(c), 49.4.2(d), and 49.4.2(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 carbon monoxide is to be introduced into the alarm chamber to determine whether the unit is operational for carbon monoxide with the transient applied. For the condition specified in 49.4.2(b), the 1-foot distance is to be measured from the transmitter-receiver (walkie-talkie or cellular phone) antenna to the surface of the carbon monoxide alarm.

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.

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

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

49.5.1 Each of two extra-low-voltage carbon monoxide alarms is 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.

49.5.2 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.

49.5.3 The alarm is to be subjected to 60 transient pulses induced at the rate of six pulses per minute as follows:

a) Twenty pulses (two at each transient voltage level specified in 49.5.1) between each circuit lead or terminal and earth ground, consisting of ten pulses of one polarity, and ten of the opposite polarity (total of 40 pulses) and

b) Twenty pulses (two at each transient voltage level specified in 49.5.1) between any two circuit leads or terminals consisting of ten pulses of one polarity and ten of the opposite polarity.

49.5.4 At the conclusion of the test, the alarm shall comply with the requirements of the Normal Operation Test, Section 36, and the Sensitivity Test, Section 39.

50 Dielectric Voltage-Withstand Test

50.1 An alarm shall withstand for 1 minute, without breakdown, the application of an essentially sinusoidal AC voltage of a frequency within the range of 40 – 70 hertz, or a DC voltage, between live parts of hazardous-voltage circuits and exposed dead (grounded) metal parts and live parts of hazardous-voltage circuits and extra-low-voltage circuits. The test voltage is to be:

a) For an alarm rated 30 volts AC rms (42.4 volts DC or AC peak) or less – 500 volts (707 volts, if a DC voltage is used).

b) For an alarm rated between 31 and 250 volts AC rms – 1000 volts (1414 volts, if a DC voltage is used).

c) For an alarm rated more than 250 volts AC rms – 1000 volts plus twice the rated voltage (1414 volts plus 2.828 times the rated AC rms voltage, if a DC voltage is used).

50.2 Any reference grounds are to be disconnected prior to the test applications.

50.3 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 maintenance of the specified AC test voltage. It is not prohibited that the capacitors and capacitor-type filters be tested using a DC voltage in accordance with 50.1.

50.4 The test voltage is to 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. Starting at zero, the applied voltage is to be increased at a rate of approximately 200 volts per minute until the required test value is reached and is to be held at that value for 1 minute.

50.5 A printed-wiring assembly or other electronic-circuit component that short circuits or is damaged by application of the test voltage, is to be removed, disconnected, or otherwise rendered inoperative before the test. It is not prohibited that a representative subassembly be tested instead of an entire unit.

51 Abnormal Operation Test

51.1 An alarm shall operate continuously under abnormal (fault) conditions without resulting in a risk of fire or electric shock.

51.2 To determine if an alarm complies with the requirement of 51.1, it is to be operated under the most severe circuit fault conditions encountered in service while connected to a source of supply in accordance with 35.3.1. There shall not be emission of flame or molten metal, or any other manifestation of a fire, or dielectric breakdown when tested in accordance with the Dielectric Voltage-Withstand Test (Section 50) after the abnormal test.

51.3 In determining if an alarm complies with the requirement with respect to circuit-fault conditions, the fault condition is to be maintained continuously until constant temperatures are attained, or until burnout occurs, if the fault does not result in the operation of an overload protective device. Shorting of the secondary of the power supply transformer and shorting of a limited-life electrolytic capacitor represent typical fault conditions. See 68.3.2.

52 Overvoltage Test

52.1 An alarm other than one operating from a main battery power supply shall operate as intended in the standby condition at both maximum and minimum sensitivity settings and while performing its intended function and connected to a supply source of 110 percent of rated value. If a nominal rated voltage value is specified, the overvoltage shall be 110 percent of the test voltage specified in 35.3.1. If an operating voltage range is specified, the overvoltage shall be either 110 percent of the high value of the voltage range or 110 percent of the test voltage specified in 35.3.1, whichever is higher. Sensitivity measurements at the increased voltage shall not exceed the limits specified in 39.1.1.

52.2 For alarms intended for connection in a multiple station configuration, the minimum number of alarms specified by the installation instructions are to be interconnected with zero line resistance between alarms and tested for their intended operation.

52.3 For operation at the higher voltage, three alarms are to be subjected to the specified increased voltage in the standby condition for at least 16 hours, or as specified by the manufacturer, and then tested for their intended signaling operation and sensitivity.

53 Undervoltage Test

53.1 An alarm shall operate for its intended signaling performance while energized from a supply of 85 percent of the test voltage specified by the manufacturer and while at both maximum and minimum sensitivity settings. For units powered from a primary battery, the test shall be conducted at the battery trouble signal voltage level. Sensitivity measurements at the reduced voltage shall not exceed the limits specified in 39.1.1.

53.2 For alarms intended for connection in a multiple station configuration, the maximum number of alarms specified by the installation instructions are to be interconnected with either 10 ohms resistance between alarms, or the maximum resistance specified in the installation instructions, and tested for intended operation.

53.3 If the alarm is provided with a standby battery the test is to be conducted at 85 percent of the charged battery voltage. If 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.

53.4 For operation at the reduced voltage, three alarms are to be energized from a source of supply in accordance with 35.3.1, following which the voltage is to be reduced to 85 percent of the test voltage specified in 35.3.1 for AC operated alarms, or the battery trouble level voltage for battery operated alarms, and then tested for signaling operation and sensitivity.

54 Dust Test

54.1 The sensitivity of an alarm shall not be affected by an accumulation of dust, without an alarm or audible trouble signal being produced.

54.2 To determine compliance with 54.1, a 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).

54.3 Approximately 2 ounces (0.06 kg) of cement dust, maintained in an ambient room temperature of 23 ±3°C (73.4 ±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 airflow is to be maintained at an air velocity of approximately 50 fpm (0.25 m/s).

54.4 Following the exposure to dust, the alarm is to be removed carefully, mounted in its intended position, energized from a source of supply in accordance with 35.3.1, and tested for sensitivity. Sensitivity measurements following this test shall not exceed the limits specified in 39.1.1.

55 Static Discharge Test

55.1 The components of an alarm 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 alarm 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).

55.2 Each of two alarms is to be mounted in its intended mounting position and connected to a source of supply in accordance with 35.3.1. If an alarm is intended to be installed on a metal junction box, the alarm is to be connected to earth ground. A 250-picofarad, low-leakage capacitor, rated 10,000 volts DC, is to be connected to two insulated leads rated for more than 30 volts, 3 feet (0.9 m) long. 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 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 at least 2 seconds for each discharge. One probe is to be touched to the alarm and the other probe is then to be touched to earth ground.

55.3 Ten discharges are to be applied to different points on the exposed surface of the alarm, recharging the capacitors for each discharge. Five discharges of positive polarity are to be made with one lead connected to earth ground and 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 that are contacted by the user.

55.4 Following the discharges, the alarm is to be tested for sensitivity. Sensitivity measurements shall not exceed the limits specified in 39.1.1.

56 Vibration Test

56.1 An alarm shall withstand vibration without breakage or damage of parts. Following the vibration, the alarm shall operate as intended.

56.2 To determine compliance with 56.1, sensitivity measurements following the vibration shall comply with 39.1.1.

56.3 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.

56.4 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.

57 Replacement Test, Head and Cover

57.1 An alarm 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.

57.2 An alarm 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 then is to be subjected to the Jarring Test, Section 58.

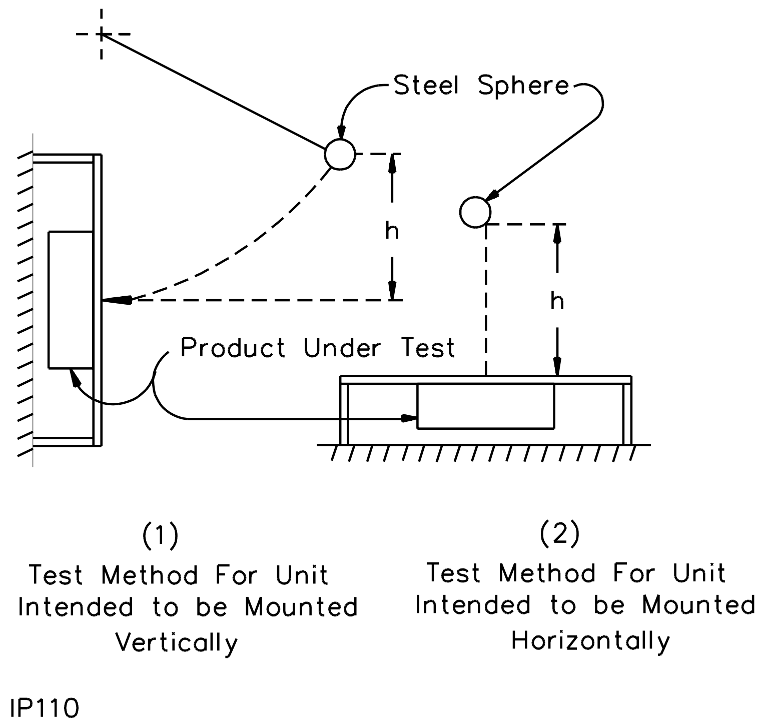
58 Jarring Test

58.1 An alarm shall withstand jarring resulting from impact and vibration such as might be experienced in service, without causing an alarm signal, without dislodgement of any parts, and without adversely affecting its operation. A momentary audible trouble signal resulting from the jarring is acceptable if the alarm operation is not affected. Dislodgement of parts shall not occur unless the dislodged part(s) does not affect the operation of the unit, there are no hazardous-voltage parts exposed, and the condition is visually obvious.

58.2 The alarm and associated equipment, if any, are to be mounted in a position of intended use to the center of a 6 by 4 foot (1.8 by 1.2 m), nominal 3/4-inch (19.1-mm) thick plywood board which is secured in place at four corners. A 3 foot-pound (4.08 J) impact is to be applied to the center of the reverse side of this board by means of a 1.18-pound (0.54-kg), 2-inch (50.8-mm) diameter steel sphere as shown in Figure 58.1 either swung through a pendulum arc from a height (h) of 2.54 feet (775 mm), or dropped from a height (h) of 2.54 feet (775 mm) to apply 3 foot-pounds (4.08 J) of energy.

58.3 During this test, the alarm is to be in the standby condition and connected to a rated source of supply in accordance with 35.3.1. Following the test, sensitivity measurements shall comply with 39.1.1.

Figure 58.1
Jarring test



59 Corrosion test

59.1 Two alarm 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.

59.2 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 10^9 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.

59.3 Following this test, the alarms shall comply with the sensitivity requirements of 39.1.1.

60 Battery Tests

60.1 If a battery is employed as the main source of power of a single station carbon monoxide alarm, 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 12 hours of alarm, followed by 7 days of trouble signal. See 38.3.1.

60.2 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 ambient 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.

60.3 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.

60.4 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.

60.5 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.

60.6 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.

60.7 At the end of the 12 months, all batteries shall have sufficient capacity to operate the alarm signal for a minimum of 12 hours followed by 7 days of trouble signal. To obtain the trouble signal level, continue the test with the standby current drain for longer than 12 months if necessary. The length of time that the batteries subjected to conditions in 60.2(b), 60.2(c), and 60.2(d) are to operate the alarm signal shall be less than 12 months only if the alarm is marked to indicate the battery limitations for the ambient condition involved. In no case shall the length of time that the batteries are subjected to the condition in 60.2(b), 60.2(c) and 60.2(d) be less than 6 months.

61 Audibility Test

61.1 General

61.1.1 Except as permitted in 61.4.1, the alarm sounding appliance, either integral with the alarm 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 61.2.1 – 61.3.2 is to be employed.

61.2 Sound output measurement

61.2.1 The sound power output of the alarm 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.

61.2.2 Each alarm 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.

61.2.3 For this test an AC powered alarm is to be energized from a source of rated voltage and frequency. A battery powered alarm is to be energized from batteries under each of the following conditions along the trouble signal level curve illustrated in Figure 37.2, 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 37.2), 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 61.2.3(a) and 61.2.3(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.

61.2.4 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 37.

61.2.5 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 53.2. For AC powered units employing a nonrechargeable standby battery, the measurement shall be made with the alarm 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.

61.3 Alarm duration test

61.3.1 An alarm sounding appliance of an alarm powered by a primary battery that has been discharged to the trouble level condition shall provide 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.

61.3.2 To determine compliance with 61.3.1, 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 alarm is to be mounted 1 foot (302 mm) from the microphone placed in a direct line with the alarm. The alarm 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.

61.4 Supplementary remote sounding appliances

61.4.1 The sound output of a supplementary remote sounding appliance, shall not be less than 85 dbA.

62 Tests of Thermoplastic Materials

62.1 General

62.1.1 Thermoplastic materials intended for the sole support of current-carrying parts or as an enclosure of an alarm shall be subjected to the following tests. If possible, a complete alarm shall be used.

62.2 Accelerated air-oven aging test

62.2.1 There shall not be excessive warping or exposure of uninsulated hazardous-voltage circuit parts so as to impair operation or provide access to uninsulated 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.

62.2.2 At least three representative samples are to be mounted on supports as intended in service and placed in the oven. At the end of the aging period indicated in 62.2.1, the samples are to be removed, permitted to cool, and then examined for adverse distortion. It is not prohibited that the alarm cover fall off during the test if no hazardous-voltage circuit parts are exposed and the cover is replaceable as intended.

[a]A suitable meter for the purpose is a General Radio, Type 1551, sound level meter (Type II).

62.3 Flame test (3/4 inch)

62.3.1 When equipment is tested as described in 62.3.2 – 62.3.6, 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.

Exception: Parts that are molded from materials that are classed as 5VA, 5VB, V-0, 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 flammability test described in 62.3.2 – 62.3.6.

62.3.2 Three samples of the equipment are to be placed in a forced draft circulating air oven maintained at a uniform temperature not less than 10°C (18°F) higher than the maximum temperature of the material measured under normal operating conditions, and not 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 in 62.3.3 – 62.3.6.

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.

62.3.3 Three samples of the part are to be subjected to the flame test described in 62.3.5. In the performance of the test, the equipment is to be supported in its normal operating position in a draft free location. Nonpolymeric portions are not to be removed and insofar as 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.

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.

62.3.4 With reference to 62.3.3, the sections judged capable of becoming ignited are to be those adjacent to coil windings, splices, open-type switches, or arcing parts.

62.3.5 The flame of a Bunsen or Tirrill burner having a tube with a length of 100 ±10 mm (3.94 ±0.39 inches) and an inside diameter of 9.5 ±0.3 mm (0.374 ±0.12 inch) is to be adjusted to have a 3/4 inch (19 mm) height of yellow flame with no blue cone. Two 30-second applications of the tip of the flame are to be made to each section of the equipment specified as indicated above, with 1 minute intervals between the applications. A supply of technical-grade methane gas is to be used with a regulator and meter for uniform gas flow.

Exception: Natural gas having a heat content of 1000 Btu/ft^3 (37 MJ/m^3 at 23°C) has been found to provide similar results and is appropriate for use.

62.3.6 When one sample from a set of three does not comply with 62.3.1, an additional set of three samples shall be tested. All samples from the second set shall comply with 62.3.1.

62.4 Flame test (5 inch)

62.4.1 When equipment is tested as described in 62.4.1 – 62.4.5, 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 12 inches (305 mm) 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.

Exception: Parts that are molded from materials that are classed as 5VA by the five inch 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 flammability tests described in 62.4.1 – 62.4.6.

62.4.2 Three samples of the complete equipment or three test specimens of the molded part shall 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) greater than 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 ±2.0°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.

62.4.3 The three samples shall perform as described in 62.4.1. 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 the new specimens shall comply with 62.4.1.

62.4.4 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 5 inches (127 mm), the height of the inner blue cone is 1-1/2 inches (38 mm). The tube is not to be equipped with end attachments, such as stabilizers.

62.4.5 When a complete enclosure is used to conduct the flame test, the sample is to be mounted as intended in service, as long as it does not impair the flame testing, in a draft-free test chamber, enclosure, or laboratory hood. A layer of surgical cotton is to be located 12 inches (305 mm) below the point of application of the test flame. The 5-inch (127-mm) 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: 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. 2: Natural gas having a heat content of 1000 Btu/ft^3 (37 MJ/m^3 at 23°C) has been found to provide similar results and is appropriate for use.

62.4.6 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.

62.5 Impact test

62.5.1 An alarm employing a nonmetallic enclosure shall withstand one 5 foot-pound (6.8 N·m) impact without exposure of live parts, impairment of operation, or creation of a risk of electric shock.

62.5.2 The alarm is to be mounted securely in a position of intended use on a surface representative of a typical installation. A 1.18-pound (535-g), 2-inch (50.8-mm) diameter steel sphere is to be dropped from a height of 51 inches (1300 mm) or swung through a pendulum arc from a sufficient height to apply 5 foot-pounds (6.8 N·m) of energy to the weakest section of the enclosure.

62.5.3 Following the impact, the alarm is to be examined and energized from a source of rated voltage and frequency and checked for normal operation. Cracking of the enclosure is acceptable if it does not impair the operation of the alarm. Sensitivity measurements recorded after the impact test shall comply with the Sensitivity Test, Section 39.

63 Paint Loading Test

63.1 Unless marked in accordance with 83.1(j), an alarm shall operate as intended and shall comply with the requirements of the Sensitivity Test, Section 39, after painting, if the alarm assembly, screens, openings, or similar items are capable of becoming clogged or covered by painting.

63.2 The exterior surface of two samples, including screened openings, or the like are to be coated with a latex based paint which is spread at approximately two times the paint manufacturer's recommended spreading rate. The paint is to be allowed to dry for 5 days at room temperature. Following this, the samples are to be given a second identical application of paint and again permitted to dry for 5 days. The alarms are to be tested for sensitivity before and after the specified paint loading. Sensitivity measurements following this test shall not exceed the limits specified in 39.1.1.

64 Battery Replacement Test

64.1 The battery clips and holders of a battery operated single station carbon monoxide alarm 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 device shall not sound for more than 1 second. The test shall not have an adverse effect on the operation of the alarm.

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

65 Polarity Reversal Test

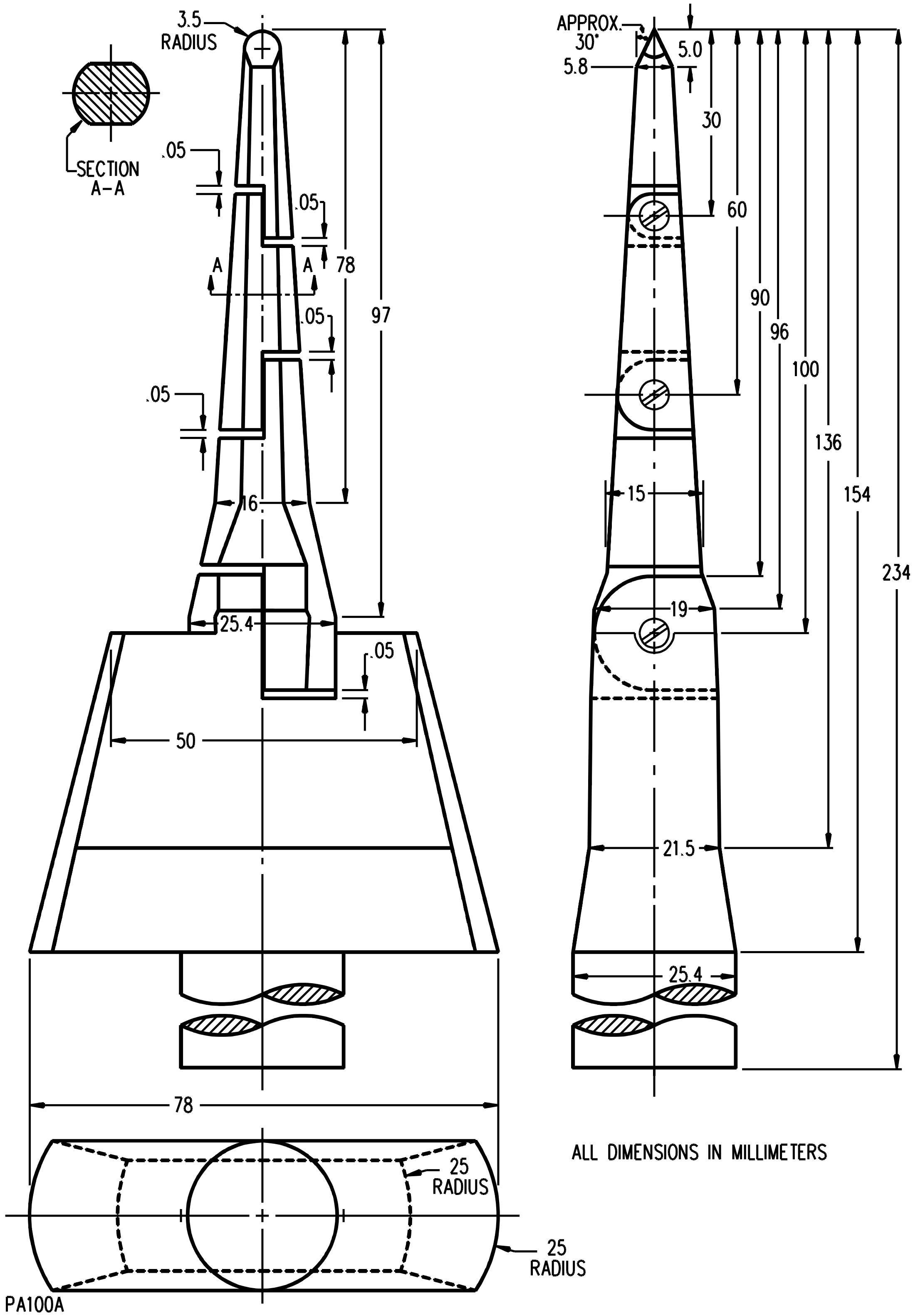
65.1 A carbon monoxide alarm shall operate as intended after being connected in each polarity. While energized under either polarity, the alarm shall comply with the requirements of the Electric Shock Current Test, Section 66. This includes cord connected and fixed wiring (splice lead) types, battery types (main or standby) and multiple station interconnection leads. Each polarity is to be applied for at least 24 hours on all units unless a trouble signal or alarm signal is obtained. For battery operated alarms intended to be connected by a polarized clip assembly, the reverse polarity is to be applied for a minimum of 1 second. A trouble or alarm signal is to be not prohibited under any incorrect polarity applied. A maximum 1-second alarm is not prohibited when the correct polarity is connected.

65.2 Two samples are to be subjected to this test. Sensitivity measurements shall comply with 39.1.1.

66 Electric Shock Current Test

66.1 If the open circuit potential between any part that may be contacted by the probe shown in Figure 66.1 either during normal operation or during operator servicing (servicing as defined in the operating or installation instruction) and either earth ground or any other exposed accessible part, exceeds 42.4 volts peak, the part shall comply with the requirements of 66.2 and 66.4.

Figure 66.1
Articulated probe



66.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 66.1 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 66.1
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 nonsinusoidal or sinusoidal waveforms.

66.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 66.2 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 66.2.

Table 66.2
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
10.0	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

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

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

or

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

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 or similar method.

Typical calculated values of maximum capacitance are shown in Table 66.3.

Table 66.3
Electric shock – stored energy

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

Table 66.3 Continued on Next Page

Table 66.3 Continued

Potential across capacitance prior to discharge, volts	Maximum capacitance, microfarads
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.00
45	150.00
42.4	169.00

66.5 With reference to the requirements in 66.2 and 66.3, 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.

66.6 With reference to the requirements in 66.5, 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. 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.

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

66.8 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.

66.9 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.

67 Strain Relief Test

67.1 General

67.1.1 A cord or lead that depends upon a thermoplastic part for strain relief is to be subjected to the applicable tests specified in 67.2.1 – 67.4.1 following exposure to either temperature conditioning test described in 46.1.2.

67.2 Power-supply cord

67.2.1 When tested in accordance with 67.1.1, the strain relief means provided on the flexible cord shall withstand for 1 minute, without displacement, a pull of 35 pounds-force (156 N) applied to the cord with the connections within the alarm disconnected.

67.2.2 A 35 pound-mass (15.9 kg) weight is to be suspended on the cord and supported by the alarm so that the strain relief means is stressed from any angle that the construction of the alarm permits. The strain relief shall not, at the point of disconnection of the conductors, show such movement of the cord as to indicate that stress resulted on the connections.

67.3 Field-wiring leads

67.3.1 Each lead employed for field connections, including a battery clip lead assembly, shall withstand for 1 minute a pull of 10 pounds-force (44.5 N) without any evidence of damage or of transmittal of stress to internal connections.

67.4 Special connector

67.4.1 A connector used in the lead assembly of a Class 2 or Class 3 circuit shall withstand a pull of 5 pounds force (22.2 N) without any evidence of damage, transmittal of stress to internal connections, or separation.

68 Power Supply Tests

68.1 General

68.1.1 If 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 68.2.2 – 68.3.2.

68.2 Volt-amperes capacity

68.2.1 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.

68.2.2 To determine compliance with the requirements of 68.2.1, 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 nor 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. If an overcurrent protective device is provided, it shall be shunted out during the test, if necessary.

68.3 Burnout test

68.3.1 There shall not be damage to the enclosure, charring or burning of the cheesecloth, nor emission of flame or molten metal when a power supply is operated under the conditions described in 68.3.2. While still in a heated condition following this test, the power supply shall comply with the requirements of the Leakage Current Test, Section 48, and the Dielectric Voltage-Withstand Test, Section 50.

68.3.2 With the output shorted the supply circuit of the power supply is to be connected to a rated source of voltage and frequency, with the enclosure grounded, and operated for at least 7 hours or until burnout occurs. A single layer of mercerized cotton cheesecloth is to be loosely draped over the device during the test. If accessible fuses are provided on the power supply, they are to be shunted out, but inaccessible fuses are to remain in the circuit.

69 Drop Test

69.1 This test is to be conducted only on portable alarms intended for transient use, such as a travel alarm, and is not to be conducted on alarms intended for stationary installation.

69.2 An alarm 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 or affecting its intended operation and sensitivity. The sample is to be held so that each impact with the floor is at a different location on the alarm. Parts shall not become dislodged unless the dislodged part does not affect operation or sensitivity of the unit, the dislodged part is replaceable (such as a cover), there are no hazardous-voltage parts exposed, and the condition is visually obvious.

69.3 Each of two alarms is to be raised to a height of 7 feet (2.1 m) and permitted to drop five times onto a concrete floor covered with a 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 39.1.1.

CARBON MONOXIDE ALARMS FOR USE IN RECREATIONAL VEHICLES AND UNCONDITIONED AREAS

70 General

70.1 A carbon monoxide alarm intended for use in recreational vehicles and unconditioned areas such as garages, attics, and the like shall comply with the requirements specified in Sections 71 – 74, in addition to the requirements specified in Sections 1 – 69 and 76 – 84, inclusive.

70.2 Marking

Added 70.2 effective February 20, 2015

70.2.1 In addition to the applicable requirements in Section 83, a carbon monoxide alarm for use in a Recreational Vehicle or Unconditioned Area shall be permanently and legibly marked with the following information. The markings shall be in a contrasting color, finish, or equivalent, in letters at least 3/64 inch (1.2 mm) high. Items (f) and (g) shall be readily visible after installation:

a) Manufacturer’s or private labeler’s name or identifying symbol;

b) Model, type, or catalog designation;

c) Date of manufacture (in code is not prohibited);

d) Electrical rating in volts and amperes;

e) Reference to owner's manual;

f) The type of product, such as ″Recreational Vehicle Carbon Monoxide Alarm″, or "Unconditioned Area CO Alarm" or equivalent. It is not prohibited that this marking be incorporated in (g); and

g) Identification of switches and light indicators.

Added 70.2.1 effective February 20, 2015

71 Variable Ambient Temperature and Humidity Test

71.1 There shall not be false alarms or adverse change in performance when two units, one at maximum and one at minimum sensitivity, are subjected to each of the following conditions:

a) Thirty days in air at 66 ±3°C (150 ±6°F),

b) At least 72 hours at minus 40 ±2°C (minus 40 ±4°F), and

c) Ten days in 93 ±2 percent humidity at 61 ±2°C (142 ±4°F).

71.2 Sensitivity measurements immediately after conditioning as described in 71.1 shall comply with 39.1.1. During the sensitivity measurement, the environmental chamber is to be within the limits specified in 71.1.

71.3 During each test condition, the alarm is to be connected to a source of rated voltage. Battery operated alarms and Self Contained Units shall be powered by a battery installed in the alarm that meets or exceeds 71.4 during each test condition. The tests in 71.1 shall be conducted sequentially on the same two samples, and using the same battery samples for all three environments. The tests shall be conducted using each battery model specified in the marking or the installation instructions.

Revised 71.3 effective February 20, 2015

71.4 All batteries included with Carbon Monoxide alarms intended for use in recreational vehicles or Unconditioned Areas shall at a minimum have a published operational specification range of minus 20 – 60 °C (minus 4 – 140 °F). Recommended replacement batteries must also meet the temperature range.

Added 71.4 effective February 20, 2015

72 Corrosion (Salt Spray) Test

72.1 An alarm 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.

72.2 Two alarms, 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 Test, Section 39.

72.3 Sensitivity measurements following the exposure shall comply with the Sensitivity Test, Section 39, using carbon monoxide.

73 Vibration Test

73.1 After vibration in accordance with 73.2, an alarm shall not false alarm or be adversely damaged. Sensitivity measurements shall comply with the Sensitivity Test, Section 39.

73.2 Two alarms, one at maximum and one at minimum sensitivity, are to be subjected to vibration for 120 hours in accordance with the Vibration Test, Section 56. Sensitivity measurements are to be recorded before and after the test.

74 Contamination Test (Cooking By-Products)

74.1 After exposure in accordance with 74.2 – 74.5, an alarm shall not false alarm or otherwise be adversely affected. Sensitivity measurements following the exposure shall comply with the Sensitivity Test, Section 39.

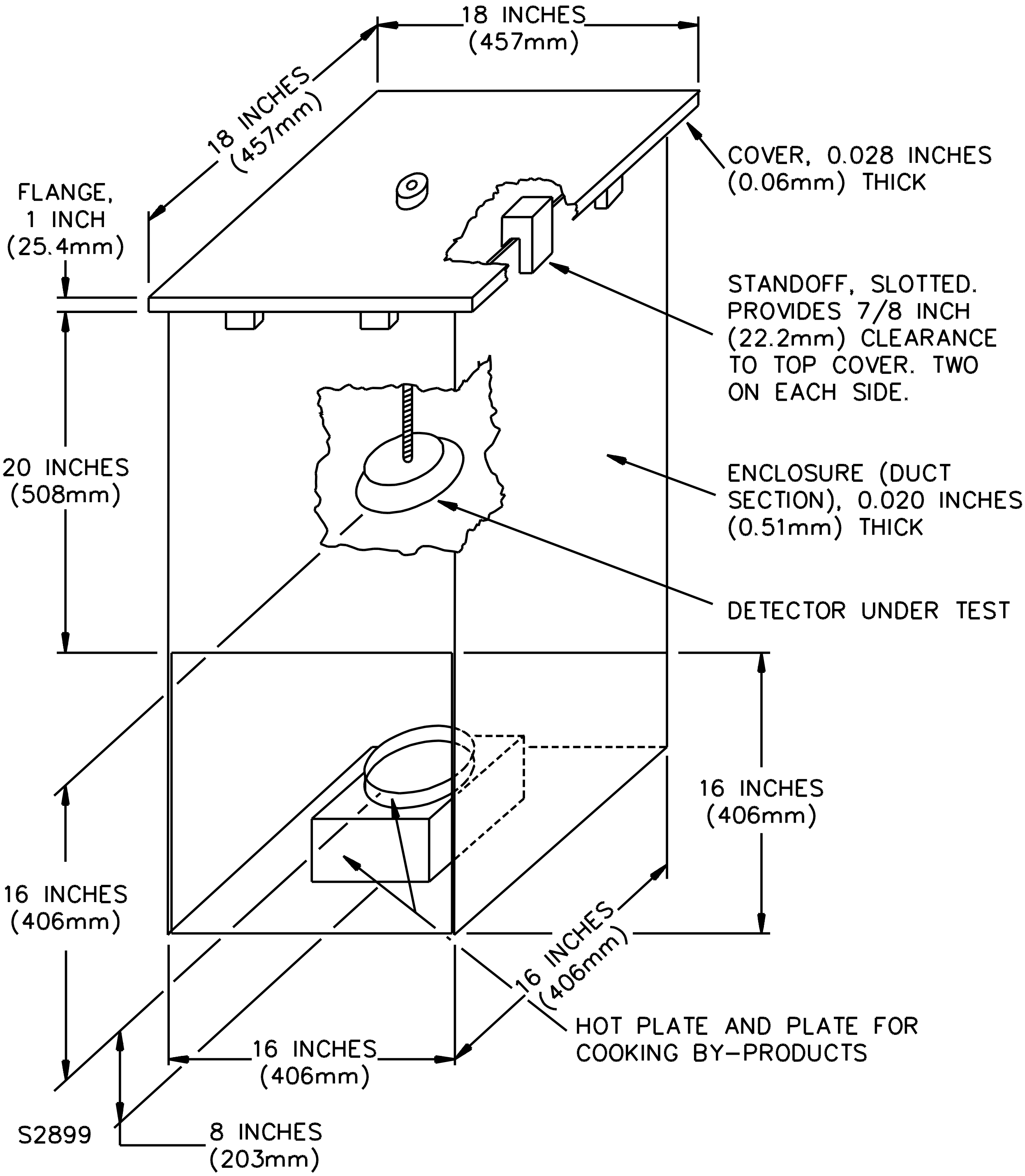
74.2 Two samples are to be subjected to the vaporization of a mixture of 50 grams of animal fat (lard), 50 grams of vegetable fat[a], and 100 grams of beef gravy[b]. The mixture is to be placed in an 8-inch (203-mm) diameter aluminum plate that is heated on an 8-1/2-inch (216-mm) diameter hotplate located on the bottom center of a galvanized sheet metal enclosure.

[a] Crisco or the equivalent is acceptable.

[b]Franco-American or the equivalent is acceptable.

74.3 The enclosure is to measure approximately 3 feet (914 mm) high, 16 inches (406 mm) square and have an open top and a 16 inch square opening at the bottom of one side. A sheet metal cover, approximately 18 inches (457 mm) square, with 1 inch (25 mm) flanges, is to be supported at the enclosure top by 7/8 inch (20 mm) high standoffs. See Figure 74.1.

Figure 74.1
Contamination test (cooking by-products)



74.4 The alarm under test is to be supported on the end of a threaded 1/4 inch (6.4 mm) steel rod positioned so that the exposed face of the alarm is approximately 12 inches (304 mm) below the enclosure cover and 16 inches (406 mm) above the aluminum plate. The alarm is not to be energized during the test.

74.5 Each sample is to be subjected to five complete vaporization exposures. Following the fifth exposure, each sample is to be removed, permitted to cool for at least 3 hours, and then tested for sensitivity as specified in the Sensitivity Test, Section 39.

75 Carbon Monoxide Alarms for Use on Recreational Boats

75.1 General

75.1.1 These requirements apply to the construction and performance characteristics of battery-operated (nominal 12, 24, and 32 volts DC) single and multistation carbon monoxide gas alarm systems, fully integrated systems, and self contained units (internal batteries).

75.1.2 These carbon monoxide gas alarms are intended to be installed inside or immediately outside enclosed accommodation spaces in a boat or in areas people inhabit and where carbon monoxide tends to accumulate. These devices shall be wired in accordance with the Standard for the National Fire Protection Association for Motor-Craft (Pleasure and Commercial), NFPA 302, and the applicable regulations of the United States Coast Guard,33 CFR, Part 183, and shall comply with the appropriate installation standards of the American Boat and Yacht Council, Inc., including Carbon Monoxide Gas Detection Systems on Boats, A-24.

75.1.3 These alarms shall be constructed to be watertight or drip-proof. See 75.3 and 75.4.

75.1.4 A metallic part, including mounting brackets, shall be resistant to corrosion. Metal shall be used in combinations that are galvanically compatible. See Corrosion (Salt-Spray) Test, Section 72.

75.1.5 These alarms shall comply with the requirements specified in Section 1 – 69 and 76 – 84 inclusive. The same three sample alarms are to be used for the tests indicated in Table 75.1. The tests are to be conducted in the order specified.

75.1.6 An alarm that requires a warm-up period to attain intended operation shall not indicate a satisfactory operating condition during the required warm-up period.

Table 75.1
Samples for performance tests

Number of samples[a]	Test
3	Sensitivity test, Section 39
3	Operation tests following conditioning, Section 75.2
1	Watertightness test, Section 75.3
1	Drip test, Section 75.4
3	Abnormal operation tests, Section 75.5
1	Salt-spray corrosion test, Section 75.6
3	Overvoltage and undervoltage tests, Sections 52 and 53
3	Endurance test, Section 45
3	Audibility test, Section 61

[a] The same 3 samples are to be used for each test. When only 1 sample is required it shall be any one of the previously tested samples.

75.1.7 During each test condition, the alarm is to be connected to a source of rated voltage. Battery operated alarms and Self Contained Units shall be powered by a battery installed in the alarm that meets or exceeds 75.1.8 during each test condition. The same battery samples shall be used for all of the test conditions. The tests shall be conducted using each battery model specified in the markings or the installation instructions.

Added 75.1.7 effective February 20, 2015

75.1.8 All batteries included with Carbon Monoxide alarms intended for use in recreational boats shall at a minimum have a published operational specification range of minus 20 – 60 °C (minus 4 – 140 °F). Recommended replacement batteries must also meet the temperature range.

Added 75.1.8 effective February 20, 2015

75.2 Operation tests following conditioning

75.2.1 Immediately following each of the conditions specified in 75.2.3 – 75.2.15, an alarm shall operate in accordance with the levels specified in Table 39.1. When specified by the manufacturer, it is not prohibited that the alarms be warmed-up prior to the calibration check, in accordance with 75.1.6. During the warm up period and sensitivity measurements, the environmental chamber is to be within the limits specified in 75.2.3 and 75.2.4.

Revised 75.2.1 effective August 1, 2009

75.2.2 The same samples, including remote sensors, are to be used for each of the conditions in this section. The samples are to be energized (except for humidity) during each exposure.

75.2.3 Three sample alarms are to be placed in an air-circulating oven maintained at 70 ±2°C (158 ±4°F) for 24 hours.

75.2.4 Immediately following the conditioning specified in 75.2.3 and the calibration check specified in 75.2.1, the same alarms are to be placed in a cold chamber maintained at minus 30 ±2°C (minus 22 ±4°F) for 24 hours.

75.2.5 The same three alarms used for the temperature conditioning are to be used for the vibration conditioning specified in 75.2.6 and 75.2.7.

75.2.6 The alarms, including all components, are to be mounted on a vibration table so as to simulate as closely as possible an actual installation on a boat in accordance with the manufacturer's installation instructions. The means used for such mounting shall be rigid enough to reduce resonant frequencies of the mounting means. The vibration table is to produce the vibration frequencies and amplitude specified in 75.2.7.

75.2.7 The alarms are to be subjected to a variable frequency vibration along each of three rectilinear orientation axes (horizontal, lateral, and vertical) for 4 hours in each plane (12 hours total) at a peak-to-peak amplitude of 0.015 ±0.001 inches (0.40 ±0.05 mm). The frequency of vibration is to be continuously varied, at a uniform rate, from 10 to 60 to 10 hertz every 4 minutes.

75.2.8 For this test, peak-to-peak amplitude is defined as the maximum displacement of sinusoidal motion (total machine displacement).

75.2.9 The same three alarms used for the vibration conditioning are to be used for the conditioning specified in 75.2.10 – 75.2.13.

75.2.10 The alarms are to be mounted on a shock machine in the same manner as described in the vibration conditioning specified in 75.2.6 and 75.2.7. The shock machine is to produce repeated shock pulses as specified in 75.2.11.

75.2.11 The samples are to be subjected to 5000 shock impacts of 10 g acceleration (98 m/s2) and having a shock duration of 20 – 25 milliseconds as measured at the base of the half-sine shock envelope.

75.2.12 The machine used for this conditioning is to be of the automatic cycling type capable of producing a half-sine shock pulse at the acceleration level and duration specified. The acceleration and shock pulse duration is to be measured by a piezoelectric accelerometer mounted on the test machine platform on an axis parallel to the axis of motion.

75.2.13 The test samples are to be mounted so that the center of gravity of the sample is as close as possible to the geometric center of the machine platform.

75.2.14 The same three alarms used for the shock conditioning are to be used for this conditioning. The alarms are to be subjected to air at a relative humidity of 90 ±5 percent and a temperature of 40 ±2°C (104 ±4°F) for 96 hours. The alarms are not to be energized during this conditioning.

75.2.15 Immediately following the conditioning specified in 75.2.14, the alarms are to be subjected to air at a relative humidity of 30 ±5 percent and a temperature of 23 ±3°C (73 ±5°F) for 96 hours. The alarms are not to be energized during this conditioning.

75.3 Watertightness test

75.3.1 A alarm marked ″Watertight″ is to be tested as specified in 75.3.2. There shall be no evidence of water leakage so as to reach energized parts. No false alarms shall be generated and the alarm shall operate as intended.

75.3.2 One sample detector from the humidity conditioning is to be used for this test. The assembly is to be mounted in accordance with the manufacturer's installation instructions and energized. A solid stream of water from a nozzle not less than 1-inch (25.4 mm) in diameter and a flow rate of 65 gallons per minute (3 psig), measured at the nozzle, is to be directed at the enclosure in all directions from a distance of 10 feet (3.1 m) for 5 minutes.

75.3.3 Any water on the exterior of the enclosure is to be removed with a cloth and the enclosure then opened and examined for any evidence of leakage.

75.3.4 An alarm that complies with this test shall be marked in accordance with 75.7.4. See also 75.7.5.

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75.4 Drip test

75.4.1 An alarm not marked "Watertight" is to be tested as specified in 75.4.2 and 75.4.3. No false alarms shall be generated and the alarm shall operate as intended.

Exception: An alarm determined to be watertight complies with this test and does not require testing. See Section 75.3.

75.4.2 One sample alarm from the humidity conditioning, 75.2.14 and 75.2.15, is to be used for this test. The alarm is to be energized and mounted in accordance with the manufacturer's installation instructions beneath a drip pan that produces both splashing and dripping and that extends beyond all exposed sides of the enclosure. The bottom of the drip pan is to be equipped with uniformly distributed spouts; one spout for each 20 square inches (129 cm^2) of pan area. Each spout is to drip water at a rate of 20 drops per minute. The enclosure is to be subjected to continuously dripping water for 30 minutes.

75.4.3 The alarm is to be oriented from 0 – 15 degrees from the vertical during the test.

75.4.4 An alarm that complies with this test shall be marked in accordance with 75.7.5.

75.5 Abnormal operation tests

75.5.1 After each of the conditions described in 75.5.3, 75.5.5, and 75.5.6, three sample alarms shall activate the alarm in the time specified in 75.5.4, 75.5.5, and 75.5.7, respectively.

75.5.2 The same three alarms used in the Operation Tests Following Conditioning, Section 75.2 are to be used for the tests in 75.5.3 – 75.5.8.

75.5.3 The alarms are to be energized and placed in a controlled chamber maintained at 23 ±3°C (73 ±5°F). The chamber is to be filled with a carbon monoxide concentration of 5,000 ±125 ppm.

75.5.4 As soon as or before the carbon monoxide concentration in the chamber reaches 5,000 ± 125 ppm, each detector shall activate the alarm (for presence of carbon monoxide) in 3 minutes or less.

75.5.5 Immediately following the test in 75.5.4 and while still in the chamber, each detector is to be turned off for 4 hours and subjected to 5,000 ±125 ppm. Following this exposure, each detector is to be energized and shall activate either the presence of carbon monoxide alarm or the malfunction alarm in 3 minutes or less.

75.5.6 While the alarms are still energized and in the chamber following the test in 75.5.5, the chamber is to be completely purged with fresh air and maintained at 23 ±3°C (73 ±5°F). The alarms shall return to their normal operating mode within 4 hours. As soon as the alarms have returned to their normal operating mode the chamber is to be filled with 150 ppm of carbon monoxide as specified in Table 39.1 part A.

75.5.7 The sensitivity reading of the alarm samples shall not, in any case, exceed the 50 minutes as specified in Table 39.1 part A.

75.5.8 Immediately following the test in 75.5.7 and while still in the chamber, each alarm is to be turned off for 4 hours and subjected to 185 ppm. Following this exposure, each alarm is to be energized and shall activate either the presence of carbon monoxide alarm or the malfunction alarm in 100 minutes or less.

75.6 Salt-spray corrosion test

75.6.1 One sample alarm from the Abnormal Operation Tests, Section 75.5, shall operate as intended and its mounting means shall show no signs of structural deformation 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. To determine compliance with this test, an alarm is to be subjected to the Sensitivity Test, Section 39.

75.6.2 An alarm is to be mounted in accordance with the manufacturer's installation instructions and subjected to the salt spray while in a de-energized condition. Following the exposure, the samples are to be removed and air dried for 48 hours at 23 ±3°C (73 ±5°F) in a de-energized condition.

75.7 Marking

75.7.1 In addition to the applicable requirements in Section 83, a carbon monoxide alarm for use in a Recreational Boat shall be permanently and legibly marked with the following information. The markings shall be in a contrasting color, finish, or equivalent, in letters at least 3/64 inch (1.2 mm) high. Items (f) and (g) shall be readily visible after installation:

a) Manufacturer's or private labeler's name or identifying symbol;

b) Model, type, or catalog designation;

c) Date of manufacture (in code is not prohibited);

d) Electrical rating in volts and amperes;

e) Reference to owner's manual;

f) The type of product, such as ″Marine Carbon Monoxide Alarm,″ or the equivalent. It is not prohibited that this marking be incorporated in (g); and

g) Identification of switches and light indicators.

Item f) effective August 1, 2009

75.7.2 When a manufacturer uses one light to indicate more than one condition, a key to interpret the signals shall be provided on the face of the alarm.

75.7.3 When a manufacturer produces an alarm at more than one factory, each such assembly shall have a distinctive marking to identify it as the product of a particular factory.

75.7.4 An alarm that complies with the requirements in the Watertightness test, Section 75.3, shall be marked ″Watertight.″

75.7.5 An alarm not marked in accordance with 75.7.4 shall be marked ″For enclosed spaces only,″ or the equivalent.

75.8 Operating and installation instructions

75.8.1 Each alarm shall be provided with installation and operating instructions that include the following information:

a) Typical installation drawing layouts for the detector(s) indicating appropriate locations and wiring methods. Locations where alarm installations are not appropriate shall also be included;

b) Description of the operation, testing, and proper maintenance procedures for the alarm(s) including the warm-up period (including time), when applicable;

c) Replacements parts, such as lamps or batteries, shall be identified in the instructions by a part number, manufacturer's model number, or the equivalent, and information on where to obtain the part;

d) Description of the various conditions in which the alarm becomes ineffective or contaminated. Test the alarm when a possibility of one of these conditions has existed;

e) In addition to the conditions described in (d), and to reduce the risk of nuisance tripping of the alarm circuit, the instructions shall state that accommodation spaces are to be well ventilated when household cleaning supplies or similar contaminates are used;

f) Information regarding the alarm and an indication where false alarms are to be anticipated;

g) Identification of the owner's manual or instruction sheet by number or equivalent;

h) An indication that the device shall not be installed in locations where temperature, moisture, and/or ultraviolet light affect the operation, unless the alarm is intended and tested for installation in these areas;

i) The name and address of the company to whom the alarm is to be sent for servicing;

j) The word ″WARNING″, and the following or equivalent text: ″TO REDUCE THE RISK OF CARBON MONOXIDE POISONING, TEST ALARM OPERATION WHEN NOT IN USE FOR 10 DAYS OR MORE;″

k) The word ″CAUTION″ and the following or equivalent: ″The alarm only indicates the presence of carbon monoxide gas at the sensor. Carbon monoxide gas may be present in other areas;″

l) The instructions shall also state that individuals with medical problems consider using detection devices with lower COHb alarming capabilities; and

m) A statement shall be provided to specify that the alarm, including a sensor, is not to be located within 5 feet (1.5 m) of any cooking appliance.

75.8.2 The instructions shall be incorporated on the outside of the alarm, on a separate sheet, or as part of a manual. When not included directly on the alarm, the instructions or manual shall be referenced in the marking information on the alarm.

75.8.3 The material shipped with the alarm, including the package, instructions, or user's manual, shall not include information contrary to that specified in 75.7.1, such as manufacturer's claims on the operation of the alarm which have not been substantiated by the performance tests included in this standard.

MANUFACTURING AND PRODUCTION TESTS

76 General

76.1 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 77 – 81 conducted on 100 percent of the production. See the Manufacturing and Production Tests, Supplement SB.

77 Sensitivity Calibration Tests

77.1 The sensitivity of each alarm 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 ppm carbon monoxide and time.

77.2 For the warm-up period, the alarms are to be energized from a source of supply in accordance with 35.3.1. If the alarm sensitivity is not within the manufacturer's specifications, the unit is to be corrected and retested. If a retested sample is still outside the specification, it is to be rejected.

77.3 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.

77.4 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.

78 Measurement of In-Service Reliability

78.1 Required in-service reliability

78.1.1 Reliability for Supervised Failures: CO detectors 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' specified lifetime. At this failure rate the cumulative Supervised Failures over the devices' specified lifetime shall not exceed 23 percent at a 90 percent confidence level.

Revised 78.1.1 effective August 1, 2009

78.1.2 Reliability for Unsupervised Failures: CO detectors 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' specified lifetime. At this failure rate the cumulative Unsupervised Failures over the devices' specified lifetime shall not exceed 14.6 percent at a 90 percent confidence level.

Revised 78.1.2 effective August 1, 2009

78.2 Sample frequency and sample size

78.2.1 In-service reliability shall be estimated by subjecting a suitable sample of devices to the Sensitivity Test of Section 39 and Table 39.1 for tests at CO concentrations of 70, 150, and 400 ppm. The test at 30 ppm shall be excluded.

78.2.2 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.

78.2.3 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' specified lifetime. During the installation period the alarms 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' specified 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' specified lifetime. The data from the shorter installation period shall be replaced with data from progressively longer durations, up to the devices' specified lifetime, as it becomes available. When no data is available to demonstrate the applicability of the shorter duration data it is still usable.

Revised 78.2.3 effective August 1, 2009

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

78.3 Test results and record keeping

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

79 Production Line Dielectric Voltage-Withstand Tests

79.1 Each alarm 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 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 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, the enclosure of 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.

79.2 If the alarm 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.

79.3 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.

79.4 A 500 volt-amperes or larger transformer, the output voltage of which is variable, is to be used to determine compliance with 79.1. 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.

79.5 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.

79.6 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 is to be tested using a DC test voltage in accordance with 79.1.

80 Production Line Grounding Continuity Tests

80.1 The manufacturer shall test each alarm 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.

80.2 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.

80.3 If an investigation of the alarm 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.

81 Audibility Test

81.1 The manufacturer shall test a minimum of two sample alarms per production lot and shift to verify that the sound output level of the representative production samples can produce a minimum 85 db sound pressure level, as measured in accordance with 61.2 or the equivalent.

82 Alarm Shipment

82.1 The battery intended to be employed with the alarm 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.

82.2 A nonrechargeable standby battery of an AC operated accessory to a single- or multiple-station alarm 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.

MARKING

83 General

83.1 An alarm shall be permanently marked on a Class IIIC marking material with the following information unless specifically indicated that it appears on the installation wiring diagram. The marking shall be in a contrasting color, finish, or equivalent. Unless the letter height is specified, all markings shall be at least 3/64 inch (1.2 mm) high.

a) Name or identifying symbol and address of the manufacturer or private labeler.

b) Model number and date of manufacture. The date of manufacture shall be non-coded and in the format YEAR (in 4 digits), MONTH (in letters), and DAY (in 2 digits) located on the outside surface of the CO alarm.

c) Electrical rating, in volts, amperes, or watts, and frequency.

Exception: Not required for battery operated alarms.

d) Correct mounting position if a unit is intended to be mounted in a definite position. As an alternative, the correct mounting position shall appear in the installation instructions.

e) Identification of the product (carbon monoxide alarm shall be marked in contrasting color from the background on the face of the unit), lights, switches, and meters, regarding their function unless their function is obvious. The following message shall be located adjacent to the visual indicator for alarm: ″Move to fresh air.″

f) Maximum rating of fuse in each fuseholder.

g) Identification of spare lamps and batteries by part number, manufacturer's model number or equivalent, located adjacent to the component.

h) Reference to an installation diagram or owner's manual, or both.

i) The following warning shall be placed on the carbon monoxide alarm. The warning label shall be of Class IIIC marking material. The hazard symbol and letters used for the word ″WARNING″ shall be boldfaced type having a minimum uppercase letter height of 0.120 inch (3.05 mm). The minimum vertical spacing between lines of type shall be 0.046 inch (1.17 mm). (These dimensions correspond to 12 point type.) Lowercase letters shall be compatible with the uppercase letter specification.

⚠ ″WARNING″

″Carbon Monoxide cannot be seen or smelled but can kill you.

If alarm signal sounds:

1) Operate reset/silence button.

2) Call your emergency services (fire department or 911).

3) Immediately move to fresh air – outdoors or by an open door/window.″

j) An alarm not intended to be painted in use shall be marked on the outer surface of the enclosure with the following or equivalent notice: ″Do Not Paint.″ The letters shall not be less than 1/8 inch (3.2 mm) high and shall be located so as to be readily visible after the is mounted in its intended manner. See the Paint Loading Test, Section 63.

k) The following or equivalent qualifying statement on a battery-operated alarm where battery operation, under other than normal room temperature conditions during the long term battery tests, is less than 12 months but not less than 6 months. Applicable wording is to be used.

″CONSTANT EXPOSURES TO HIGH OR LOW TEMPERATURES OR HIGH HUMIDITY MAY REDUCE BATTERY LIFE.″

l) Distinction between alarm, end-of-life, and trouble signals on units employing these signals.

m) Reference to a source for battery replacement. As an alternative, this information shall appear in the users manual.

n) For a battery operated alarm, the word ″WARNING″ and the following or equivalent marking shall be included on the unit: ″Use Only Batteries Specified In Marking. Use Of A Different Battery May Have A Detrimental Effect On Alarm Operation.″ The letter height shall be a minimum of 1/8 inch (3.2 mm) for ″WARNING″ and 3/64 inch (1.2 mm) for the rest of the notice.

o) For an alarm employing a nonrechargeable standby battery the marking information described in 14.1, 14.3, and 14.4 shall be in letters not less than 1/8 inch (3.2 mm) high.

p) Test instructions and frequency. Not less than once per week for battery-powered alarms and not less than once per month for other than battery-powered alarms.

q) Maintenance instructions, such as cleaning, lamp, and battery replacement.

r) Name and address of firm to whom alarm is to be sent for servicing.

s) Sealed units intended to be returned to the manufacturer for servicing shall be marked as follows on the outside of the alarm: ″RETURN TO (+) FOR SERVICING,″ or equivalent. Units on which the cover is removable but that are also intended to be returned to the manufacturer for servicing may have the marking on the inside of the alarm.

(+) Name and address of manufacturer or supplier

t) An AC operated alarm without a standby battery shall be marked with the word ″WARNING″ and the following: ″UNIT WILL NOT OPERATE DURING POWER FAILURE, AND DO NOT INSTALL IN A WALL SWITCH CONTROLLED OUTLET.″ The marking shall be in a location on the unit that is visible after installation. The letter height for the word ″WARNING″ shall be minimum 1/8 inch (3.2 mm).

u) The sensitivity setting for an alarm having a fixed setting. If an alarm is intended to be adjusted in the field, the range of sensitivity shall be indicated. The marked sensitivity shall be indicated by ppm and time.

Item i) effective August 1, 2009

83.2 Information required to appear directly on the alarm shall be readily visible after installation. Except for 83.1(j), the removal or opening of an enclosure cover or the removal of not more than one mounting screw, or an equivalent arrangement to view the marking is acceptable.

83.3 If markings are placed on the base (bottom) of an alarm intended for permanent installation, the word ″CAUTION″ and the following or equivalent marking in letters 1/8 inch (3.2 mm) high is to be provided on the outside or inside of the alarm: ″Additional marking on back. Disconnect power.″

83.4 Additional marking requirements are specified in 9.2.1, 11.6.4, 14.3, 17.5.1, 19.2.1, and 84.2.

83.5 If a manufacturer produces alarms at more than one factory, each such assembly shall have a distinctive marking to identify it as the product of a particular factory.

83.6 With regard to the requirement in 5.2, a warning flag, hinged cover as described in 5.1 (inside or outside), or equivalent, shall be marked with the word ″WARNING″ and the following or equivalent text: ″Battery Has Been Removed.″ The letter height shall be a minimum of 3/8 inch (9.5 mm).

INSTRUCTIONS

84 General

84.1 Each single and multiple station carbon monoxide alarm shall be provided with installation instructions which shall include the following information:

a) Typical installation drawing layouts for the unit(s) indicating locations and wiring methods which shall be in accordance with the National Electrical Code or Canadian Electrical Code. Locations where alarms are not to be installed shall also be included.

b) Description of the operation, testing, and proper maintenance procedures for the unit(s).

c) Replacement parts, such as lamps or batteries, shall be identified in the instructions by a part number, manufacturer's model number, or the equivalent, and information included as to where parts are obtainable.

d) The hazard symbol ⚠, the word ″WARNING,″ and at least the following or equivalent information in an obvious and prominent manner, such as by being underlined, encircled, or printed in larger or different color type. The letters used for the word ″warning″ shall be boldfaced in a color that contrasts with the background and shall be a minimum size of 18 points or a minimum of 1.5 times larger than the safety message letters. The letters used for the safety message words shall be boldfaced Helvetica type with a minimum size of 12 points. Lowercase letters shall be compatible with the uppercase letter specification. The safety message shall be separate and distinct from the other messages and graphics in the owner's manual.

⚠ ″WARNING″

″Actuation of your CO alarm indicates the presence of carbon monoxide (CO) which can KILL YOU. If alarm signal sounds:

1) Operate reset/silence button;

2) Call your emergency services (Telephone Number) [fire department or 911];

3) Immediately move to fresh air – outdoors or by an open door/window. Do a head count to check that all persons are accounted for. Do not reenter the premises nor move away from the open door/window until the emergency services responders have arrived, the premises have been aired out, and your alarm remains in its normal condition.

4) After following steps 1 – 3, if your alarm reactivates within a 24 hour period, repeat steps 1 – 3 and call a qualified appliance technician (Telephone Number) to investigate for sources of CO from fuel burning equipment and appliances, and inspect for proper operation of this equipment. If problems are identified during this inspection have the equipment serviced immediately. Note any combustion equipment not inspected by the technician and consult the manufacturers' instructions, or contact the manufacturers directly, for more information about CO safety and this equipment. Make sure that motor vehicles are not, and have not been, operating in an attached garage or adjacent to the residence.

e) This carbon monoxide alarm is designed to detect carbon monoxide gas from ANY source of combustion. It is NOT designed to detect smoke, fire or any other gas, unless the product has been investigated and determined to comply with the applicable requirements.

f) More detailed information on the alarm, end-of-life, and trouble signals and an indication where false alarms or trouble signals would be anticipated; such as to reduce the possibility of nuisance tripping of the alarm's alarm circuit, the instructions shall state that accommodation spaces are to be well ventilated when household cleaning supplies or similar contaminants are used. The end-of-life information shall include details on how long the unit may be expected to last and shall indicate if the end-of-life is based on the date the unit was manufactured or the date that the user places the unit into service.

g) Identification of the users manual or instruction sheet by number or equivalent.

h) An indication that the device shall not be installed in locations where the normal ambient temperature is below 4.4°C (40°F) or exceeds 37.8°C (100°F), unless the alarm has been determined to be acceptable for installation at a higher or lower ambient temperature, in which case those tested extreme operating temperatures shall be listed in the manual.

i) Reference to a source(s) of limited energy cable for multiple station interconnection or connection of supplementary devices.

j) The following symptoms are related to CARBON MONOXIDE POISONING and are to be discussed with ALL members of the household:

1) Mild Exposure: Slight headache, nausea, vomiting, fatigue (often described as ″Flu-like″ symptoms).

2) Medium Exposure: Severe throbbing headache, drowsiness, confusion, fast heart rate.

3) Extreme Exposure: Unconsciousness, convulsions, cardiorespiratory failure, death.

4) Many cases of reported CARBON MONOXIDE POISONING indicate that while victims are aware they are not well, they become so disoriented they are unable to save themselves by either exiting the building or calling for assistance. Young children and household pets are typically the first affected.

k) The following information:

1) Name and address of manufacturer or private labeler.

2) Model number.

3) Electrical rating in volts, amperes or watts, and frequency. Not required for battery operated alarms.

4) Name and address of firm to whom alarm is to be sent for servicing.

l) For alarm-transmitters intended to be installed with compatible audible signal receiver units, instructions shall include the limitations of use in typical single level and multilevel dwelling units as well as in apartment buildings where adjacent apartments may have similar systems.

m) For alarms also acceptable for installation in recreational vehicles, the word ″WARNING,″ and the following or equivalent text: ″TEST ALARM OPERATION AFTER VEHICLE HAS BEEN IN STORAGE, BEFORE EACH TRIP, AND AT LEAST ONCE PER WEEK DURING USE.″ A label with identical marking is to be provided by the alarm manufacturer, with instructions that it be permanently and visibly located within 24 inches (610 mm) of the alarm.

n) The word ″WARNING″ and the following or equivalent text: ″ This product is intended for use in ordinary indoor locations of family living units. It is not designed to measure compliance with Occupational Safety and Health Administration (OSHA) commercial or industrial standards.″

Exception: If a manufacturer chooses a concentration level below 70 ppm for the tests in this standard it is not prohibited that the warning be revised to reflect actual testing.

o) The word ″CAUTION″ and the following or equivalent: ″This alarm will only indicate the presence of carbon monoxide gas at the sensor. Carbon monoxide gas may be present in other areas.″

p) The instructions shall also state that individuals with medical problems may consider using warning devices which provide audible and visual signals for carbon monoxide concentrations under 30 ppm.

q) A statement shall be provided to specify that the alarm, including a sensor, is not to be located within 5 feet (1.5 m) of any cooking appliance.

r) More detailed information on conditions which can result in transient CO situations, such as:

1) Excessive spillage or reverse venting of fuel burning appliances caused by:

i) Outdoor ambient conditions such as wind direction and/or velocity, including high gusts of wind; heavy air in the vent pipes (cold/humid air with extended periods between cycles).

ii) Negative pressure differential resulting from the use of exhaust fans.

iii) Simultaneous operation of several fuel burning appliances competing for limited internal air.

iv) Vent pipe connection vibrating loose from clothes dryers, furnaces, or water heaters.

v) Obstructions in or unconventional vent pipe designs which amplify the above situations.

2) Extended operation of unvented fuel burning devices (range, oven, fireplace, etc.).

3) Temperature inversions which can trap exhaust gasses near the ground.

4) Car idling in an open or closed attached garage, or near a home.

s) A minimum of two self-adhesive labels with the information as described in 84.1(d) shall be provided by the alarm manufacturer. Directions shall instruct the user of the alarm to add the telephone numbers of their emergency service provider and a qualified technician to the labels. Instructions shall be given for the user of the alarm to place one label next to the alarm, and the other label near a source of fresh air where they plan to gather after the alarm indicates the presence of carbon monoxide.

Items f) and h) effective August 1, 2009

84.2 The instructions may be incorporated on the outside of the unit, on a separate sheet, or as part of a manual. If not included directly on the device, the instructions or manual shall be referenced in the marking information on the unit.

84.3 The material shipped with the alarm, including the package, instructions, or user's manual, shall not include information other than that specified in 84.1, such as manufacturer's claims on the operation of the alarm which have not been substantiated by the performance tests included in this or other standards. The package, instructions, and user's manual shall include the information described in 84.1 (c), (k), (n), and (p). The package shall also include the end-of-life information described in 84.1(f).

Revised 84.3 effective August 1, 2009

85 Installation and Operating Instructions for Evaluation

85.1 A copy of the installation and operating instructions intended to accompany each unit or component, or equivalent information, is to be included in the examination and test of the equipment. For this purpose a draft, rather than a printed edition, is suitable.

85.2 The instructions and drawings shall include such directions and information as deemed by the manufacturer to be necessary for proper and safe installation, testing, maintenance, operation, and use of the alarm. Such instructions and drawings shall comply with the requirements of Instructions, General, Section 84.

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SUPPLEMENT SA - RELIABILITY AND FAILURE RATE DETERMINATION INFORMATION

The information contained in this supplement is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this supplement may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary to fulfill the objectives of the standard.

GENERAL

SA1 Instructions for Determining a Reliability Prediction for Carbon Monoxide Alarms

SA1.1 Make a list of every component in the alarm.

SA1.2 By circuit analysis or experimentation, determine the effect of any failure mode (short or open) of each component on the alarm 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 alarm for alarm and trouble signals, and will not affect the alarm sensitivity.

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 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 alarm, and does not result in a trouble signal[a].

[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.

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 217b).

SA2 Methods of Determining Failure Rate

SA2.1 PARTS COUNT METHOD – When using this method the failure rate is to be determined as follows, using Section 3 of Military Handbook 217b):

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 SA5.1	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 217B, Section 2. 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.

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

[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 alarm 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 Continued on Next Page

Table SA2.11 Continued

Type device	Applicable equation	MIL-HDBK-217B 9/20/74 page reference
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
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 SA5.1 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

λ_P = Failure rate for Component – Failures/10^6hours (Sum of numbers for that Component)

Overall System Failure Rate Failures/10^6hours

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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 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 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 other component of an 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 SA5.1.

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

SA3.1 The overall failure rates for the alarm shall not be greater than indicated in Table SA3.1.

SA3.1 revised October 15, 1997

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

CRITERIA FOR ACCEPTANCE OF MICROELECTRONIC DEVICES

SA4 General

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

SA5.1 The following minimum screening program (see Table SA5.1) is to be established by either the component manufacturer (vendor) or the 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.

Table SA5.1
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.

[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.

SA5.2 The test methods and conditions referenced in Table SA5.1 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

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 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

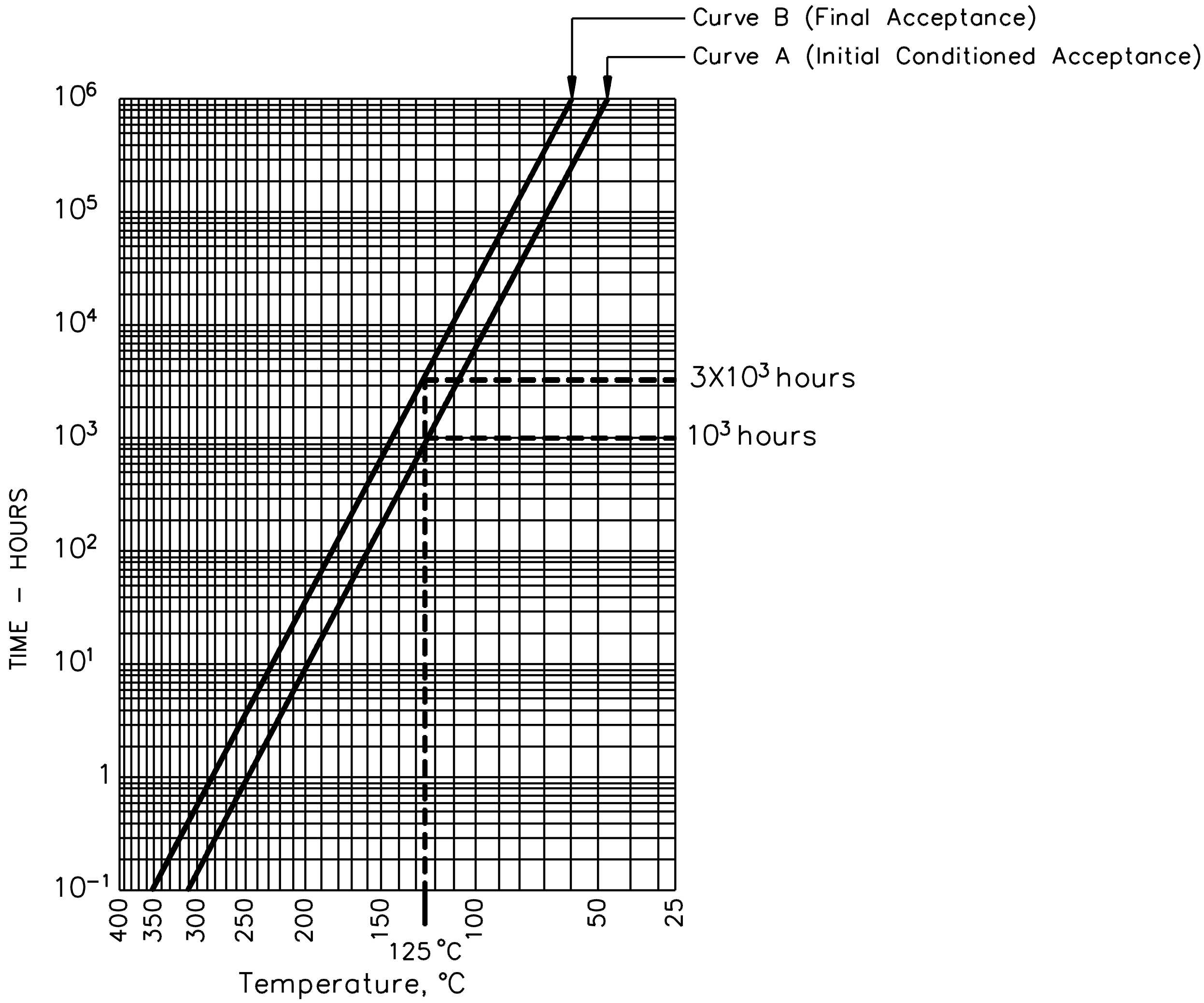

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Table SA6.1 part 1
Sample lot size for burn-in test

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 SA6.1 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.

$$\lambda = Ae^{\left(-\frac{E}{KT}\right)}$$

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 Figure SA6.1 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:

C = 0	N = 47
C = 1	N = 109
C = 2	N = 155, and the like.

From the equation and Table SA6.1, with no failures from a sample lot size of 47 at a test ambient of 125°C, the failure rate is 0.1 Failure/10^6 hours at the conditional acceptance point of 1000 hours. The failure rate may be less at the final acceptance point of 3000 hours.

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SUPPLEMENT SB - MANUFACTURING AND PRODUCTION TESTS

The information contained in this supplement is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this supplement may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary to fulfill the objectives of the standard.

Glossary

For the purpose of this document, the following definitions apply:

ALARM, MULTIPLE STATION – A single station alarm that may be interconnected with one or more other alarms for common alarm annunciation.

ALARM, SINGLE STATION – An alarm device consisting of an assembly of electrical and mechanical components including a sensor or sensors, an audible alarm, and an optional visual alarm constructed to detect the presence of carbon monoxide gas. It is powered either from an external source by means of splice leads or a cord and plug arrangement or from an integral battery or batteries. It may have terminals for connection to a remote audible signaling appliance or accessory. It may also contain an integral transmitter for energizing a remote audible signaling appliance.

ALARM SIGNAL – An audible signal intended to indicate a gas concentration in excess of the preset alarm level. This may include a visual signal as an additional feature.

CARBON MONOXIDE (CO) – A colorless, odorless, highly poisonous gas, formed by the incomplete combustion of carbon.

MANUFACTURER'S TEST PROGRAM – The tests described in Instructions for Tests and/or Inspection at the Factory of this document are to be conducted by the manufacturer on a periodic or 100 percent basis, for which the manufacturer may be required to keep records.

PPM – Gas concentration in parts per million.

RECOGNIZED COMPONENT – A part or 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.

SENSITIVITY – The gas concentration versus time at or above which the alarm must initiate or remain in alarm.

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.

UL REPRESENTATIVE'S DUTIES

General

The UL Representative's duties include, but are not limited to:

a) Examine the construction of production 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) 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 S E E X T R E M E C A U T I O N

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.

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 Carbon Monoxide Sensitivity test 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 ″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.

INSTRUCTIONS FOR FOLLOW-UP TESTS AT UL

Engineering services department

The samples forwarded to the Follow-Up Services Department shall be subjected to the following test. The test method is described in the Standard.

Carbon Monoxide Sensitivity Test

Method

The units shall be tested in accordance with the Electrical Supervision Test, Section 38, 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 maximum allowable time and concentration for carbon monoxide.

Results

All the samples shall respond within the prescribed time limits of sensing carbon monoxide per concentration of gas. The time limits are 90 minutes at 100 ±5 ppm, within 35 minutes at 200 ±10 ppm and within 15 minutes at 400 ±20 ppm.

INSTRUCTIONS FOR TESTS AND/OR INSPECTION AT THE FACTORY

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 carbon monoxide 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

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 Supplement.

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 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 Supplement.

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 Supplement.

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 100 ppm of CO, 200 ppm of CO, and 400 ppm of CO.

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 Supplement.

Method

The sensitivity test method shall be as specified in Instructions for Tests and/or Inspection at the Factory of this Supplement.

Basis for acceptability

The selected samples shall respond with the following carbon monoxide gas concentration and time limits.

Single and multiple-station carbon monoxide alarms (CZHF)	
Concentration of CO	**Maximum alarm time response**
100 – 5 ppm	90 minutes (not less than 16 minutes)
200 – 10 ppm	35 minutes (not less than 8 minutes)
400 – 20 ppm	15 minutes (not less than 4 minutes)

Sensitivity calibration test

Family designation –

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 Supplement.

Method

The test method shall be as specified in the Instructions for Tests and/or Inspection at the Factory of this Supplement.

Basis for acceptability

The selected samples shall respond with the following carbon monoxide gas concentration and time limits.

Single and multiple-station carbon monoxide alarms (CZHF)	
Concentration of CO	**Maximum alarm time response**
100 – 5 ppm	90 minutes (not less than 16 minutes)
200 – 10 ppm	35 minutes (not less than 8 minutes)
400 – 20 ppm	15 minutes (not less than 4 minutes)

Sensitivity calibration test (per shift)

Family designation –

Test equipment –

Method –

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APPENDIX A

Standards for Components

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Title of Standard − UL Standard Designation

Standards under which components of the products covered by this standard are evaluated include the following:

Attachment Plugs and Receptacles – UL 498
Class 2 Power Units – UL 1310
Control Units and Accessories for Fire Alarm Systems – UL 864
Flexible Cords and Cables – UL 62
Fuseholders – UL 512
Motors, Overheating Protection for – UL 2111
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Printed-Wiring Boards – UL 796
Switches, Snap, General-Use – UL 20
Tape, Polyvinyl Chloride, Polyethylene, and Rubber Insulating – UL 510
Transformers, Low Voltage, – Part 1: General Requirements – UL 5085-1
Transformers, Low Voltage, – Part 2: General Purpose Transformers – UL 5085-2
Transformers, Low Voltage, – Part 3: Class 2 and Class 3 Transformers – UL 5085-3
Tubing, Extruded Insulating – UL 224
Wire Connectors – UL 486A-486B
Wires and Cables, Thermoplastic-Insulated – UL 83
Wires and Cables, Thermoset-Insulated – UL 44

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APPENDIX B – MARKING

The information contained in this appendix is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this appendix may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary to fulfill the objectives of the standard.

Marking material shall be identified by class number and shall meet the following specifications. All metal marking materials shall be rustproof. All markings shall be suitable for application to surfaces upon which applied. The designation of any class of marking shall not preclude the use of marking of a lower number class.

B1 Class I Integral Marking

Marking that is embossed, cast, stamped or otherwise formed in the part. This includes markings baked into an enamelled surface.

B2 Class IIA-1 Permanent Plate

Shall be made of metal having a minimum thickness of 0.012 inch (0.30 mm) and shall be securely attached by mechanical means.

B3 Class IIA-2 Permanent Plate

Shall be made of metal having a thickness of 0.006 to 0.012 inch (0.15 to 0.30 mm) and shall have mechanical attachment means at all corners with a maximum spacing of 6 inches (152 mm) between mechanical fasteners.

B4 Class IIA-3 Permanent Plate

Shall be made of metal having a thickness less than 0.006 inch (0.15 mm). Such plates shall be attached by means of non-water soluble adhesive which will comply with the quality of adhesion test specified in Appendix B. These materials shall not be located on surfaces having temperatures exceeding 300°F (149°C) as determined during the Temperature Test, Section 43.

B5 Class IIA-4 Permanent Plate

Shall be made of pressure-sensitive metal foil requiring no solvent or activator, when such plates comply with the quality of adhesion test specified in Appendix B. These materials shall not be located on surfaces having temperatures exceeding 300°F (149°F) as determined during the Temperature Test, Section 43.

B6 Class IIIA-1 Permanent Plate

Shall be made of material not adversely affected by water, shall be attached by means of non-water soluble adhesive and shall comply with the quality of adhesion test specified in Appendix B) These materials shall not be located on surfaces having temperatures exceeding 300°F (194°C) as determined during the Temperature Test, Section 43.

B7 Class IIIA-2 Permanent Plate

Shall be made of material not adversely affected by water, shall be attached by means of non-water soluble adhesive and shall comply with the quality of adhesion test specified in Appendix B. These materials shall not be located on surfaces having temperatures exceeding 175°F (79°C) as determined during the Temperature Test, Section 43.

B8 Class IIIB Waterproof Marking

Shall be printed directly on the part with waterproof marking not adversely affected by a temperature of 175°F (79°C). This marking shall not be used on surfaces having temperatures exceeding 175°F (79°C) as determined during the Temperature Test, Section 43.

B9 Class IIIC Waterproof Label

Shall be made of material not soluble in water and may use water-soluble adhesive for attachment means.

B10 Class IV Semipermanent Label

Shall be made of material which may be soluble in water, and may use water-soluble adhesive for attachment means.

B11 Class V Printed Marking

Marking shall be clear and prominent and may be applied directly by any printing means.

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APPENDIX C – MARKING MATERIAL ADHESION

The information contained in this appendix is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this appendix may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary to fulfill the objectives of the standard.

The adhesive quality of Class IIA-3, IIA-4, IIIA-1, and IIIA-2 marking materials (see Appendix B) shall not be adversely affected when the marking materials are exposed to heat and moisture as specified in the following Method of Test.

Method of Test

These tests shall be conducted with the marking materials applied to a sample test panel having the particular type of finish used on the appliance in production.

A sample metal panel of this finish shall be cleaned with a solvent and dried. Half of the panel shall be wiped with a clean cloth lightly oiled with SAE-30 medium machine oil.

Two samples of marking material shall be applied to the panel, one on the dry area and one on the oiled area. Test samples shall be applied with firm pressure, unless the manufacturer's application instructions specify otherwise, and allowed to set for 24 hours at room temperature.

Each sample of marking material shall exhibit:

a) Good adhesion and no curling at edges;

b) No illegible or defaced printing by rubbing with thumb or finger pressure; and

c) Good adhesion when a dull metal blade (as the back of pocket knife blade) is held at right angles to the applied marking and scraped across edges of the marking.

Samples shall then be placed in an oven for a period of 2 weeks with the oven temperature maintained at:

a) 350°F (177°C) for Class IIA-3, IIA-4, and IIIA-1 marking materials or

b) 250°F (121°C) for Class IIIA-2 marking material.

Following the oven test, adhesion of the samples to the test panels shall be checked again as specified above.

Samples shall then be immersed in water for a period of 24 hours, after which adhesion shall be rechecked.

Good adhesion qualities shall be obtained under all of the above test conditions.

Final acceptance of marking materials shall be based on the suitability of the application of the marking material to the appliance.

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Appendix D – Sample Size Determination for In Service Reliability Testing

The information contained in this appendix is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this appendix may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary to fulfill the objectives of the standard.

D1 General

The objective of this Appendix is to assist manufacturers of CO alarming devices in identifying sample sizes for testing under Section 77. This discussion is a summary of the material provided in the GRI report ″Test Protocols for Residential Carbon Monoxide Alarm, Phase 1″ (GRI-96/0055), Section 6, ″Target Reliabilities and the Number of Units Tested″.

This program requires that alarms must adhere to an upper bound on their cumulative failure rate over a presumptive three year lifetime. Briefly, it requires that the average MTBF over the lifetime of the alarm be not less than 100,000 hours for supervised failures or 166,667 hours for unsupervised failures when estimated at a 90% confidence level. Compliance must be verified through quarterly testing that continues for a minimum period of 3 years. This reliability procedure must be re-initiated whenever there is a significant change in the design or manufacturing process.

Table D1 places into perspective the consequences of various failure rates.

Table D1
Field consequences of various mean-times-between-failure

MTBF (hours)	Failures per month (percent/month)	Portion of field units in failure [a]	Cumulative lifetime failures [b]
500,000	0.15%	2.6%	5.1%
250,000	0.29%	5.1%	10.0%
166,667[c]	0.44%	7.5%	14.6%
100,000[d]	0.73%	12.1%	23.1%
50,000	1.45%	22.2%	40.9%
20,000	3.58%	44.4%	73.1%

[a]The portion of field units in failure at any time, making the ideal assumptions of a uniform distribution in the age of alarms, their continuous replacement at the end of a 3 year lifetime, and an average age of installed units of only 18 months. The failed portion is given by the average of the integral of equation 3 over the interval of Δt = (0, 3 years). It is approximately one-half of the cumulative portion failed over the alarms' entire lifetime, given directly by equation 3.

[b]Assuming a lifetime of 3 years.

[c]The reliability limit for unsupervised failures.

[d]The reliability limit for supervised failures.

Mean-time-between-failure is estimated by tallying the failures in a sample over time. To develop the mathematical basis for the calculation of MTBF first express the assumption of a constant failure rate as an equation. For a fixed number of devices under test, N_{DUT}, the rate at which the number of failures, N_f, increases over time is given by the quotient of the number of unfailed devices at any given time and the MTBF as:

Equation 1

$$d/dt\ N_f(t) = N_{DUT} - N_f(t)/MTBF$$

If, instead of using a fixed number of devices, failed devices are replaced so that the number of unfailed devices under test, N_o, remains constant during the test, then the rate of failure is constant and given by:

Equation 2

$d/dt\ N_f(t) = N_o/MTBF$

We can solve these differential equations to find the number of accumulated failures after time Δt as:

Equation 3

$N_f/N_{DUT} = 1 - \exp[-\Delta t / MTBF]$ and

Equation 4

$N_f/N_o = \Delta t / MTBF$

Because it is impractical to promptly replace failed devices during the test time, the more generally useful expression is Equation 3. This equation is used to estimate the number of expected failures from a known MTBF. For example, using a MTFB of 166,667 hours, the portion of detectors failing over the course of a presumptive 3 year lifetime (Δt = 26,298 hours) would be 14.6%. Consequently, if there were 100 devices under test there would be approximately 15 failures.

In reliability testing the MTBF should be estimated from the number of failures observed in a test. Equation 3 for the MTBF sample above, can be solved:

Equation 5

$MTBF_S = \Delta t/1n\ [1 - N_{fS}/N_{DUT}]$

in which N_{fS} is the actual number of failures observed in time Δt out of the number of devices in the sample N_{DUT}, and 1n is the natural logarithm.

Equation 5 is the fundamental equation to use to estimate the MTBF when a cumulative test time and number of failures are known. It is easily applied when there is a single cohort of devices all held for the same amount of time. However, it is difficult to apply if different numbers of devices are held for different lengths of time. In that case Equation 5 may be approximated with a more easily applied form as:

Equation 6

$MTBF_S = \alpha\ \Delta t\ (N_{DUT}/N_{fS})$

in which α is a parameter adjusted to make Equation 6 agree with Equation 5 at a particular cumulative failure rate. For the lifetime cumulative failure rates for supervised and unsupervised failures allowed by this Standard, the best values for α are 0.878 and 0.925, respectively; i.e.

Equation 7

supervised failures: $MTBF_S = 0.878 * \Delta t * (N_{DUT}/N_{fS})$

Equation 8

unsupervised failures: $MTBF_S = 0.925 * \Delta t * (N_{DUT}/N_{fS})$

These approximations work well over a wide range of accumulated failures, but for fewer accumulated failures than the maximum allowed they slightly underestimate the MTBF, while for greater accumulated failures they slightly overestimate it.

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These approximations are used because they can be easily extended to account for devices held for different amounts of time. For different numbers of units held for different times a total device time is computed as:

Equation 9

$$T_{DUT} = \sum_{i} \Delta t_i N_{DUT\ i}$$

and a total number of failures as

Equation 10

$$N_{fs} = \sum_{i} N_{fs\ i}$$

in which the index, i, pertains to different samples of devices held for different amounts of time. Using these definitions, Equations 7 and 8 become:

Equation 11

$$\text{for supervised failures: } MTBF_S = 0.878 \frac{\sum_i \Delta t_i N_{DUT\ i}}{\sum_i N_{f\ S\ i}}$$

and

Equation 12

$$\text{for unsupervised failures: } MTBF_S = 0.925 \frac{\sum_i \Delta t_i N_{DUT\ i}}{\sum_i N_{f\ S\ i}}$$

For example, if 100 alarms are held for a first quarter, and in addition to these 50 more alarms are held for a second quarter, the total device time is given by equation 9 as:

T_{DUT} = 100 * 2 + 50 * 1 = 250 device-quarters or

T_{DUT} = 100 * 2 * 2191.5 + 50 * 2191.5 = 547,875 device-hours.

If at the end of the first quarter the 100 alarms are tested and two unsupervised failures detected, and at the end of the second quarter 148 alarms are tested (all 150 minus the two that had already failed) an additional unsupervised failure detected, then the total number of unsupervised failures would be $N_{fS} = 3$.

The observed $MTBF_S$ for the test is computed using Equation 12 as:

$MTBF_S$ = 0.925 * 547,875/3 = 168,928 hours.

The number of failures observed will fluctuate from sample to sample about an ideal average with a standard deviation (called the counting error) roughly equal to the square root of the ideal average. Consequently, if a different number of sample devices had been drawn and tested a somewhat different number of failure, N_{fS}, would have been observed. The mean time between failure at 90% confidence level should be predicted. This $MTBF_{90}$ is not based solely on the observed number of failures, but on the upper limit on the number of failures at 90% confidence level. Consequently, in Equations 11 and 12 replace N_{fSi} with N_{f90i} from Table D2as:

Equation 13

$$\text{for supervised failures: } MTBF_{90} = 0.878 \frac{\sum_i \Delta t_i N_{DUT\ i}}{\sum_i N_{f\ 90\ i}}$$

and

Equation 14

$$\text{for unsupervised failures: } MTBF_{90} = 0.925 \; \frac{\sum_i \Delta t_i N_{DUT\ i}}{\sum_i N_{f\ 90\ i}}$$

where N_{f90} is the upper limit on N_{fS} at the 90% confidence level, as determined from Table D2, and the index i pertains to different cohorts of devices held in operating condition for different lengths of time.

Table D2
Upper bound on the expected number of failures at a 90% confidence level, based on the number of failures observed

Failures observed N_{fS}	Upper bound $N_{f\ 90}$
0	2.30
1	3.89
2	5.32
3	6.68
4	8.00
5	9.28
6	10.54
7	11.77
8	13.00
9	14.21
10	15.14
11	16.60
12	17.78
13	18.96
14	20.13
15	21.30
20	27.05
30	38.33
40	49.39
50	60.35
100	114.06
N_{fS}>100	$N_{fS} + 0.82 + 1.28\sqrt{(N_{fS} + 0.41)}$

Continuing the above example, if of the 150 alarms held for a total device time of 547,875 device-hours there were three observed unsupervised failures, the upper limit on the number of failures is found from Table D2 to be 6.68 failures. The $MTBF_{90}$ is computed as:

$$MTBF_{90} = 0.925 * 547{,}875/6.68 = 75{,}866 \text{ hours.}$$

Given a sample of operating devices, the length of time they have been operating, and the number of failures observed, Equations 13 and 14 allow the computation of their $MTBF_{90}$. However the minimum sample size to be tested must be determined. The goal is to estimate the alarms' lifetime failure rate in the minimum elapsed time possible (one-quarter) and then to successively refine that estimation as the alarms are held in operating condition for longer periods of time, up to their minimum lifetime of 3 years. Consequently, the minimum device time required to estimate the failure rate at 90% confidence level in one quarter must be computed.

Assuming no failures are observed in the sample, the minimum device time required is calculated from Equations 13 and 14 using the target $MTBF_{90}$ and the minimum upper limit on the number of failures, N_{f90}, of 2.30 as:

Equation 15

for supervised failures:

$$T_{DUT} = N_{f90}MTBF_{90}/0.878$$

$$T_{DUT} = 2.3 * 100{,}000/0.878 = 261{,}959$$

from which

Equation 16

$$N_{DUT} = T_{DUT}/\Delta t = 119.5$$

and

for unsupervised failures:

Equation 17

$$T_{DUT} = N_{f90}\ MTBF_{90}/0.925$$

$$T_{DUT} = 2.3 * 166{,}667/0.925 = 414{,}415$$

from which:

Equation 18

$$N_{DUT} = T_{DUT}/\Delta t = 189.1$$

In order to verify that the mean-time-between-failure is at least 166,667 hours at 90% confidence level 190 (rounded up from 189.1) devices must be operated continuously for one quarter, at the end of which they are to be tested and found to have no failures. Because the device-time required for unsupervised failures is greater than that for unsupervised failures the greater number of units must be used. Only 120 units are required for testing for supervised failures.

The results of calculations of Equations 15 – 18 for observed failures from 1 to 100 are presented in the ″In-Service reliability sampling plan″, see Table D3.

Table D3
In-Service Reliability Sampling Plan

Number of failures allowed [a]	Number allowed for an increase in device time [b]	Minimum device time for required $MTBF_{90}$			
		Supervised failures		Unsupervised failures	
		Device-hours	Device-quarters	Device-hours	Device-quarters
0	2	262,000	120	414,000	190
1	3	443,000	203	701,000	320
2	5	606,000	277	959,000	438
3	6	761,000	348	1,204,000	550
4	8	911,000	416	1,441,000	658
5	9	1,057,000	483	1,672,000	763
6	10	1,200,000	548	1,899,000	867
7	11	1,341,000	612	2,121,000	968
8	13	1,481,000	676	2,342,000	1,069
9	14	1,618,000	739	2,560,000	1,169
10	15	1,755,000	801	2,777,00	1,267
11	16	1,891,000	863	2,991,000	1,365
12	17	2,025,000	925	3,204,000	1,462
13	18	2,159,000	986	3,416,000	1,559
14	20	2,293,000	1,047	3,627,000	1,655
15	21	2,426,000	1,107	3,838,000	1,752
20	27	3,081,000	1,406	4,874,000	2,224
30	38	4,366,000	1,993	6,906,000	3,152
40	49	5,625,000	2,567	8,899,000	4,061
50	60	6,874,000	3,317	10,874,000	4,962
100	114	12,991,000	5,928	20,551,000	9,378

[a]The number of failures allowed at the cumulative device time that demonstrates compliance with a minimum MTBF of 100,000 hours for supervised failures or 166,667 hours for unsupervised failures at a 90% confidence level.

[b]The number of failures beyond which it is unlikely that compliance will be demonstrated even if the device time of the test is increased. For an observed number of failures greater than the ″number of failures allowed″ and less than or equal to the ″number allowed for an increase in device time″, it is likely that compliance will eventually be demonstrated if the device time is increased sufficiently.

If no failures are observed the devices are considered in-compliance and the entire sample need not be held for a second quarter. It is required that, for the next quarter's test, a cumulative device time of 190 device-quarters be maintained while maximizing the age of the sample of retained devices. Consequently only the following must be retained for the second quarter:

$$N_{DUT} = T_{DUT}/\Delta t = 190 \text{ device-quarters}/2 \text{ quarters} = 95 \text{ devices}$$

In fact, as long as no failures are observed the number of retained devices may continue to be reduced on a schedule given by:

$$N_{DUT} = T_{DUT}/\Delta t$$

in which T_{DUT} is given in device-quarters from Table D3 and Δt is given in quarters. Quarter by quarter the number of devices retained may continue to be reduced. As this is done a constant cumulative device-time is maintained, but the age of the retained devices steadily increased toward their specified lifetime, providing an increasingly more realistic measure of lifetime reliability. As long as no failures are encountered only 16 devices need be retained by the end of the three years.

It is not necessary to reduce the size of the retained sample. In fact, more accurate measures of device reliability will be made by retaining as many devices as possible. In addition, having more retained devices than the minimum required simplifies further testing if more failures are observed.

If a failure is observed when testing at the end of the first quarter the device time may be increased.

For example, if one unsupervised failure is observed in testing 190 devices, in accordance with Table D3, if one failure is observed the required device time increases to 320 device-quarters. In accordance with Equation 19 at least 320/2 = 160 devices must be retained. By the end of the second quarter there will be 160 devices, all having been held for the entire two quarters. If, when all retained devices are tested at the end of the second quarter, no other failures are observed, then compliance with the required $MTBF_{90}$ has been demonstrated. The test may then be continued with a constant device time of 320 device-quarters, reducing the number of devices retained to 320/3 = 107 for the third quarter and further reducing the number quarter by quarter if desired. If, however, more failures had been observed, the device time would again be increased for the third quarter.

For another example, in a test of 190 devices for one quarter no unsupervised failures occur and one supervised failure occurs. From Table D3 it is found that the minimum number of device-quarters required while allowing zero unsupervised failures is 190, and the minimum number required while allowing one supervised failure is 203. Therefore it is required that the device time be increased to the greater of these, to 203 device-quarters. A minimum of 203/2 = 102 devices must be retained for the second quarter. In the case where no additional failures occur during the second quarter compliance with the required $MTBF_{90}$ will have been shown for both supervised and unsupervised failures.

In some cases it will not be possible to increase the device time simply by retaining devices; additional devices may need to be added to the sample. For example, in cases where only the minimum number of devices, 190, are tested in the first quarter, and two unsupervised failures occur, then, according to Table D3, in the next quarter 438 device-quarters are needed. When held for an additional quarter the original 190 devices can account for only 380 of those device-quarters. Unless a larger sample was initially drawn and operated in a simulated residential environment, 58 newly manufactured additional devices must be added. The sample now contains devices of mixed age, and its cumulative device time is calculated using Equation 9.

If at any time the tested sample is augmented with new devices, reliability tests should be continued for longer than the 3 year lifetime, until the average age of the sample of devices achieves the 3 year lifetime.

If compliance cannot be shown in a particular quarter due to too many observed failures, increasing the device time of the test is no guarantee that compliance can be demonstrated in the next quarter. If the population failure rate is too great, more failures are likely to become apparent in tests at the greater device times. There is a level of observed failures for each device time that signals the unlikelihood of demonstrating compliance even if the device time is increased. This number of failures is the number that results in a calculation (using Equations 11 and 12) of a $MTBF_S$ of less than the required minimum $MTBF_{90}$. The number of failures allowing for an increase in test time if compliance is not achieved is also tabulated in Table D3.

If, in the first quarter, 190 devices are tested and four unsupervised failures are found it is pointless to continue into the second quarter by increasing the test time. This is because the number of failures exceeds the ″Number allowed for an increase in device time″ from Table D3. The devices should be deemed not-in-compliance. The observed sample mean-time-between-failure, $MTBF_S$, is given by equation 12 as:

$$MTBF_S = 0.925 * 414,000/4 = 95,700 \text{ hours.}$$

This time is less than the target $MTBF_{90}$, indicating that it is unlikely that an increase in the device time will demonstrate compliance.

D2 Procedure

All data pertaining to the sampling procedure and test results must be recorded on a controlled test sheet and maintained in a file for future reference.

A minimum of 190 packaged, market-ready devices is initially selected for testing. These are serialized, placed in a simulated residential environment, and powered up. At the manufacturer's discretion devices may be installed in actual residences. The devices must be continuously monitored so that false alarms or supervised failures are recorded. The history of each device, including time of power-up and times of supervised failures, must be logged.

At the conclusion of each quarterly period the devices are tested to the sensitivity test, and the number of supervised and unsupervised failures, and the total device time tallied. The sample mean-time-between-failure, $MTBF_S$, and the lower limit on the mean-time-between-failure at 90% confidence level, $MTBF_{90}$, must be computed using Equations 11 – 14. The numbers of observed failures are compared to the values in Table D3 to determine whether the devices are in compliance, and whether the total device time should be increased for the next quarter.

For successive quarters, devices should be retained or augmented on a schedule that results in a total device time chosen from Table D3 using the observed failures of the prior quarter.

If the number of observed failures is less than or equal to the ″Number of failures allowed″ in Table D3, the devices are deemed to be in-compliance for the quarter, otherwise they are not-in-compliance for the quarter.

If the number of failures observed is greater than the ″Number of failures allowed″ in Table D3, but not greater than the ″Number allowed for an increase in device time″, then either the total sample size may be increased in an effort to demonstrate compliance at a greater device time in the next quarter, or the manufacturer may forfeit compliance. If for the greater device time the number of observed failures remains in this interval, the device time may be increased again for the next quarter.

If for any quarter the number of observed failures is greater than the ″Number allowed for an increase in device time″ in Table D3 (or, equivalently, the observed sample $MTBF_S$ is less than the target $MTBF_{90}$ for either supervised or unsupervised failures), it is recommended that the device time not be increased further, and that the devices be deemed to be not-in-compliance.

If the devices are not-in-compliance corrective action must be taken to determine the cause of the failure rate. Underwriters Laboratories must be notified and approve an action plan to reduce the failure rate. The action plan should include the diagnostic tests, disposition, redesign or rework done to the failed model. Depending on the action plan the reliability testing may need to be restarted.

As long as the devices remain in-compliance and the model is produced, quarterly testing should be continued.

D3 Statistical Derivation of Table D2

Assuring in-service reliability makes use of a statistical table that provides an upper limit on the number of estimated failures at a 90% confidence level given an observed number of failures (Table D2). Table D4 provides a derivation for the values of Table D2.

Because it is generally not feasible to test the entire population of manufactured units, statistical methods for sampling and testing fewer units are used. Each of these tests can be considered a binomial experiment in which the outcome is classified as either a ″pass″ or a ″failure″. Tests of each sampled unit are assumed to be independent of the outcome of tests of other units, and the probability of failure of each unit is assumed to be the same. Using a tally of observed failures from the sample, an upper bound on the entire population's failure rate is found at a chosen confidence level.

Statistically assessing the failure rate places a lower bound on the number of units required for testing. The number of units needed for testing is estimated as follows: In a large population of devices there will be some fraction, F, that will fail a test of any particular characteristic. Call F the ″population failure rate″. The goal of any particular test is to establish an upper bound on F at a given confidence level) eg, 60%, 80%, or 90%) by testing a smaller sub-population, or sample, of only N_{DUT} units. However, the sample size, N_{DUT}, must be sufficiently large to confidently place an upper bound on the failure rate. The number of units expected to fail a test, N_f, is given by the size of the sub-population or sample tested times the population failure rate as:

Equation 20

$$N_f = N_{DUT}F$$

Although N_f is the expected number of failures, the actual number of failures, N_{fS}, observed in any particular sample of N_{DUT} units may be more or less. There is approximately a 50% chance that the observed failures would be more numerous than the expected number and a 50% chance that they would be less numerous. In fact, any number of failures from 0 to N_{DUT} might be observed but with different probabilities.

The actual population failure rate cannot be known. There is no statistical universe of values from which the failure rate is drawn. There is only a single population failure rate, the correct one, and it can't really be measured by testing only a sample.

However, if the probability of observing the actual number of failures, N_{fS}, is too small it can be concluded that the population failure rate under consideration is ″unlikely″ to be the correct one. The number of failures should not be too improbable for the correct assumption of population failure rate. Moreover, a likely upper bound on the correct population failure rate can be established by asking the question ″Assuming that if the population failure rate were to equal a certain upper bound, what is the probability of observing more than the actual number of failures?″ If that probability is great, then there can be confidence that the population failure rate is truly less than the hypothetical upper bound.

In other words, it is possible to identify the probability of observing more than the actual number of failures in a sample given an upper bound on the population failure rate as the likelihood of the true population failure rate's being less than the upper bound given the actual number of failures. This is as close to a notion of a ″probability that a population failure rate is correct″ as can be obtained. Although this definition of likelihood is entirely based on intuition, and has no formal mathematical basis in and of itself, it is the basis of many extremely useful methods of statistics.

So, assuming a particular population failure rate, F, it is possible to identify the cumulative probability of observing more than an actual number of failures as the likelihood of, or confidence level for, being correct when using that assumed value as an upper bound on the true population failure rate. This identification is the core assumption for statistical assessment of failure rate. Consequently, if the expected number of failures given an assumed failure rate of F were actually to be observed, that is, if N_{fS} were to equal N_f, then the test would have established that the failure rate is truly less than or equal to F with only about 50% confidence. If the observed number of failures were found to be much less than the number expected from a particular assumed failure rate, then there would be high confidence that the actual failure rate is less than or equal to the assumed failure rate. The assumed failure rate could then be used as an upper bound on the actual failure rate with great confidence.

To establish an upper bound on the failure rate, consider the probability distribution for observing differing numbers of failures given a particular population failure rate. This distribution is given by the binomial probability distribution. The probability of observing a particular number, N_{fS}, or fewer failures, $P(\leq N_{fS})$, is given by one minus the cumulative binomial probability for observing more than N_{fS} failures with a probability of F each in a sub-population of D_{NUT} units, and is related to the incomplete beta function as:

Equation 21

$$P(\mathcal{L} N_{fs}) = 1 - \sum_{N_{fs}+1}^{N_{DUT}} [N_{DUT}! / j!(N_{DUT-j})!] F^{j} (1-F) N_{DUT-j} = 1 - I_f (N_{fs}+1, N_{DUT} - N_{fs})$$

where

$I_f\ (N_{fS} + 1, N_{DUT} - N_{fS})$ is the incomplete beta function.

Tabulations of the incomplete beta function are not as commonly available as those of the gamma or chi-squared functions so it is preferable to approximate the above in terms of those distributions. This may be done by assuming that the number of observed failures is much less than the total number of units tested, $N_{fS} \ll N_{DUT}$, generally a good assumption, so that the Poisson distribution may be used as an approximation for the binomial distribution. The probability that the number of observed failures, N_{fS}, is equal to or fewer than the expected number, N_f, is given by the cumulative Poisson distribution function, $P(N_{fS} \leq N_f)$, which in turn is given by the complement of the incomplete gamma function, often called GAMMAQ, or the chi-squared function as:

Equation 22

$P(N_{fS} \leq N_f) = GAMMAQ(N_{fS} + 1, N_f) = P[chi\ ]^2(2N_f, 2N_{fS}+2)$.

This probability equals one minus the confidence that the failure rate is actually less than or equal to the value responsible for the expected number of failures, N_f. In the above equation $P[chi\ ]^2(2N_f, 2N_{fS}+2)$ represents the probability that an observed chi-squared, $[chi\ ]^2$, will exceed a value of $2N_f$ by chance for $2\ N_{fS} + 2$ degrees of freedom. Note that the standard interpretation of this distribution in terms of chi-squared and degrees of freedom is not particularly meaningful in this application. Rather the chi-squared distribution is used for its availability; it is the most widely tabulated form of the gamma function. Even so, the chi-squared distribution is usually tabulated not as probability as a function of squared error, P[chi $]^2$, but rather as reduced-chi-squared as a function of probability, [chi $]^2_v$, (where reduced-chi-squared, [chi $]^2_v$, is [chi $]^2$ divided by the number of degrees of freedom). Recast in these terms, Equation 22 becomes:

Equation 23

$N_{DUT}F = N_fC (N_{fS} + 1)$ [chi $]^2_v (1 – C, 2N_{fS} + 2)$

Thus the failure rate is bounded for a given confidence level as:

Equation 24

$F \leq (N_{fS} + 1)$ [chi $]^2_v (1 – C, 2N_{fS} +2)/N_{DUT}$

where:

N_{DUT} is the number of units undergoing test;

F is the hypothesized population failure rate;

N_{fS} is the actual number of failures observed in a test of N_{DUT} units;

C is the degree of confidence in the bound on the failure rate; and

[chi $]^2_v (1 – C, 2N_{fS} +2)$ is the reduced chi-squared distribution at a significance of 1 – C and a number of degrees of freedom $v = 2N_{fS} + 2$.

In a manner similar to that of the derivation above, a lower bound on the population failure rate can also be established, given the observed number of failures. This is done by assuming a particular population failure rate, F, and identifying the probability of observing fewer than the actual number of failures as the likelihood of, or confidence level for being correct when using the assumed value as a lower bound on the true population failure rate. In this case a lower bound is found for the population failure rate as:

Equation 25

$F \leq N_{fS}$[chi $]^2_v (C, 2N_{fS})/N_{DUT}$

Knowing this lower bound is generally less useful than knowing the upper bound, but it is useful for estimating minimum failure rates from field data.

Using these equations, Table D4 lists upper and lower bounds on the expected number of failures, $N_f = N_{DUT}F$, at various confidence levels and numbers of failures observed after testing any sample size. As expected, at the 50% confidence level these bounds are approximately the actual numbers of failures observed. Also, for any number of failures observed the upper bound on the expected number increases with increasing confidence level.

Table D4
Upper and lower bounds on the expected number of failures at various confidence levels given an observed number of failures

Number of failures observed	Confidence level (CL) Upper bound/lower bound					
	99%	95%	90%	80%	60%	50%
0	4.6/0.0	3.0/0.0	2.3/0.0	1.6/0.0	0.92/0.0	0.69/0.0
1	6.6/0.01	4.7/0.05	3.9/0.11	3.0/0.22	2.0/0.15	1.7/0.69
2	8.4/0.15	6.3/0.36	5.3/0.53	4.3/0.82	3.1/1.4	2.7/1.7
3	10/0.44	7.8/0.82	6.7/1.1	5.5/1.5	4.2/2.3	3.7/2.7
4	12/0.82	9.2/1.4	8.0/1.7	6.7/2.3	5.2/3.2	4.7/3.7
5	13/1.3	11/2.0	9.3/2.4	7.9/3.1	6.3/4.2	5.7/4.7
6	15/1.8	12/2.6	11/3.2	9.1/3.9	7.3/5.1	6.7/5.7
8	17/2.9	14/4.0	13/4.7	11/5.6	9.4/7.0	8.7/7.7
10	20/4.1	17/5.4	15/6.2	14/7.3	12/8.9	10.7/9.7
15	27/7.5	23/9.2	21/10	19/12	17/14	15.7/14.7
20	33/11	29/13	27/15	25/16	22/19	20.7/19.7
50	69/35	63/39	60/41	57/44	52/48	50.7/49.7
100	126/78	118/84	114/87	109/92	103/97	101/99.7
N_{fS}>100	N_{fS} + /-2.33$\checkmark N_{fS}$	N_{fS} + /-1.65$\checkmark N_{fS}$	N_{fS} + /-1.28$\checkmark N_{fS}$	N_{fS} + /-0.84$\checkmark N_{fS}$	N_{fS} + /-0.25$\checkmark N_{fS}$	N_{fS} /N_{fS}

The final row of the table, for $N_{fS} > 100$, is found by approximating the Poisson distribution with a Gaussian distribution. In this case the obtained upper bound is:

Equation 26

$$N_{fS} + \beta^2/2 + \beta\checkmark(\beta^2/4 + N_{fS})$$

the lower bound is:

Equation 27

$$N_{fS} + \beta^2/2 - \beta\checkmark(\beta^2/4 + N_{fS})$$

where β is the number of standard deviations from the mean of a Gaussian distribution, the integral of which is equal to the confidence level (i.e., β=0.0, 0.25, 0.84, 1.28, 1.65, and 2.33 for CL = 50, 60, 80, 90, 95, and 99 percent). If N_{fS} is great enough that the standard deviations of the distributions at the lower and upper bounds are comparable, then these bounds are simplified to N_{fS} +/– β ✔ N_{fS} as shown in the table.

The values of Table D2 are taken from the upper bounds at the 90% confidence level of Table D4.

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APPENDIX E

The information contained in this appendix is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this appendix may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary to fulfill the objectives of the standard.

The information in these appendix pages is taken from the Follow-up Services Standarized Appendix Pages for Carbon Monoxide Detectors.

E1 UL Representative's Responsibilities and Instructions for Examination of the Product

E1.1 UL representatives responsibilities

The UL Representative's responsibilities include, but are not limited to:

a) Examine the construction of production bearing, or intended to bear the UL MARK or Marking to determine compliance with the description of the product and any other requirements expressed in this Procedure.

b) Where so specified in this Appendix, forward samples to UL for Follow-Up Tests. The packaging and shipment of samples are the responsibility of the manufacturer.

c) Where so specified in this Appendix, inspect the test records and facilities of the manufacturer to ensure that:

1) The proper number of samples are undergoing the required tests;

2) The required tests are being performed correctly;

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.

d) Report to the manufacturer and UL Reviewing Office by means of a Variation Notice (VN) if:

1) Variations in construction are found;

2) The manufacturer's method and/or frequency of test is not as described;

3) The records maintained by the manufacturer are not as described;

4) The manufacturer's inspection program is not being performed as described;

5) Nonconforming test results are witnessed during tests conducted specifically for the UL Representative; or

6) Improper markings or references to UL on the products and/or packaging are found.

Explain to the manufacturer that a Variation Notice is a means of communication with the manufacturer and forms a record of those items where nonconformance to the Procedure has been encountered.

E1.2 Procedure in the event of nonconformance

When a product does not comply with the Follow-Up Services Procedure it is required that the manufacturer shall either:

a) Remove any markings referencing UL from the product,

b) Suitably modify all products that do not comply with the Follow-Up Services Procedure, or

c) Hold shipment pending further instructions from UL.

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 FUS Engineer to whom the appeal is to be made. As an alternative to contacting a Follow-Up Services Engineer for the appeals process, the manufacturer may also be offered the option of contacting their new work assignment engineer in Engineering Services to resolve issues involving variations in construction only. Hold shipment appeals involving Follow-Up Services issues (e.g. improper labeling, etc.) are not to be directed to an Engineering Services staff member. 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.

E1.3 Construction Considerations

At each inspection, samples of current production and/or stock shall be examined by the UL representative for compliance with the applicable description and requirements contained in the Procedure. In conducting this examination consideration shall also be given to the general requirements described below, which also apply to products covered by the Procedure. It is the manufacturer's responsibility to assure the compliance of production with these requirements.

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 so as to ensure the insulation and containment of all bare wiring strands.

d) Markings – Information required shall be legibly marked on the products, 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) Adaptors – Three to two-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 in the instruction manual, or 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 which are described in detail shall show no burning, bubbling or other visual evidence of damage to their conductors or substrate material as a result of the fabrication process. With respect to printed wiring boards using Surface Mounted Technology (SMT), if the SMT assembly process is done at temperatures and times below the soldering limits, the boards may be accepted. If the SMT assembly process is conducted on-site with temperatures/times in excess of soldering limits or if the process is conducted off-site and the temperatures/times cannot be verified, a visual inspection is to be conducted as described in the Follow-Up Services Manual. The printed wiring boards should be inspected for mechanical damage or evidence of exposure to excessive temperatures that may have occurred during the soldering operation. If nonconforming features are found after visual inspection, the lot is to be rejected. Otherwise the use of printed wiring boards may continue without any interruption. If any instructions for SMT components are specified in the Follow-Up Service Procedure, then the above instructions are superseded.

E1.4 Glossary

For the purpose of this document the following definitions apply.

ALARM SIGNAL – An audible and visual signal intended to indicate a gas concentration in excess of the preset alarm level.

CARBON MONOXIDE (CO) – A colorless, odorless, highly poisonous gas, formed by the incomplete combustion of carbon.

ALARM, SINGLE STATION – An alarm device consisting of an assembly of electrical and mechanical components including a sensor or sensors, an audible alarm, and an optional visual alarm constructed to detect the presence of carbon monoxide gas. It is powered either from an external source by means of splice leads or a cord and plug arrangement or from an integral battery or batteries. It may have terminals for connection to a remote audible signaling appliance or accessory. It may also contain an integral transmitter for energizing a remote audible signaling appliance.

ALARM, MULTIPLE STATION – A single station alarm that may be interconnected with one or more other alarms for common alarm annunciation.

MANUFACTURER'S TEST PROGRAM – The tests described in Appendix D of this document are to be conducted by the manufacturer on a periodic or 100 percent basis, for which the manufacturer may be required to keep records.

RECOGNIZED COMPONENT – A part or 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.

PPM – Gas concentration in parts per million.

SENSITIVITY – The gas concentration versus time at or above which the device must initiate or remain in alarm.

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.

E1.5 Instructions for Inspection of Test Equipment

E1.5.1 Operation check

During every inspection visit, the dielectric voltage withstand test equipment should be checked to make certain it is operating properly.

E1.5.2 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 seconds.

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. USE EXTREME CAUTION.

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 and

2) Maximum: 120 percent of the required test voltage.

Note: The required test voltage varies based on whether the production line test time is 1 second or 1 minute. See Manufacturers Responsibilities and Requirements for Factory Test.

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 step (d).

f) If the dielectric test equipment indicates ″breakdown″ in 0.5 seconds or less after application of the required test voltage, the results are acceptable.

g) If the dielectric test equipment does not indicate a ″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.

E2 Instructions to UL Representative – Sample Selection

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. These samples shall be subjected to the Carbon Monoxide Sensitivity and Audibility Tests and at the rated voltage only. 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 ″Carbon Monoxide Sensitivity and Audibility Tests″.

b) For manufacturers with three or less families of alarms, select samples from one family each quarter until all families have been selected.

c) 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 and Audibility Test. The samples shall be properly tagged and identified along with the required data specified in this appendix (a copy of the completed Inspection Datasheet 3000-610G shall be attached), and forwarded to the Follow-Up Services Department at the Reviewing Office. Only samples that acceptably pass the Production Line Sensitivity Calibration and Audibility Tests shall be sent to the Reviewing Office.

E3 Instructions for Follow-Up Tests at UL

The samples forwarded to the UL Reviewing Office by the UL Representative in accordance with this Appendix shall be subjected to the following tests.

E3.1 Carbon monoxide sensitivity test

METHOD – The units shall be tested in accordance with UL 2034, Sensitivity Tests. The response times of samples 1 and 2 (as indicated by these instructions in this appendix) shall be recorded and compared to the maximum allowable time and concentration for carbon monoxide.

BASIS OF ACCEPTABILITY – The samples shall respond within the prescribed response time limits of sensing carbon monoxide per concentration of gas. The response time limits are within 60 to 240 minutes at 70 ±5 ppm, 10 to 50 minutes at 150 ±5 ppm and with 4 to 15 minutes at 400 ±10 ppm.

E3.2 Carbon monoxide audibility test

METHOD – The units shall be tested in accordance with the Audibility Test section of this standard. The decibel level shall be recorded for samples 1 and 2 and compared to the allowable decibel level.

BASIS OF ACCEPTABILITY – The samples shall produce a minimum of 85 decibels (db).

E4 Manufacturer's Responsibilities and Requirements for Factory Tests

E4.1 Manufacturer's responsibilities

The manufacturer's responsibility 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 markings that are understood to indicate acceptable 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, 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 Recognition Card must be checked to ensure 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 this Appendix.

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 from an off-site manufacturer's 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 tests performed, number of units tested, test results and action taken on rejections. Records for test performance shall be retained for six (6) months and shall be readily available for review by the UL Representative.

E4.2 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 carbon monoxide 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 Table E1.1. Samples for Follow-Up tests to be conducted at UL are to be selected in accordance with the instructions provided in this appendix.

Table E1.1
Sample selection index

Family	Product designation (Cat. No. or Model No.)	Rating	Procedure Section

E4.2.1 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).

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 V ac or less – either 1000 V ac (1414 dc) applied for 60 seconds or 1200 V ac (1697 V dc) applied for 1 second.

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

Test equipment – The equipment noted in the Dielectric Voltage-Withstand Test Equipment information included with this appendix has been evaluated with respect to the applicable requirements and is suitable for this test. The equipment used to perform the test shall provide the following features:

a) When the probes are touched together, there shall be either a visible or audible means of indicating an electrical breakdown to the operator.

b) There shall be either a manually resettable device to restore the equipment after electrical breakdown, or an automatic feature that rejects any nonconforming unit.

c) When a marking is used to indicate the test potential without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually resettable device has been reset following a dielectric breakdown.

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.

E4.2.2 Test equipment

E4.2.2.1 Production line dielectric voltage-withstand test

The manufacturer shall use the following equipment for this test. The following equipment has been evaluated with respect to the requirements expressed in this appendix and has been found suitable for this test:

a) Manufacturer________________

b) Identification Markings___________________

Exception: Based on engineering judgement this test is not required to be performed on the following products:

Product name	*Catalog number*	*Procedure section*

E4.2.2.2 Production line grounding continuity test

General – The manufacturer shall subject 100 percent of production of all products that have a power supply cord with a grounding conductor to a routine production-line grounding continuity test in accordance with the following.

Test equipment – Any suitable continuity indicating device (such as an ohmmeter, a battery and buzzer combination, or the like) may be used to determine compliance with the grounding continuity test requirements. An ohmmeter set on lowest impedance scale which is not to exceed 10 ohm maximum.

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.

E4.2.2.3 Electrical function and calibration

General – The following tests shall be performed on 100 percent of production.

Test equipment – The test equipment used by the manufacturer shall be as specified in this appendix.

Method – Each detector shall be subjected to a complete functional electrical test which shall verify the following:

a) Operation of alarm relays,

b) Operation of trouble relays, and

c) Audibility of signaling devices.

Alarm annunciation shall be verified by operation of the sensitivity test feature, or the electrical and/or mechanical equivalent.

The sensitivity of each alarm shall be calibrated to the sensitivity level indicated in this appendix.

Basis for acceptability – Each alarm and/or trouble relay shall operate.

<u>Electrical Function and Calibration:</u>

Family Designation

Test Equipment

Method

Basis of Acceptability

E4.2.3 Sensitivity calibration test

General – The sensitivity calibration 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.

Once per quarter the UL Representative shall select two samples for Follow-Up testing at UL. (See Instructions to UL Representative – Sample Selection.) These samples shall be ″1″ and ″2″.

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:

a) Ambient temperature

b) Relative humidity

c) Barometric pressure

d) Time of operation of alarm at 70 ppm of CO, 150 ppm of CO and 400 ppm of CO.

Test equipment – Refer to this appendix

Method – Refer to this appendix

Basis for acceptability – The selected samples shall respond with the following carbon monoxide gas concentration and time limits.

Single and Multiple-Station Carbon Monoxide Alarms (CZHF)	
Concentration of CO	**Maximum Alarm Time Response**
70 ±5 ppm	240 min (not less than 60 min)
150 ±5 ppm	50 min (not less than 10 min)
400 ±10 ppm	15 min (not less than 4 min)

Sensitivity Calibration Test:

Test Equipment:

Method:

Basis of Acceptability:

E4.2.4 Audibility test

General – The following test shall be performed on two samples per shift.

Test equipment – Refer to this appendix.

Method – Refer to this appendix.

Basis of acceptability – Refer to this appendix. The sound level meter reading should be equal to or greater than the decibel level indicated in this appendix.

Audibility Test:

Test Equipment:

Method:

Basis of Acceptability

E5 Annual market Survey of Carbon Monozide Alarms

Overview:

The UL Northbrook office will initiate an annual market survey of single and multiple stations carbon monoxide alarms. Samples will be selected from the market place by UL personnel and subjected to the Sensitivity test as described in this Standard.

Northbrook Office duties include, but are not limited to:

a) Initiating the annual market survey,

b) Obtaining samples from the marketplace,

c) Conducting the Sensitivity test,

d) Informing applicants of the market survey results for their respective alarms, and

e) Reporting to the applicant and UL's Consumer Affairs Department if nonconforming test results are found during the market survey.

Superseded requirements for
the Standard for
Single and Multiple Station Carbon Monoxide Alarms

2034, Third Edition

The requirements shown are the current requirements that have been superseded by requirements in this edition. The numbers in parentheses refer to the new requirements with future effective dates that have superseded these requirements. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

3.5 (3.7) COMPONENT, LIMITED LIFE – A component that is expected to fail, but provides a minimum of one year service, and be periodically replaced and whose failure is supervised, if failure of the component affects normal operation or sensitivity. Typical examples of such components include incandescent lamps, electronic tube heaters, functional heating elements, sensors, and batteries. See also 37.4.1.

37.1.1 (38.1.1) A carbon monoxide alarm 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, or

c) A ground fault in any externally connected wiring.

71.3 (71.3) During each test condition, the alarm is to be connected to a source of rated voltage or battery.

72A.2.1 (75.2.1) Immediately following each of the conditions specified in 72A.2.3 – 72A.2.15, an alarm shall operate in accordance with the levels specified in Table 38.1. When specified by the manufacturer, it is not prohibited that the alarms be warmed-up prior to the calibration check.

72A.7.1 (75.7.1) In addition to the applicable requirements in Section 79, a carbon monoxide alarm for use in a Recreational Boat shall be permanently and legibly marked with the following information. The markings shall be in a contrasting color, finish, or equivalent, in letters at least 3/64 inch (1.2 mm) high. Items (f) and (g) shall be readily visible after installation:

a) Manufacturer’s or private labeler’s name or identifying symbol;

b) Model, type, or catalog designation;

c) Date of manufacture (in code is not prohibited);

d) Electrical rating in volts and amperes;

e) Reference to owner’s manual;

f) The type of product, such as ″Carbon Monoxide Alarm,″ or the equivalent. It is not prohibited that this marking be incorporated in item (g); and

g) Identification of switches and light indicators.

74A.1.1 (78.1.1) Reliability for Supervised Failures: CO detectors 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.

74A.1.2 (78.1.2) Reliability for Unsupervised Failures: CO detectors 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.

74A.2.3 (78.2.3) 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 alarms 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.

79.1 (83.1) An alarm shall be permanently marked on a Class IIIC marking material with the following information unless specifically indicated that it appears on the installation wiring diagram. The marking shall be in a contrasting color, finish, or equivalent. Unless the letter height is specified, all markings shall be at least 3/64 inch (1.2 mm) high.

a) Name or identifying symbol and address of the manufacturer or private labeler.

b) Model number and date of manufacture. The date of manufacture shall be non-coded and in the format YEAR (in 4 digits), MONTH (in letters), and DAY (in 2 digits) located on the outside surface of the CO alarm.

c) Electrical rating, in volts, amperes, or watts, and frequency.

Exception: Not required for battery operated alarms.

d) Correct mounting position if a unit is intended to be mounted in a definite position. As an alternative, the correct mounting position shall appear in the installation instructions.

e) Identification of the product (carbon monoxide alarm shall be marked in contrasting color from the background on the face of the unit), lights, switches, and meters, regarding their function unless their function is obvious. The following message shall be located adjacent to the visual indicator for alarm: ″Move to fresh air.″

f) Maximum rating of fuse in each fuseholder.

g) Identification of spare lamps and batteries by part number, manufacturer's model number or equivalent, located adjacent to the component.

h) Reference to an installation diagram or owner's manual, or both.

i) The following warning shall be placed on the carbon monoxide alarm. The warning label shall be of Class IIIC marking material. The hazard symbol and letters used for the word ″WARNING″ shall be boldfaced type having a minimum uppercase letter height of 0.120 inch (3.05 mm). The minimum vertical spacing between lines of type shall be 0.046 inch (1.17 mm). (These dimensions correspond to 12 point type.) Lowercase letters shall be compatible with the uppercase letter specification.

⚠ ″WARNING″

″Carbon Monoxide cannot be seen or smelled but can kill you.

If alarm signal sounds:

1) Operate reset/silence button.

2) Call your emergency services (fire department or 911).

3) Immediately move to fresh air – outdoors or by an open door/window.″

j) An alarm not intended to be painted in use shall be marked on the outer surface of the enclosure with the following or equivalent notice: ″Do Not Paint.″ The letters shall not be less than 1/8 inch (3.2 mm) high and shall be located so as to be readily visible after the is mounted in its intended manner. See the Paint Loading Test, Section 62.

k) The following or equivalent qualifying statement on a battery-operated alarm where battery operation, under other than normal room temperature conditions during the long term battery tests, is less than 12 months but not less than 6 months. Applicable wording is to be used.

″CONSTANT EXPOSURES TO HIGH OR LOW TEMPERATURES OR HIGH HUMIDITY MAY REDUCE BATTERY LIFE.″

l) Distinction between alarm and trouble signals on units employing these signals.

m) Reference to a source for battery replacement. As an alternative, this information shall appear in the users manual.

n) For a battery operated alarm, the word ″WARNING″ and the following or equivalent marking shall be included on the unit: ″Use Only Batteries Specified In Marking. Use Of A Different Battery May Have A Detrimental Effect On Alarm Operation.″ The letter height shall be a minimum of 1/8 inch (3.2 mm) for ″WARNING″ and 3/64 inch (1.2 mm) for the rest of the notice.

o) For an alarm employing a nonrechargeable standby battery the marking information described in 13.1, 13.3, and 13.4 shall be in letters not less than 1/8 inch (3.2 mm) high.

p) Test instructions and frequency. Not less than once per week for battery-powered alarms and not less than once per month for other than battery-powered alarms.

q) Maintenance instructions, such as cleaning, lamp, and battery replacement.

r) Name and address of firm to whom alarm is to be sent for servicing.

s) Sealed units intended to be returned to the manufacturer for servicing shall be marked as follows on the outside of the alarm: ″RETURN TO (+) FOR SERVICING,″ or equivalent. Units on which the cover is removable but that are also intended to be returned to the manufacturer for servicing may have the marking on the inside of the alarm.

(+) Name and address of manufacturer or supplier

t) An AC operated alarm without a standby battery shall be marked with the word ″WARNING″ and the following: ″UNIT WILL NOT OPERATE DURING POWER FAILURE, AND DO NOT INSTALL IN A WALL SWITCH CONTROLLED OUTLET.″ The marking shall be in a location on the unit that is visible after installation. The letter height for the word ″WARNING″ shall be minimum 1/8 inch (3.2 mm).

u) The sensitivity setting for an alarm having a fixed setting. If an alarm is intended to be adjusted in the field, the range of sensitivity shall be indicated. The marked sensitivity shall be indicated by ppm and time.

80.1 (84.1) Each single and multiple station carbon monoxide alarm shall be provided with installation instructions which shall include the following information:

a) Typical installation drawing layouts for the unit(s) indicating locations and wiring methods which shall be in accordance with the National Electrical Code or Canadian Electrical Code. Locations where alarms are not to be installed shall also be included.

b) Description of the operation, testing, and proper maintenance procedures for the unit(s).

c) Replacement parts, such as lamps or batteries, shall be identified in the instructions by a part number, manufacturer's model number, or the equivalent, and information included as to where parts are obtainable.

d) The hazard symbol ⚠ , the word ″WARNING,″ and at least the following or equivalent information in an obvious and prominent manner, such as by being underlined, encircled, or printed in larger or different color type. The letters used for the word ″warning″ shall be boldfaced in a color that contrasts with the background and shall be a minimum size of 18 points or a minimum of 1.5 times larger than the safety message letters. The letters used for the safety message words shall be boldfaced Helvetica type with a minimum size of 12 points. Lowercase letters shall be compatible with the uppercase letter specification. The safety message shall be separate and distinct from the other messages and graphics in the owner's manual.

⚠ ″WARNING″

″Actuation of your CO alarm indicates the presence of carbon monoxide (CO) which can KILL YOU. If alarm signal sounds:

1) Operate reset/silence button;

2) Call your emergency services (Telephone Number) [fire department or 911];

3) Immediately move to fresh air – outdoors or by an open door/window. Do a head count to check that all persons are accounted for. Do not reenter the premises nor move away from the open door/window until the emergency services responders have arrived, the premises have been aired out, and your alarm remains in its normal condition.

4) After following steps 1 – 3, if your alarm reactivates within a 24 hour period, repeat steps 1 – 3 and call a qualified appliance technician (Telephone Number) to investigate for sources of CO from fuel burning equipment and appliances, and inspect for proper operation of this equipment. If problems are identified during this inspection have the equipment serviced immediately. Note any combustion equipment not inspected by the technician and consult the manufacturers' instructions, or contact the manufacturers directly, for more information about CO safety and this equipment. Make sure that motor vehicles are not, and have not been, operating in an attached garage or adjacent to the residence.

e) This carbon monoxide alarm is designed to detect carbon monoxide gas from ANY source of combustion. It is NOT designed to detect smoke, fire or any other gas, unless the product has been investigated and determined to comply with the applicable requirements.

f) More detailed information on the alarm and trouble signals and an indication where false alarms or trouble signals would be anticipated; such as to reduce the possibility of nuisance tripping of the alarm's alarm circuit, the instructions shall state that accommodation spaces are to be well ventilated when household cleaning supplies or similar contaminants are used.

g) Identification of the users manual or instruction sheet by number or equivalent.

h) An indication that the device shall not be installed in locations where the normal ambient temperature is below 4.4°C (40°F) or exceeds 37.8°C (100°F), unless the alarm has been determined to be acceptable for installation at a higher or lower ambient temperature.

i) Reference to a source(s) of limited energy cable for multiple station interconnection or connection of supplementary devices.

j) The following symptoms are related to CARBON MONOXIDE POISONING and are to be discussed with ALL members of the household:

1) Mild Exposure: Slight headache, nausea, vomiting, fatigue (often described as ″Flu-like″ symptoms).

2) Medium Exposure: Severe throbbing headache, drowsiness, confusion, fast heart rate.

3) Extreme Exposure: Unconsciousness, convulsions, cardiorespiratory failure, death.

4) Many cases of reported CARBON MONOXIDE POISONING indicate that while victims are aware they are not well, they become so disoriented they are unable to save themselves by either exiting the building or calling for assistance. Young children and household pets are typically the first affected.

k) The following information:

1) Name and address of manufacturer or private labeler.

2) Model number.

3) Electrical rating in volts, amperes or watts, and frequency. Not required for battery operated alarms.

4) Name and address of firm to whom alarm is to be sent for servicing.

l) For alarm-transmitters intended to be installed with compatible audible signal receiver units, instructions shall include the limitations of use in typical single level and multilevel dwelling units as well as in apartment buildings where adjacent apartments may have similar systems.

m) For alarms also acceptable for installation in recreational vehicles, the word ″WARNING,″ and the following or equivalent text: ″TEST ALARM OPERATION AFTER VEHICLE HAS BEEN IN STORAGE, BEFORE EACH TRIP, AND AT LEAST ONCE PER WEEK DURING USE.″ A label with identical marking is to be provided by the alarm manufacturer, with instructions that it be permanently and visibly located within 24 inches (610 mm) of the alarm.

n) The word ″WARNING″ and the following or equivalent text: ″ This product is intended for use in ordinary indoor locations of family living units. It is not designed to measure compliance with Occupational Safety and Health Administration (OSHA) commercial or industrial standards.″

Exception: If a manufacturer chooses a concentration level below 70 ppm for the tests in this standard it is not prohibited that the warning be revised to reflect actual testing.

o) The word ″CAUTION″ and the following or equivalent: ″This alarm will only indicate the presence of carbon monoxide gas at the sensor. Carbon monoxide gas may be present in other areas.″

p) The instructions shall also state that individuals with medical problems may consider using warning devices which provide audible and visual signals for carbon monoxide concentrations under 30 ppm.

q) A statement shall be provided to specify that the alarm, including a sensor, is not to be located within 5 feet (1.5 m) of any cooking appliance.

r) More detailed information on conditions which can result in transient CO situations, such as:

1) Excessive spillage or reverse venting of fuel burning appliances caused by:

i) Outdoor ambient conditions such as wind direction and/or velocity, including high gusts of wind; heavy air in the vent pipes (cold/humid air with extended periods between cycles).

ii) Negative pressure differential resulting from the use of exhaust fans.

iii) Simultaneous operation of several fuel burning appliances competing for limited internal air.

iv) Vent pipe connection vibrating loose from clothes dryers, furnaces, or water heaters.

v) Obstructions in or unconventional vent pipe designs which amplify the above situations.

2) Extended operation of unvented fuel burning devices (range, oven, fireplace, etc.).

3) Temperature inversions which can trap exhaust gasses near the ground.

4) Car idling in an open or closed attached garage, or near a home.

s) A minimum of two self-adhesive labels with the information as described in 80.1 (d) shall be provided by the alarm manufacturer. Directions shall instruct the user of the alarm to add the telephone numbers of their emergency service provider and a qualified technician to the labels. Instructions shall be given for the user of the alarm to place one label next to the alarm, and the other label near a source of fresh air where they plan to gather after the alarm indicates the presence of carbon monoxide.

80.3 (84.3) The material shipped with the alarm, including the package, instructions, or user's manual, shall not include information other than that specified in 80.1, such as manufacturer's claims on the operation of the alarm which have not been substantiated by the performance tests included in this or other standards. The package, instructions, and user's manual shall include the information described in 80.1 (c), (k), (n), and (p).

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