

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

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

Second Edition, Dated October 29, 1996

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

Future Effective Date	References
May 14, 2003	Paragraphs 45.2.1, 45.2.2, 64.1, 64A.1, 64A.2, 64A.3, 64A.4, 64A.5, 64A.6, 64A.7, 64A.8, 64A.9, 74A.1.1, 74A.1.2, 74A.2.1, 74A.2.2, 74A.2.3, 74A.2.4, and 74A.3.1 Tables 39.1, 64A.1, 64A.2, and 64A.3 Figure 64A.1
November 14, 2003	48.4.2

The new and/or revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated September 2, 1999, October 29, 1999, March 15, 2000, May 3, 2000 and March 14, 2001. These bulletins are now obsolete and may be discarded.

These revisions also include editorial changes for clarification only.

The revisions dated November 14, 2001 include a reprinted title page (page1) for this Standard.

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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.

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

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. 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.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

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.

1.1 revised November 14, 2001

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 38.1, Part A, Alarm – carbon monoxide concentration and response time.

1.2 revised November 14, 2001

1.2.1 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 38.1, Part B, False alarm resistance specifications.

Added 1.2.1 effective October 1, 1998

1.3 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 34.2.1.

1.3 revised October 15, 1997

1.4 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 Protective 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.

1.4 revised June 2, 1999

1.5 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.

1.5 revised November 14, 2001

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.

2.1.2 revised November 14, 2001

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

2.1.3 revised November 14, 2001

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.

2.1.4 revised November 14, 2001

2.2 Units of measurement

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

2.2.1 revised November 14, 2001

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 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 $\pm$ 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.

Revised 3.2 effective October 1, 1998

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

3.4 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.

3.5 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.

3.5 revised October 15, 1997

3.6 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.

3.6.1 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.

3.6.1 added June 2, 1999

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

3.7 revised November 14, 2001

3.8 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.

3.8 revised November 14, 2001

3.9 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.

3.9 revised November 14, 2001

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

Added 3.9.1 effective October 1, 1998

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

Added 3.9.2 effective October 1, 1998

3.10 PPM – Gas concentration in parts per million.

3.10.1 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.

Revised 3.10.1 effective October 1, 1999

3.11 Relocated to Supplement SB November 14, 2001

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

3.12 revised October 15, 1997

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

3.13 revised October 15, 1997

3.14 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.

3.14 revised October 15, 1997

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

3.15 revised October 15, 1997

3.16 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.

3.16 revised October 15, 1997

3.17 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.)

3.17 revised November 14, 2001

3.18 Relocated as 7A.1 November 14, 2001

3.19 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).

Revised 3.19 effective October 1, 1998

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

3.20 added June 2, 1999

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.

4.1 revised November 14, 2001

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.

4.2 revised November 14, 2001

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.

4.3 revised November 14, 2001

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.)

4.4 revised November 14, 2001

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 38.1 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 37. All predicted failure modes shall result in a trouble signal.

4.5 added October 15, 1997

5 Installation and Operating Instructions for Evaluation

5.1 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.

5.1 revised November 14, 2001

5.2 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 80.

5.2 revised October 15, 1997

6 Battery Removal Indicator

6.1 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.

6.2 If a warning flag, or equivalent, is employed to comply with the requirement of 6.1, it shall be marked as required in 79.6.

7 Alarm Reset/Silence Button

7.1 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 38. 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.

Revised 7.1 effective October 1, 1998

7A Voltage Classification

7A.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.

3.18 relocated as 7A.1 November 14, 2001

CONSTRUCTION

8 General

8.1 Accessories

8.1.1 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.

8.1.1 revised October 15, 1997

8.2 Sensitivity adjustment

8.2.1 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 38.1.

8.2.1 revised November 14, 2001

8.3 Supplementary signaling feature

8.3.1 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.

8.3.1 revised October 15, 1997

9 Service and Maintenance Protection

9.1 General

9.1.1 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.

9.1.1 revised November 14, 2001

9.1.2 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.

9.1.2 revised October 15, 1997

9.1.3 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.

9.2 Sharp edges

9.2.1 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.

9.2.1 revised October 15, 1997

10 Enclosure

10.1 General

10.1.1 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.

10.1.1 revised November 14, 2001

10.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two are to be considered in determining compliance with the requirement of 10.1.1.

10.1.3 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.

10.1.3 revised October 15, 1997

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

10.1.4 revised November 14, 2001

10.1.5 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.

10.1.5 revised November 14, 2001

10.1.6 To comply with 10.1.4 and 10.1.5, 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.

10.1.6 revised November 14, 2001

10.1.7 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.

10.1.7 revised October 15, 1997

10.1.8 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.

10.1.9 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 72A.2.5– 72A.2.13.

10.1.9 added June 2, 1999

10.1.10 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.

10.1.10 added June 2, 1999

10.1.11 Materials which are to be exposed to moist environments shall not be adversely affected when subjected to the humidity conditioning specified in 72A.2.14 and 72A.2.15.

10.1.11 added June 2, 1999

10.2 Cast metal enclosures

10.2.1 The thickness of cast metal for an enclosure shall be as indicated in Table 10.1. Cast metal having a thickness 1/32 inch (0.8 mm) less than that indicated in Table 10.1 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.

10.2.1 revised November 14, 2001

Table 10.1
Cast metal enclosures

Table 10.1 revised November 14, 2001

Use, or dimensions of area involved	Minimum thickness			
	Die-cast metal,		Cast metal of other than the	
	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.				

10.2.2 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.

10.2.2 revised November 14, 2001

10.2.3 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.

10.3 Sheet metal enclosures

10.3.1 The thickness of sheet metal employed for the enclosure of an alarm shall not be less than that indicated in Table 10.2 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.

10.3.1 revised November 14, 2001

10.3.2 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 10.2
Sheet metal enclosures

Maximum dimensions of enclosure				Minimum thickness of sheet metal					
				Steel				Brass or aluminum,	
Length or width, inches	(mm)	Area, inches ²	(cm ²)	Zinc-coated, inch	(mm)	Uncoated, 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

10.3.3 A ferrous plate or plug closure for an unused conduit opening or other hole in the enclosure shall have a thickness not less than 0.027 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.

10.3.4 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.

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

10.3.6 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 33.

10.3.6 revised November 14, 2001

10.4 Nonmetallic enclosures

10.4.1 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 10.2. See also the Tests of Thermoplastic Materials, Section 61.

10.4.1 revised November 14, 2001

10.4.2 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.

10.4.2 revised November 14, 2001

10.4.3 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.

10.4.3 revised December 21, 1998

10.5 Ventilating openings

10.5.1 Ventilating openings in an enclosure for hazardous-voltage circuits including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening permits passage of a rod having a diameter of 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.

10.5.1 revised November 14, 2001

10.5.2 Except as noted in 10.5.3, 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.

10.5.3 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 cm²) and has no dimension greater than 12 inches (305 mm²) or
- b) The width of an opening so protected is not greater than 3-1/2 inches (88.9 mm).

10.5.3 revised November 14, 2001

10.5.4 The wires forming a screen protecting hazardous-voltage parts shall not be smaller than No. 16 AWG (1.3 mm²) and the screen openings shall not be greater than 1/2 square inch (3.2 cm²) in.

10.6 Covers

10.6.1 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.

10.6.1 revised October 15, 1997

10.6.2 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.

10.6.2 revised November 14, 2001

10.6.3 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 79.1(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.

10.6.3 revised October 15, 1997

10.6.4 A hinged cover is not required where the only fuse(s) enclosed is intended to provide protection to portions of internal circuits, such as 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."

10.6.4 revised November 14, 2001

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

10.7 Transparent panels

10.7.1 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 10.3.

Table 10.3
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.					

10.7.2 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.

10.7.2 revised November 14, 2001

10.7.3 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 35 – 67) of this standard.

10.7.3 revised October 15, 1997

11 Corrosion Protection

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

11.2 The requirement of 11.1 applies to all sheet steel or cast iron enclosures, and to all springs and other parts upon which mechanical operation depends. It does not apply to minor parts, such as washers, screws, and bolts, 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.

11.2 revised November 14, 2001

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

11.4 Hinges and other attachments shall be resistant to corrosion.

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

11.5 revised November 14, 2001

POWER SUPPLY

12 Primary Power Supply

12.1 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 10.1.8) 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.

12.1 revised October 15, 1997

12.2 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.

12.2 revised November 14, 2001

13 Secondary Power Supply

13.1 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.

13.1 revised November 14, 2001

13.2 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.

13.2 revised November 14, 2001

13.3 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.

13.3 revised November 14, 2001

13.4 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) *Deleted*

c) Monitored battery where a trouble indication, as described in 37.1.3, is obtained.

13.4 revised November 14, 2001

14 Batteries

14.1 General

14.1.1 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 59.

14.1.1 revised October 15, 1997

14.1.2 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.

14.1.2 revised October 15, 1997

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

14.1.4 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.

14.1.4 revised October 15, 1997

14.1.5 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.

14.1.5 revised November 14, 2001

14.2 Battery connections

14.2.1 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.

14.2.1 revised November 14, 2001

14.2.2 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 unplated or plated metal which is resistant to the corrosive action of the electrolyte.

14.2.3 Each lead of a clip-lead assembly employed as part of a battery operated alarm shall be a minimum of No. 26 AWG (0.21 mm²) stranded wire with a minimum 1/64-inch (0.4-mm) insulation.

14.2.3 revised October 15, 1997

15 Supplementary Signaling Circuits

15.1 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 66.2.1 and 66.2.2.

15.1 revised October 15, 1997

15.2 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 66.2.1 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).

15.2 revised November 14, 2001

FIELD WIRING

16 Permanent Connection

16.1 General

16.1.1 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.

16.1.1 revised October 15, 1997

16.2 Field-wiring compartment for hazardous voltage connection

16.2.1 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.

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

16.3 Field-wiring terminals

16.3.1 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.

16.3.1 revised November 14, 2001

16.3.2 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).

16.3.3 Except as noted in 16.3.4, 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.

16.3.4 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.

16.3.4 revised November 14, 2001

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

16.3.5 added October 15, 1997

16.4 Field-wiring leads

16.4.1 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 No. 18 AWG (0.82 mm²); 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 No. 26 AWG (0.13 mm²) 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 65; and*
- d) The installation instructions indicate that the lead cannot be spliced to a conductor larger than No. 18 AWG.*

16.4.1 revised October 15, 1997

16.4.2 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 No. 16 AWG (1.3 mm²), for a single conductor, No. 19 AWG (0.65 mm²) for two or more conductors, and No. 26 AWG (0.13 mm²) 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 No. 18 AWG (0.82 mm²) and larger conductors.

16.4.2 revised November 14, 2001

16.5 Grounded supply terminals and leads

16.5.1 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.

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

16.5.3 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.

17 Power Supply Cord

17.1 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.*

17.1 revised October 15, 1997

17.2 The flexible cord shall be of Type SP-1, SPT-1, SP-2, SPT-2, SV, SVT, SJ, SJT, SPE, SVE, or equivalent, minimum No. 18 AWG (0.82 mm²). 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).

17.2 revised October 15, 1997

17.3 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.

17.3 revised November 14, 2001

17.4 A smoothly rounded restraining means shall be provided for securing the attachment plug to the receptacle. See the Strain Relief Test, Section 65.

17.4 revised October 15, 1997

17.5 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 65.

17.5 added October 15, 1997

17.6 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.

17.6 added October 15, 1997

17.7 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.

17.7 added October 15, 1997

18 Equipment Grounding

18.1 General

18.1.1 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.

18.1.1 revised November 14, 2001

18.1.2 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.

18.1.2 revised November 14, 2001

18.2 Permanently-connected units

18.2.1 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.

18.2.1 revised November 14, 2001

18.3 Cord-connected units

18.3.1 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.

18.3.1 revised October 15, 1997

19 Remote Power Supply Leads

19.1 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 No. 18 AWG (0.82 mm²) and shall not be longer than 20 feet (6.1 m). The interconnecting wiring is to be provided by the manufacturer.

19.1 revised October 15, 1997

19.2 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.

19.2 revised November 14, 2001

INTERNAL WIRING

20 General

20.1 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.

20.1 revised November 14, 2001

20.2 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.

20.3 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).

20.3 revised November 14, 2001

20.4 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.

20.4 revised November 14, 2001

20.5 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.

21 Wireways

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

21.1 revised November 14, 2001

22 Splices

22.1 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.

22.1 revised November 14, 2001

22.2 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.

22.3 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.

23 Barriers

23.1 A metal barrier shall have a thickness at least equal to that required by Table 10.2, 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).

24 Grounding and Bonding

24.1 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.

24.1 revised November 14, 2001

24.2 Except as indicated in 24.3, 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.

24.2 revised November 14, 2001

24.3 Metal parts as described below, are not required to comply with the requirement of 24.1 and 24.2:

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.

24.3 revised November 14, 2001

24.4 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.

24.5 A bolted or screwed connection that incorporates a star washer or serration under the screwhead is acceptable for penetrating nonconductive coatings as required by 24.4.

24.6 The use of two or more screws, or two full threads engagement of a single screw in metal, complies with 24.4 if the bonding means depends upon screw threads.

24.7 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.

24.7 revised November 14, 2001

24.8 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.

24.8 revised October 15, 1997

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

24.10 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.

24.10 revised November 14, 2001

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

ELECTRICAL COMPONENTS

25 General

25.1 Mounting of components

25.1.1 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 33.

25.1.1 revised November 14, 2001

25.1.2 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.

25.1.3 Uninsulated live parts, for example field-wiring terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they 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.

25.1.3 revised November 14, 2001

25.2 Operating components

25.2.1 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.

25.2.1 revised November 14, 2001

25.2.2 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.

25.2.2 revised November 14, 2001

25.3 Current-carrying parts

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

25.3.1 revised November 14, 2001

25.4 Electrical insulating material

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

25.4.2 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.

25.4.2 revised November 14, 2001

25.4.3 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 25.4.1.

25.4.3 revised November 14, 2001

25.4.4 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.

25.4.4 revised November 14, 2001

25.4.5 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.

25.4.5 revised November 14, 2001

25.4.6 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).

26 Bushings

26.1 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.

26.1 revised November 14, 2001

26.2 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.

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

26.3 revised November 14, 2001

26.4 Fiber shall be employed only where:

- a) It is not subjected to a temperature higher than 90°C (194°F) under normal operating conditions,
- b) The bushing is not less than 1/16 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.

26.4 revised November 14, 2001

26.5 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.

26.5 revised November 14, 2001

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

26.6 revised November 14, 2001

27 Lampholders and Lamps

27.1 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.

27.1 revised October 15, 1997

27.2 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.

27.2 revised October 15, 1997

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

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

27.5 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.

27.6 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.

27.6 revised October 15, 1997

28 Protective Devices

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

29 Printed-Wiring Boards

29.1 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 33.1). 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.

29.2 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.

29.2 added June 2, 1999

30 Switches

30.1 A switch shall have a current and voltage rating not less than that of the circuit which it controls.

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

31 Transformers and Coils

31.1 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 16.5.1 and 16.5.2.

31.1 revised November 14, 2001

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

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

32 Dropping Resistors

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

32.1 revised October 15, 1997

33 Spacings

33.1 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 33.1.

33.2 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 33.1.

33.3 The "Through air" and "Over surface" spacings of Table 33.1 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.

33.4 The spacing requirements in Table 33.1 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 33.1.

33.4 revised October 15, 1997

33.5 The "To wall of enclosure" spacings of Table 33.1 are not to be applied to an individual enclosure of a component part within an outer enclosure.

33.6 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 33.1
Minimum spacings

Table 33.1 revised November 14, 2001

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 No. 16 AWG (1.3 mm²).

^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

34 General

34.1 Test units and data

34.1.1 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.

34.1.1 revised October 15, 1997

34.1.2 Revised and relocated as 34.1.6 October 15, 1997

34.1.3 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 5.1 and 5.2 and Section 80).
- 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.

34.1.3 revised November 14, 2001

34.1.4 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 59.)

34.1.4 added October 15, 1997

34.1.5 Before, during, and after the tests specified in Sections 38, 39, 41, 45, and 46 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.

34.1.5 added October 15, 1997

34.1.6 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.

34.1.6 revised November 14, 2001

34.2 Accessories

34.2.1 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 35;
- b) Circuit Measurement Test, Section 36;
- c) Temperature Test, Section 42;
- d) Overload Test, Section 43;
- e) Endurance Test, Section 44;
- f) Variable Ambient Temperature Test, Section 45;
- g) Humidity Test, Section 46A;
- h) Leakage Current Test, Section 47;
- i) Transient Tests, Section 48;
- j) Dielectric Voltage-Withstand Test, Section 49;
- k) Overvoltage Test, Section 51;
- l) Undervoltage Test, Section 52;
- m) Jarring Test, Section 57;
- n) Audibility Test, Section 60;
- o) Tests of Thermoplastic Materials, Section 61; and
- p) Drop Test, Section 67 (portable appliance only).

Revised 34.2.1 effective October 1, 1998

34.3 Test voltages

34.3.1 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

34.3.1 revised October 15, 1997

34.3.2 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 5.1 and 5.2 and Section 80).
- 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.

34.3.2 revised November 14, 2001

34.3.3 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 59.)

34.3.3 revised October 15, 1997

34.4 Component reliability data

34.4.1 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.

34.4.1 revised October 15, 1997

34.4.2 The data required by 34.4.1 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 42.1.
- 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.

34.4.2 revised November 14, 2001

35 Normal Operation Test

35.1 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.

35.1 revised October 15, 1997

35.2 The test voltage is to be in accordance with 34.3.1. 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.

35.2 revised October 15, 1997

35.3 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.

Revised 35.3 effective October 1, 1998

35.4 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.

35.4 revised October 15, 1997

35.5 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 27.6.

35.5 revised October 15, 1997

35.6 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 80.1 (I) 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.

35.6 revised November 14, 2001