UL 1484

STANDARD FOR SAFETY

Residential Gas Detectors

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UL Standard for Safety for Residential Gas Detectors, UL 1484

Fourth Edition, Dated December 28, 2000

Summary of Topics

Reaffirmation and Continuance of the Fourth Edition of the Standard for Residential Gas Detectors, UL 1484, as an American National Standard.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated November 16, 2012.

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UL 1484

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Fourth Edition

December 28, 2000

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The most recent designation of ANSI/UL 1484 as a Reaffirmed American National Standard (ANS) occurred on January 17, 2013. 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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CONTENTS

INTRODUCTION

1 Scope 9
2 General 9
2.1 Components 9
2.2 Units of measurement 10
2.3 Undated references 10
2.4 Terminology 10
3 Glossary 10
4 Detector Reliability Prediction 11
4A Lifetime 12
5 Installation and Operating Instructions 12

CONSTRUCTION

ASSEMBLY

6 Product Assembly 12A
7 Detection-Threshold Adjustment 12A
8 Supplementary Signaling Feature 12A
9 Sharp Edges 12A
10 Enclosures 13
10.1 General 13
10.2 Electrical component enclosures 13
10.3 Sheet metal enclosures 13
10.4 Cast metal enclosures 14
10.5 Nonmetallic enclosures 14
10.6 Product mounting 15
10.7 Ventilating openings 15
10.8 Screens and expanded metal 15
10.9 Glass panels 16
11 Protection Against Corrosion 17

FIELD-WIRING CONNECTIONS

12 General 17
13 Cord-Connected Products 18
14 Permanently Connected Products 18
14.1 General 18
14.2 Field-wiring compartment 19
14.3 Field-wiring terminals 19
14.4 Field-wiring leads 19
14.5 Grounded supply terminals and leads 20
15 Supplementary Signaling Circuits 20
16 Grounding 20

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INTERNAL WIRING

17 General 21
18 Wiring Methods 21
18.1 Wireways 21
18.2 Splices 21
18.3 Bushings 22
18.4 Barriers 22
19 Separation of Circuits 22
20 Bonding for Grounding 23

ELECTRICAL COMPONENTS

21 General 23
21.1 Mounting of components 23
21.2 Insulating materials 24
21.3 Uninsulated live parts 25
21.4 Current-carrying parts 25
22 Lampholders and Lamps 25
23 Printed-Wiring Boards 26
24 Protective Devices 26
25 Switches 26
26 Transformers 26

SPACINGS

27 General 27

PERFORMANCE

GENERAL

28 Samples and Data for Test 30
29 Test Voltages 32

TESTS

30 Normal Operation Test 33
31 Input-Measurement Test 33
32 Electrical-Supervision Test 33
32.1 General 33
32.2 Power loss 34
32.3 Power interruption 34
32.4 Silencing means 34
32.5 Component failure 34
33 Temperature Test 35
34 Dielectric Voltage-Withstand Test 38
35 Abnormal-Operation Test 38
36 Overload Test 39
36.1 Detector 39
36.2 Separately energized circuits 39
37 Endurance Test 39
37.1 Detector 39

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37.2 Separately energized circuits 40
37.3 Audible signaling appliance 40
38 Audibility Test 40
39 Leakage Current Test 41
40 Tests of Thermoplastic Materials 43
40.1 General 43
40.2 Accelerated air-oven aging test 43
40.3 Flame test 43
41 Power Supply Tests 44
41.1 General 44
41.2 VA capacity 44
41.3 Burnout test 44
41A Polarity Reversal Test 44
41B Electric Shock Current Test 44A
42 Ignition Test 44G
43 Detection Threshold Tests 45
43.1 General 45
43.2 Overvoltage test 48
43.3 Undervoltage test 48
43.4 Variable ambient test – all gas detectors 48
43.5 Variable ambient test – RV gas detectors 49
43.6 Humidity test 49
43.7 Effect of shipping and storage 49
43.8 Transient tests 50
43.9 Stability tests 54
43.10 Jarring test 55
43.11 Static discharge test 55
43.12 Dust test 56
43.13 Vibration test – all gas detectors 56
43.14 Vibration test – RV gas detectors 57
43.15 Corrosion test – all gas detectors 57
43.16 Corrosion (salt spray) test – RV gas detectors 58
43.17 Contamination test (cooking by-products) – all gas detectors 58
44 Permanence of Marking Tests 60
45 Strain-Relief Test 60
45.1 General 60
45.2 Power supply cord 60
45.3 Field-wiring leads 60

MANUFACTURING AND PRODUCTION TESTS

46 General 61
47 Production-Line Detection-Threshold Calibration Tests 61
48 Production-Line Dielectric Voltage-Withstand Test 61
49 Production-Line Grounding Continuity Tests 62

MARKING

50 General 62

INSTRUCTIONS

51 General 63

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SUPPLEMENT SA - RELIABILITY AND FAILURE RATE DETERMINATION INFORMATION

GENERAL

SA1 Instructions for Determining a Reliability Prediction for Gas Detectors SA1
SA2 Methods of Determining Failure Rate SA2
SA3 Maximum Detector Failure Rates SA12

CRITERIA FOR ACCEPTANCE OF MICROELECTRONIC DEVICES

SA4 General SA13
SA5 Quality-Assurance-Screening Program SA13
SA6 Determination of Failure Rate Number Supplemented by Burn-In Test SA15
SA6.1 General SA15
SA6.2 Determination sequence SA15
SA6.3 Test calculations and procedures SA15
SA6.4 Test conditions SA17
SA6.5 Failure-rate number calculation SA18

APPENDIX A

Standards for Components. A1

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INTRODUCTION

1 Scope

1.1 These requirements cover electrically operated gas detectors intended for installation in residential occupancies and recreational vehicles (RVs).

1.2 These requirements cover gas detectors intended to detect flammable gases such as propane and natural gas.

1.3 These requirements also cover all remote accessories that may be connected to a gas detector.

1.4 These requirements do not cover gas detectors for use in hazardous locations, as defined by the National Electrical Code, NFPA 70, for industrial or commercial use, or for use as smoke and fire detectors.

1.5 Deleted August 24, 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 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.

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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.

2.4 Terminology

2.4.1 The term ″product″ as used in these requirements refers to all or any part of a product covered by these requirements unless specifically noted otherwise.

3 Glossary

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

3.2 ALARM SIGNAL – A signal intended to indicate a gas concentration in excess of the preset detector alarm level.

3.3 COMPONENTS:

a) Nonreliable Component – A component that is expected to fail and be periodically replaced and the failure of which is supervised. Typical examples of such components include incandescent lamps, electronic tube heaters, and functional heating elements.

b) Reliable Component – A component that is not expected to fail or be periodically replaced and is not supervised. A reliable component shall have a predicted failure rate of 3.5 or fewer failures per million hours.

3.4 DETECTION THRESHOLD – The minimum gas concentration at which the detector will alarm.

3.5 DETECTOR, GAS – A self-contained alarm device that consists of an assembly of electrical components including an element to detect gas concentration, an alarm sounding appliance, and provision for connection to a power supply source by either splice leads or a cord and plug arrangement. Terminals may be included for connection to a remote audible signaling appliance or accessory.

3.6 ELECTRICAL CIRCUITS:

a) High-Voltage Circuit – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts AC, rms, 42.4 volts DC or AC peak and:

1) Supplied by an NEC Class 2 transformer, or by a transformer and fixed impedance each of which, as a unit, is in compliance with the requirements for a Class 2 transformer or

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2) Limited to a maximum of 100 volt-amperes.

A circuit derived from a source of supply classified as a high-voltage circuit, by connecting resistance in series with the supply classified as a high-voltage circuit, is not considered to be a low-voltage circuit.

3.6.1 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.

Added 3.6.1 effective March 25, 2011

3.7 LOWER EXPLOSIVE LIMIT (LEL) – The minimum concentration of a gas in air which, if ignited, will propagate flame throughout the gas-air mixture independently of continued application of the source of ignition; expressed as a percent by volume of gas in air.

3.8 NORMAL STANDBY CONDITION – The operating condition of the detector as intended by the manufacturer in which the detector is ready for alarm-signaling performance.

3.8.1 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 manufacture of the fully assembled unit in its final enclosure, or the date the unit is placed into service.

Added 3.8.1 effective March 25, 2011

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

3.8.2 added November 30, 2004

3.9 TROUBLE SIGNAL – A visual or audible signal intended to indicate a fault or trouble condition, such as an open or shorted condition of a component in the device or an open or ground in the connected wiring.

4 Detector Reliability Prediction

4.1 A detector unit shall be intended for a failure rate of not more than:

a) 4.0 failures per million hours as calculated by a full part stress analysis prediction as described in Section 2.0 of MIL-HBK 217E (October 1986) or

b) 3.5 failures per million hours as calculated by a simplified parts count-reliability prediction as described in Section 3.0 of MIL-HBK 217E, or equivalent. A Ground Fixed (G_F) environment is to be used for all calculations. If equivalent data is available from the manufacturer, it may be used in lieu of the projected data for the purpose of determining acceptable reliability.

4.2 Any component, the failure of which results in an audible trouble signal, shall not be included in the failure rate calculation. The audible signal appliance shall not be included in the reliability prediction.

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4A Lifetime

Added 4A effective March 25, 2011

4A.1 The unit (including the sensor but excluding batteries) 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. 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 4A.1 effective March 25, 2011

4A.2 The unit shall indicate end-of-life, based on the manufacturer's specified lifetime, with an end-of-life signal (see 3.6.1) This signal shall be triggered either by an internal timer or by self-diagnostic test(s). See 43.1.11.

a) For a unit that employs a signal generated by an internal time, 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 gas, then the unit's specified lifetime calculations can exclude the sensor component.

Added 4A.2 effective March 25, 2011

5 Installation and Operating Instructions

5.1 A copy of the installation and operating instructions and related schematic wiring diagrams and installation drawings shall be used as guides in the examination and test of the detector. For an investigation, a printed edition is not required; however, in accordance with Instructions, General, Section 51, a printed edition is required to be provided with each finished product. The information may be included in a user's manual.

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

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CONSTRUCTION

ASSEMBLY

6 Product Assembly

6.1 A product shall be factory-built as a complete assembly and shall include all the essential components necessary for its intended function when installed as intended.

6.2 A product shall be constructed so that disassembly is not possible without at least the use of a common hand tool. Disassembly of any part of the detector shall not be necessary for intended installation.

Exception: A removable detector cover, with or without the use of a hand tool, may be used if removal of the cover does not expose the installer to a risk of electric shock.

7 Detection-Threshold Adjustment

7.1 If a field detection-threshold adjustment is provided, it shall be accessible with the detector installed as intended, marked to indicate the upper or lower detection threshold, and employ a mechanical stop at both extremes. The detection threshold at the upper detection threshold end shall be within the limits specified in 43.1.1.

7.2 Removal of a snap-on cover to gain access to the detection threshold control is permissible if no high-voltage parts can be contacted by the user.

8 Supplementary Signaling Feature

8.1 A supplementary signaling feature, such as a transmitter for remote signaling, integral with a gas detector, shall be compatible with the device with which it is intended to be used and shall comply with the requirements in this standard.

9 Sharp Edges

9.1 An enclosure, a frame, a guard, a handle, or the like of a gas detector shall be smooth and rounded so as not to cause an injury when contacted during use, and shall be evaluated in accordance with the Standard for Test for Sharpness of Edges on Equipment, UL 1439.

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10 Enclosures

10.1 General

10.1.1 The enclosure of a detector shall be sufficiently strong and rigid to resist the abuses likely to be encountered in intended use. The degree of resistance to abuse inherent in the detector shall preclude total or partial collapse with the consequent reduction of spacings, loosening or displacement of parts, and other defects that alone or in combination constitute an increase in the risk of fire, electric shock, or injury to persons.

10.2 Electrical component enclosures

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

10.2.2 All electrical parts of a detector, including a separate power supply, except for plug-in blades, shall be enclosed to reduce the risk of unintentional contact with uninsulated live parts. A separate enclosure is not required for field-wiring terminals that will be enclosed by a back box.

10.3 Sheet metal enclosures

10.3.1 The thickness of sheet metal used for the enclosure of a detector shall not be less than specified in Table 10.1.

Exception: Sheet metal 20 percent thinner may be used if 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 determined to be provided.

Table 10.1
Sheet metal enclosures

Maximum dimensions of enclosure				Minimum thickness of sheet metal					
				Steel					
Length or width,		Area,		Zinc-coated,		Uncoated,		Aluminum or brass,	
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	1524	Over 1500	9678	0.097	2.46	0.093	2.36	0.122	3.10

10.3.2 At any point where conduit or metal-clad cable is attached, sheet metal shall be of such thickness or so formed or reinforced that it will have a stiffness at least equivalent to that of an uncoated flat sheet steel having a minimum thickness of 0.053 inch (1.35 mm).

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10.4 Cast metal enclosures

10.4.1 The thickness of cast metal for an enclosure shall be as specified in Table 10.2. Cast metal having a thickness 1/32 inch (0.8 mm) less than that specified in the table may be used if 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.

Table 10.2
Cast-metal enclosures

Use, or dimensions of area involved	Minimum thickness			
	Die-cast metal,		Cast metal other than die-cast,	
	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) thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

10.4.2 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 three and one-half nor more than five threads in the metal, and the construction shall permit a standard conduit bushing to be attached.

10.4.3 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 three and one-half full threads in the metal, and there shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

10.5 Nonmetallic enclosures

10.5.1 An enclosure or parts of an enclosure of nonmetallic material shall have the mechanical strength and durability and be formed so that operating parts will be protected against damage. The mechanical strength of the enclosure shall be at least equivalent to a sheet metal enclosure of the minimum applicable thickness specified in Table 10.1. See the Tests of Thermoplastic Materials, Section 40.

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10.6 Product mounting

10.6.1 The enclosure of a detector shall be provided with means for mounting in the intended manner. Any fittings, such as brackets, hangers, or the like, necessary for intended mounting shall be furnished with the detector. The mounting means shall be accessible without disassembling any operating part of the detector. A detector cover is not to be considered an operating part if its removal does not expose the installer to a risk of electric shock.

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

10.7 Ventilating openings

10.7.1 Ventilating openings in an enclosure for high-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 openings will permit passage of a rod having a diameter of 9/64 inch (3.6 mm). An enclosure for a fuse or other overload protective device provided with ventilating openings shall afford protection against the emission of flame or molten metal.

10.8 Screens and expanded metal

10.8.1 Perforated sheet metal used for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) thick, 0.046 inch (1.17 mm) thick if zinc coated.

Exception: If the indentation of the guard or enclosure will 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, may 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) or

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

10.8.2 The wires forming a screen protecting high-voltage current-carrying 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 area.

10.8.3 Openings provided to permit cleaning or openings which may be used to clean internal parts shall be constructed to reduce the risk of damage to functional internal components during such cleaning operations.

10.8.4 A ferrous plate or plug closure for an unused conduit opening or other hole in the enclosure shall not be less than 0.027 inch (0.69 mm) thick, and a nonferrous metal plate or plug closure shall not be less than 0.032 inch (0.81 mm) thick, for a hole having a diameter not larger than 1-3/8 inch (34.9 mm).

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10.8.5 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. Such plates or plugs shall be securely mounted.

10.8.6 A knockout in a sheet-metal enclosure shall be secure but still able to be removed without deformation of the enclosure to the extent that:

a) Spacings are reduced;

b) Parts are loosened or displaced; or

c) There is an increased risk of fire, electric shock, or injury to persons.

10.8.7 A knockout shall be provided with a surrounding surface for correct seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those specified in Spacings, General, Section 27.

10.9 Glass panels

10.9.1 Glass covering an enclosure opening shall:

a) Not be less than 1/16 inch (1.6 mm) thick,

b) Be securely held in place so that it cannot be displaced in service, and

c) Provide mechanical protection of the enclosed parts.

10.9.2 A transparent material, other than glass, used as a cover over an opening in an enclosure shall:

a) Be mechanically equivalent to glass,

b) Not distort, and

c) Not become less transparent at the temperature to which it may be subjected under normal or abnormal service conditions.

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11 Protection Against Corrosion

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

11.2 The requirement in 11.1 applies to all enclosures whether of sheet steel or cast iron, and to all springs and other parts upon which proper mechanical operation may depend. It does not apply to minor parts, such as washers, screws, bolts, and the like, if the corrosion of such unprotected parts would not result in risk of fire, electric shock, or impaired operation of the detector. Parts made of stainless steel, polished or treated, do not require additional protection.

11.3 Bearing surfaces shall be of such materials as to prevent binding due to corrosion.

11.4 Metals used in combination for enclosures shall be galvanically compatible.

11.5 Hinges and other attachments shall be resistant to corrosion.

11.6 Nonferrous enclosures without corrosion protection may be used.

FIELD-WIRING CONNECTIONS

12 General

12.1 The primary power supply of a residential gas detector shall be a commercial power source available in a residential unit. Connection shall be:

a) In the form of permanent wiring to terminals or leads in a separate wiring compartment having provision for the connection of conduit, metal-clad or nonmetallic sheathed cable;

b) By means of a power-supply cord and attachment plug; or

c) By means of a separate power supply.

12.2 If a separate power supply is provided, it shall use low-voltage circuitry. See 3.6(b).

12.3 The primary power supply of an RV gas detector shall be:

a) A vehicle battery,

b) A backup battery,

c) A DC converter, or

d) A 120-volt supply.

Connection shall be by wiring to terminals or leads that comply with the applicable requirements in 14.3.1 – 14.5.3.

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13 Cord-Connected Products

13.1 A cord-connected detector 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.

13.2 The flexible cord shall be of Type SP-1, SPT-1, SP-2, SPT-2, SV, SVT, SJ, SJT, or that which has been determined to be the equivalent, and shall be a minimum of 18 AWG (0.82 mm^2) in size. It shall be rated for use at the voltage and ampacity rating of the detector in accordance with the National Electrical Code, ANSI/NFPA 70-1999.

13.3 Means shall be provided to reduce the risk of the flexible cord being pushed into the enclosure through the cord-entry hole if such displacement can:

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

b) Reduce spacings below the minimum required values, or

c) Result in damage to internal components.

13.4 Where a flexible cord passes through an opening in a wall, barrier, or enclosing case, the edges of the hole shall be smooth and rounded, without burrs, fins, or sharp edges that may damage the cord jacket.

13.5 A smoothly rounded restraining means shall be provided for securing the attachment plug to the receptacle.

13.6 The supply cord for a detector shall be provided with a strain relief to prevent stresses on the supply cord from being transmitted to internal wiring or connections. See the Strain-Relief Test, Section 45.

14 Permanently Connected Products

14.1 General

14.1.1 A detector intended for permanent connection 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 70-1999, corresponding to the rating of the detector.

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14.2 Field-wiring compartment

14.2.1 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 the conduit connected to the compartment if a bushing would be required for the intended installation.

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

14.3 Field-wiring terminals

14.3.1 The parts to which wiring connections are to be made shall consist of binding screws with terminal plates having upturned lugs, or the equivalent, to hold the wires in position. Other terminal connections may be provided if determined to be equivalent.

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

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

14.4 Field-wiring leads

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

14.4.2 Leads provided for field connection to a power limited circuit or for connection to a remote signaling device shall not be smaller than 16 AWG (1.3 mm^2) for a single conductor, No. 19 AWG (0.65 mm^2) for two or more conductors, and 22 AWG (0.32 mm^2) for four or more conductors of a multiconductor cable. The conductor shall be solid, stranded, or bunch tinned stranded copper wire. However, stranded copper wire, consisting of not more than seven strands, may be used only for 18 AWG (0.82 mm^2) and larger conductors.

14.4.3 For a detector that is intended to be connected to a separate remote power supply, such as a transformer, the cord is not required to be factory wired to the detector, or to the transformer terminals or leads, if the installation instructions provided with the detector specify in detail the method of connection. The size of conductors between the detector 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 with the detector and the transformer by the manufacturer.

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14.5 Grounded supply terminals and leads

14.5.1 A field-wiring terminal for the connection of a grounded 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 identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram.

Exception: This requirement does not apply to a terminal in a low-voltage or NEC Class 2 circuit.

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

Exception: This requirement does not apply to a lead for connection to a low-voltage or NEC Class 2 circuit.

14.5.3 A terminal or lead identified for the connection of the grounded 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.

15 Supplementary Signaling Circuits

15.1 The source of energy for a detector employing a supplementary signaling circuit that is energized from a separate source of supply shall not be more than 100 volt-amperes and not more than 30 volts, 60 hertz, rms, 42.4 volts peak or DC.

Exception: The source of energy for a detector intended to be connected to a fixed wiring system, and employing a separately energized signaling circuit, may exceed the limits specified if the connections are made as a Class I wiring system as defined in the National Electrical Code, ANSI/NFPA 70-1999.

16 Grounding

16.1 An equipment-grounding terminal or lead or equivalent is required for a high-voltage detector that is provided with an overall nonmetallic enclosure and cover and that is intended to be serviced internally and that uses internal noncurrent-carrying metal parts that can be energized under a fault condition.

16.2 The grounding means for a cord-connected detector shall consist of a separate ground lead integral with the supply cord and terminating in the grounding pin of a parallel blade attachment plug if the detector has an overall nonmetallic enclosure and cover and is intended to be serviced internally.

16.3 An equipment grounding terminal or lead is not required for a low-voltage detector, or a high-voltage detector provided with an overall nonmetallic enclosure.

16.4 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.

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

INTERNAL WIRING

17 General

17.1 The internal wiring of a detector shall consist of conductors having insulation rated for the potential involved and the temperatures to which it may be subjected and having required 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.

17.2 If the use of an insulated conductor is not feasible (for example, a short coil lead or the like), electrical insulating tubing may be used. The tubing shall not be subjected to sharp bends, tension, compression, or repeated flexing, and shall not contact sharp edges, projections, or corners. The wall thickness of the tubing shall comply with the requirements for such tubing, except that the wall thickness at any point for polyvinyl chloride tubing of 3/8 inch (9.5 mm) diameter or less shall not be less than 0.017 inch (0.43 mm) thick. 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, heat and moisture resistant characteristics, and the like of polyvinyl chloride tubing having a wall 0.017 inch thick.

17.3 Stranded conductors clamped under wire-binding screws or similar parts shall have the individual strands soldered together or arranged in a manner that has been determined to be equivalent.

18 Wiring Methods

18.1 Wireways

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

18.2 Splices

18.2.1 All splices and connections shall be mechanically secured.

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

18.2.3 A splice shall be located, enclosed, and supported so that it is not subject to damage from flexing, motion, or vibration.

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18.3 Bushings

18.3.1 Where a lead or wire harness passes through an opening in a wall, barrier, or enclosing case, there shall be a metal or insulating type bushing, or the equivalent, that shall be substantial, secured in place, and have a smooth, rounded surface against which the wire may bear.

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

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

18.3.4 Fiber may be used where it will not be subjected to a temperature higher than 90°C (194°F) under intended operating conditions, the bushing is not less than 3/64 inch (1.2 mm) thick, and it will not absorb moisture under ordinary ambient humidity conditions.

18.3.5 If a soft-rubber bushing or similar material that may deteriorate with age is used in a hole in metal, the hole shall be free from sharp edges, burrs, projections, and the like, that would be likely to cut into the bushing and wire insulation.

18.3.6 An insulating metal grommet may be used in lieu of an insulating bushing if the insulating material used is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

18.4 Barriers

18.4.1 A metal barrier shall have a thickness equal to at least that required by Table 10.1 as determined by the size of the barrier.

18.4.2 A barrier of insulation material shall not be less than 0.028 inch (0.71 mm) thick but shall be of greater thickness if its deformation may be readily accomplished, defeating its purpose. Any clearance between the edge of a barrier and a compartment wall shall not exceed 1/16 inch (1.6 mm).

19 Separation of Circuits

19.1 Internal wiring of circuits which operate at different potentials shall be separated by barriers or shall be segregated, unless the conductors of the circuits of lower voltage are provided with insulation determined to be equivalent to that required for the highest voltage involved. Segregation of insulated conductors may be accomplished by clamping, routing, or other means that provide permanent separation.

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20 Bonding for Grounding

20.1 Except as indicated in 16.3, an exposed noncurrent-carrying metal part of a high-voltage detector that may become energized shall be bonded to the point of connection of the field equipment-grounding terminal or lead, if provided or required, and to the metal surrounding the knockout, hole, or bushing provided for field power-supply connections.

20.2 A bonding conductor shall be of material acceptable for use as an electrical conductor. If of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent.

20.3 The conductor shall not be smaller than the maximum size wire used in the circuit wiring of the component or part. A separate bonding conductor or strap shall be installed so that it is protected from mechanical damage.

20.4 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connecting, brazing, welding, or soldering of a mechanically secured component. 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.

20.5 A bolted or screwed connection that incorporates a star washer under the screw head is acceptable for penetrating nonconductive coatings.

20.6 Where the bonding means depends upon screw threads, two or more screws or two full threads of a single screw engaging metal may be used.

20.7 A splice shall not be used in a conductor used to bond an electrical enclosure or component.

20.8 Resistance in a bonding for grounding circuit shall not exceed 0.1 ohm.

20.8 effective October 17, 2000

ELECTRICAL COMPONENTS

21 General

21.1 Mounting of components

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

Exception No. 1: The requirement that a switch be prevented from turning may be waived if all four of the following conditions are met:

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

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

c) Spacing is not reduced below the minimum required values if the switch rotates.

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d) The intended operation of the switch is to be 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, need not be prevented from turning if rotation cannot reduce spacings below the minimum values required.

21.1.2 Operating components and assemblies, such as switches, relays, and similar devices, shall be protected by individual protection or dust-tight cabinets, against fouling by dust or by other material that may affect their intended operation.

21.1.3 An adjusting screw or similar adjustable part shall be prevented from loosening under the conditions of intended use. A toothed lock washer with spring takeup to prevent loosening may be employed.

21.2 Insulating materials

21.2.1 Material for the mounting of current-carrying parts shall be porcelain, phenolic composition, cold-molded composition, or other material that has been determined to be equivalent.

21.2.2 Vulcanized fiber may be used for an insulating bushing, a washer, a separator, and a barrier, but shall not be used as the sole support for uninsulated current-carrying parts of other than low-voltage circuits.

21.2.3 Polymeric materials may be used for the sole support of uninsulated live parts if determined to be equivalent to the materials specified in 21.2.1.

21.2.4 A flat sheet of insulating material, such as phenolic composition used for panel-mounting of parts, shall not be less than 1/16 inch (1.6 mm) thick.

Exception: Material less than 1/16 inch (1.6 mm) thick may be used if the panel is supported or reinforced to provide equivalent rigidity, as determined by compliance with 43.8.5.1; 43.8.5.2; and the Jarring Test, 43.10.1 and 43.10.2.

21.2.5 A terminal block mounted on a metal surface that may be grounded shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base unless the parts are staked, upset, sealed, or equivalently secured against from loosening so as to reduce the risk of the parts and the ends of replaceable terminal screws from coming in contact with the supporting surface or reducing spacings below the minimum required values.

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

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21.3 Uninsulated live parts

21.3.1 An uninsulated live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting in position if such motion may result in a reduction of spacings. Friction between surfaces shall not be used as a means to prevent shifting or a turning of live parts, but a toothed lock washer with spring takeup may be used.

21.3.2 An uninsulated live part, such as a field-wiring terminal, shall be secured to its supporting surfaces by methods other than friction between surfaces so that it will be prevented from turning or shifting in position if such motion may result in reduction of spacings below the minimum required values. This may be accomplished by two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other method that has been determined to be equivalent.

21.4 Current-carrying parts

21.4.1 A current-carrying part shall be of metal, such as silver, copper, or copper alloy, or of a material that has been determined to be equivalent.

21.4.2 Bearings, hinges, and the like shall not be used for carrying current between fixed and moving parts.

22 Lampholders and Lamps

22.1 A detector shall be provided with a power-on lamp to indicate energization of the detector.

22.2 If more than one lamp is provided on the detector, 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. The lamps may be of other colors if marked properly to identify function.

22.3 A lampholder and lamp shall be rated for the circuit in which they are used.

22.4 A lampholder in a high-voltage circuit shall be wired so that the screw shell will be connected to a grounded circuit conductor.

22.5 The power-on lamp required by 22.1 and any visual trouble signal shall be readily visible when the detector is mounted in accordance with the installation instructions and viewed in accordance with 22.6.

22.6 With reference to the requirements in 22.5, clearly visible is defined as visible when viewed as described herein. A gas detector intended for wall mounting shall be mounted on a simulated 8-foot (2.4-m) high wall and located vertically on the wall as described in the installation instructions. The power-on lamp and visual trouble signal, if any, are to be energized and viewed from a distance of 4 feet (1.2 m) from the simulated wall directly in front of the unit and at all heights from 53.7 to 69.4 inches (1.4 to 1.8 m) above the floor. If the unit is intended for ceiling mounting, it is to be mounted as intended on a simulated ceiling 8 feet above the floor. The power-lamp and visual trouble signal, if any, is to be energized and viewed from a distance of 4 feet from a vertical line extending from the center of the lamp or signal being viewed, as appropriate, to the floor and from all heights from 53.7 to 69.4 inches above the floor.

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