

American National Standard/
CSA Standard for
**Automatic Flammable
Vapor Sensor Systems and
Components**



AMERICAN NATIONAL STANDARD
ANSI Z21.94-2006

CSA STANDARD
CSA 6.31-2006

First Edition - 2006

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Connectors For Gas Appliances
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Preface

This publication represents a basic standard for safe operation, substantial and durable construction, and acceptable performance of flammable vapor sensor systems and components. It is the result of years of experience in the manufacture, testing, installation, maintenance, inspection and research on flammable vapor sensor systems and components. There are risks of injury to persons inherent in appliances that, if completely eliminated, would defeat the utility of the appliance. The provisions in this standard are intended to help reduce such risks while retaining the normal operation of the appliance.

Nothing in this standard is to be considered in any way as indicating a measure of quality beyond compliance with the provisions it contains. It is designed to allow compliance of flammable vapor sensor systems and components, the safety construction and performance of which may exceed the various provisions specified herein. In its preparation, full recognition has been given to possibilities of improvement through ingenuity of design. As progress takes place, revisions may become necessary. When they are believed desirable, recommendations or suggestions should be forwarded to the Chairman of Accredited Standards Committee Z21/83, 8501 East Pleasant Valley Road, Cleveland, Ohio 44131, or the Chairman of the CSA Technical Committee on Gas Appliances and Related Accessories, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada, L4W 5N6.

Safe and satisfactory operation of flammable vapor sensor systems and components depends to a great extent upon its proper installation, use and maintenance. It should be installed, as applicable, in accordance with the *National Fuel Gas Code, ANSI Z223.1/NFPA 54*, or the *Natural Gas and Propane Installation Code, CSA B149.1*.

Users of this American National Standard/Canadian Standards Association Standard are advised that the devices, products and activities within its scope may be subject to regulation at the Federal, Territorial, Provincial, state or local level. Users are strongly urged to investigate this possibility through appropriate channels. In the event of a conflict with this standard, the Federal, Territorial, Provincial, state or local regulation should be followed.

THIS STANDARD IS INTENDED TO BE USED BY THE MANUFACTURING SECTOR AND BY THOSE APPLYING THE EQUIPMENT AND BY THOSE RESPONSIBLE FOR ITS PROPER INSTALLATION. IT IS THE RESPONSIBILITY OF THESE USERS TO DETERMINE THAT IN EACH CASE THIS STANDARD IS SUITABLE FOR AND APPLICABLE TO THE SPECIFIC USE THEY INTEND.

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EFFECTIVE DATE: An organization using this standard for product evaluation as a part of its certification program will normally establish the date by which all products certified by that organization should comply with this standard.

History Of The Development Of Standards For Automatic Flammable Vapor Sensor Systems And Components

(This History is informative and is not part of the standard.)

In 1995, several industry leaders formed the Water Heater Industry Joint Research and Development Consortium. The Consortium's mission was to determine whether a residential gas-fired water heater could be designed to reduce or prevent the ignition of flammable vapors, such as gasoline, without compromising the integrity of the heater, creating hazards, or violating safety or energy efficiency standards.

One of the methods studied for accomplishing this objective was the use of a Flammable Vapor Sensor. So that a reasoned analysis of Sensors using differing technologies could be made, the Consortium conducted the necessary research and development effort to produce a Flammable Vapor Sensor Specification for its own use. That specification was then made available to CSA International and GAMA-An Associations of Appliances and Equipment Manufacturers.

Thus the framework for this standards arose, in large part, due to the work conducted by and under the auspices of the Water Heater Industry Joint research and Development Consortium.

In February 2003 GAMA's Standards Review Task Group of the Controls Division established the Flammable Vapor Sensors and Systems Working Group. The Working Group began the task of promulgating the requirements contained in the first draft of this Standard for Automatic Flammable Vapor Sensor Systems and Components, May 19, 2003. On May 12, 2004, the Working Group forwarded its final draft to the Standards Review Task Group of the Controls Division of GAMA for consideration. Then on June 24, 2004, the Standards Review Task Group adopted the final draft with modifications and agreed to forward it to the Z21/CSA Joint Technical Advisory Group on Standards for Automatic Gas Controls for its consideration.

At its August 24, 2004 meeting the Joint Technical Advisory Group on Standards for Automatic Gas Controls adopted the proposed harmonized standard for Flammable Vapor Sensor Systems and Components for distribution for review and comment. The first draft harmonized flammable vapor sensor system standard was distributed for review and comment during November 2004.

Following reconsideration and modification of the proposed harmonized draft standard, in light of comments received, the Joint TAG on standards for Automatic Gas Controls, at its May 27, 2005 teleconference meeting, recommended the proposed harmonized standard to the Z21/83 Committee and the CSA Technical Committee for Approval.

The proposed harmonized standard was approved by the Z21/83 Committee by letter ballot dated July 7, 2005. The CSA Technical Committee approved the proposed harmonized standard by letter ballot dated June 10, 2005.

The first edition of the American National Standard/CSA Standard for Flammable Vapor Sensor Systems and Components was approved by the Interprovincial Gas Advisory Council (IGAC) on January 13, 2006 and by the American National Standards Institute, Inc. (ANSI) on September 14, 2005.

The following identifies the designation and year of the harmonized standard:

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NOTE

This standard contains SI (Metric) equivalents to the yard/pound quantities, the purpose being to allow the standard to be used in SI (Metric) units. (Standard for use of the International System of Units (SI): The Modern Metric System, IEEE/ASTM SI 10, is used as a guide in making metric conversion from yard/pound quantities.) If a value for a measurement and an equivalent value in other units, the first stated is to be regarded as the requirement. The given equivalent value may be approximate. If a value for a measurement and an equivalent value in other units, are both specified as a quoted marking requirement, the first stated unit, or both shall be provided.

American National Standard/ CSA Standard for Automatic Flammable Vapor Sensor Systems and Components

Part I: Construction

1.1 Scope

1.1.1

This standard applies to flammable vapor sensors and systems intended for use in gas-burning appliances.

1.1.2

Compliance of a flammable vapor sensor or system with this standard does not imply that it is acceptable for use in gas appliance control systems without supplemental testing as applied to the particular appliance design.

1.1.3

This standard addresses the details of construction, performance, and testing of flammable vapor sensors and systems used for sensing the presence of flammable vapors in residential applications.

1.1.4

This standard applies to a sensor and/or system for incorporation into a flammable vapor sensor system. The complete system shall be a single use or manual reset type.

1.1.5

The sensor shall not require calibration or shall be self-calibrating.

1.1.6

Sensors and systems covered by this standard shall not have means for field adjustment of the manufacturers specified flammable vapor sensor response curve characteristics.

1.1.7

This standard applies to a flammable vapor sensor or system capable of operating throughout a temperature range of 32°F (0°C) to 125°F (51.5°C). The manufacturer is allowed to specify temperatures below 32°F (0°C) and above 125°F (51.5°C).

1.2 Data Furnished By Manufacturer

1.2.1

The manufacturer shall provide to the testing agency the following information regarding the sensor and system:

- a. Operating voltage range;

- b. Operating current requirements;
- c. Operating frequency range.;
- d. Interface electrical requirements;
- e. Response curve(s) showing the output of the sensor or system as a function of time upon exposure to flammable vapors.;
- f. Operating temperature range;
- g. End of life condition of the sensor; and
- h. Sensor mounting position(s) and/or orientation(s) (see [2.1.4](#)).

1.3 Electrical Enclosures

1.3.1 General:

- a. The enclosure(s) of the sensor and system shall be constructed to resist the abuses likely to be encountered in service. The degree of resistance to abuse inherent in the sensor and system 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, may result in a risk of fire, electrical shock, or injury to persons.
- b. The enclosure(s) for the sensor and system 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 sensor and system. The mounting means shall be accessible without disassembling any operating part of the sensor and system. The removal of a completely assembled panel or cover to mount the sensor and system is not considered disassembly of an operating part.
- c. Enclosures for individual electrical components, outer enclosures, and combinations of the two shall be considered in determining compliance with the requirement of [1.3.1-a](#).
- d. All electrical parts of a sensor and system, including a separate power supply, except for plug-in blades, shall be enclosed to provide protection against contact with uninsulated parts. A separate enclosure for field-wiring terminals that will be enclosed by a junction box is not required.
- e. If the sensor and system is intended for permanent connection in a line-voltage circuit external to the appliance enclosure, the sensor and system enclosure(s) shall either have provision for the connection of metal-clad cable, conduit, or metallic sheathed cable, or have provision for mounting on an outlet box.
- f. An uninsulated live part of a line-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 that may be performed with the equipment energized.
- g. The following are not considered to be uninsulated live parts.
 - 1. Coils of relays, solenoids, and transformer windings, if the coils and windings are provided with insulating over wraps;
 - 2. Terminals and splices with insulation rated for the intended application; and

3. Insulated wire.

- h. An edge, projection or corner of an enclosure, opening, frame, guard, knob, handle, or the like shall be smooth and rounded, so as not to cause a cut-type injury when contacted during use or maintenance.
- i. An enclosure or parts of an enclosure of nonmetallic material shall have the mechanical strength and durability and be so formed that operating parts will be protected against damage.
- j. The continuity of any grounding system to which a sensor and system can be connected shall not rely on the dimensional integrity of the nonmetallic material.

1.3.2 Cast Metal:

- a. The thickness of cast metal for an enclosure shall be as indicated in Table I, Cast Metal Enclosures. Cast metal having a thickness of $\frac{1}{32}$ in (0.8 mm) less than that indicated in Table I may be employed 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.
- b. If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, there shall be not less than $3\frac{1}{2}$ or more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing can be attached.
- c. If threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall be not less than $3\frac{1}{2}$ 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.

1.3.3 Sheet Metal:

- a. The thickness of sheet metal employed for the enclosure(s) of the sensor and system shall be not less than that indicated in Table II, Sheet Metal Enclosures, except that sheet metal of two gauge sizes less in thickness may be employed 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.
- b. 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 in (0.81 mm) if of uncoated steel, not less than 0.034 in (0.86 mm) if of galvanized steel, and not less than 0.045 in (1.14 mm) if of nonferrous metal.
- c. 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 in (0.69 or 0.81 mm) nonferrous metal for a hole having a $1\frac{3}{8}$ in (34.9 mm) diameter maximum dimension.
- d. A closure for a hole larger than $1\frac{3}{8}$ in (34.9 mm) diameter shall have a thickness equal to that required for the enclosure(s) of the sensor and system, or a standard knockout seal shall be used.
- e. A knockout in a sheet metal enclosure shall be secured but shall be capable of being removed without undue deformation of the enclosure.
- f. 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 likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than those indicated in [1.5.12](#), Transformers.

1.3.4 Ventilating Openings:

- a. Ventilating openings in an enclosure for line-voltage circuits, including perforated holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening will permit passage of a rod having a diameter of $\frac{9}{64}$ in (3.6 mm). An enclosure for a fuse(s) or other overload protective device provided with ventilation openings shall afford protection against the emission of flame or molten metal. Openings provided to permit cleaning, or openings that may be used to clean internal parts, shall be constructed to reduce the risk of damage to functional internal components during such cleaning operations.
- b. Except as noted in 1.3.4-c, perforated sheet metal employed for expanded metal mesh shall be not less than 0.042 in (1.07 mm) in average thickness, or 0.046 in (1.17 mm) if zinc-coated.
- c. 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 in (0.53 mm) expanded metal mesh or perforated sheet metal, or 0.024 in (0.61 mm) if zinc coated, may be employed under the following conditions:
 1. The exposed mesh on any one side or surface of the product has an area of not more than 72 in² (464 cm²) and has no dimension greater than 12 in (305 mm); or
 2. The width of an opening so protected is not greater than 3.5 in. (88.9 mm).
- d. The wires forming a screen protecting line-voltage parts shall not be smaller than No. 16 AWG (1.3 mm²) and the screen openings shall not be greater than 0.5 in² (3.2 cm²) in area.

1.3.5 Covers:

- a. An enclosure cover shall be hinged, sliding, pivoted, or similarly attached if:
 1. It provides ready access to fuses or any other over current protective device, the intended protective functioning of which requires renewal; or
 2. It is necessary to open the cover periodically in connection with the intended operation of the sensor and system.
 3. For the purpose of this requirement, intended operation is considered to be the operation of a switch for testing or operation of any other component of a sensor and system that requires such action in connection with its intended performance.
- b. A cover that is intended to be removed only for periodic maintenance may 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.
- c. If the cover is not intended to be removed for cleaning, maintenance, or both, and the sensor or system 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. These requirements do not apply if the cover is intended to be removed for cleaning, maintenance, or both, even though the sensor or system is intended to be returned to the manufacturer for servicing.
- d. A hinged cover is not required where the only a fuse(s) enclosed is intended to provide protection to portions of internal circuits, such as may be employed on a separate printed wiring board or circuit subassembly, to prevent circuit damage resulting from a fault. The use of such a fuse(s) is acceptable

if the word CAUTION and the following or equivalent marking is located under the cover of a sensor and system employing line-voltage circuits: Circuit Fuse(s) Inside – Disconnect Power Prior To Servicing.

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

1.3.6 Field Wiring:

- a. A sensor or system intended for permanent connection to a line-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, NFPA 70* or the *Canadian Electrical Code, CSA C22.1, Part I*, corresponding to the rating of the unit.
- b. Field-Wiring Compartment for Line Voltage Connection
 - 1. The field wiring compartment area shall be of sufficient size for completing all field-wiring connections as specified by the installation wiring diagram. There shall be space within the compartment to permit the use of a standard conduit bushing on conduit connected to the compartment if a bushing is required for installation.
 - 2. Protection for internal components and wire insulation from sharp edges shall be provided by insulating barriers or metal barriers having smooth rounded edges.

1.3.7 Field-Wiring Terminals:

- a. Terminal parts to which field connections are to be made shall consist of binding screws with terminal plates having upturned lugs or the equivalent to hold wires in position. Other terminal connections may be provided if found to be equivalent.
- b. If a wire-binding screw is employed at a field-wiring terminal, the screw shall not be smaller than No. 6 (3.5 mm diameter).
- c. Except as noted in 1.3.7-d, a terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 in (0.76 mm) thick and shall have not less than two full threads in the metal.
- d. A terminal plate may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Other construction may be employed if they provide equivalent security.
- e. Wiring terminal assemblies that are used for field connections shall be prevented from turning.

1.3.8 Field Wiring Leads:

- a. Power supply leads provided for field connection shall be not less than 6 in (152 mm) long, provided with strain relief, and shall not be smaller than 18 AWG (0.82 mm²). The insulation, if thermoplastic, shall not be less than 1/32 in (0.8 mm) in thickness. The following exceptions apply:
 - 1. The lead may be less than 6 in (152 mm) long if it is evident that the use of a longer lead may result in damage to the insulation.
 - 2. Solid copper leads as small as No. 26 AWG (0.13 mm²) may be used if:
 - (a) The current does not exceed 1 A for lengths up to 2 ft (61 cm) and the current does not exceed 0.4 A for lengths up to 10 ft (3.05 m).

- (b) There are two or more conductors and they are covered by a common jacket or the equivalent; or
 - (c) The installation instructions indicate that the lead cannot be spliced to a conductor larger than No. 18 AWG (0.82mm²).
- b. Leads provided for field connection to power-limited signaling circuits, shall be not 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 multi-conductor 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.

1.3.9 Grounded Supply Terminals and Leads:

- a. 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.
- b. 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.
- c. 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.

1.4 Internal Electrical Wiring

1.4.1 General:

- a. The internal wiring of a sensor and system shall consist of conductors having insulation rated for the voltage involved and the temperatures to which it may 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.
- b. 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.
- c. If the use of a short length of insulated conductor is not feasible, such as for a short coil lead or the like, electrical insulating tubing may be employed. 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 in (9.5 mm) diameter or less shall be not less than 0.017 in (0.43 mm). For insulating tubing of other types, the wall thickness shall be not 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 in (0.43 mm).

- d. 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 may be accomplished by clamping, routing, or equivalent means that provide permanent separation.
- e. 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.

1.4.2

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

1.4.3 Splices:

- a. 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 permitted where the design precludes mechanical security provided that 5 samples resist a pull force of 2 lb (8.9 N) applied for 3 seconds and the connection is subjected to 100 per cent inspection and testing with the same pull force by the manufacturer.
- b. 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.
- c. 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.

1.4.4 Barriers:

- a. With the following exceptions, an insulating barrier or liner, which is used to provide spacings, shall be of material suitable for the particular application and not less than a minimum 0.028 in (0.71 mm) thick. A barrier or liner which is used in conjunction with not less than one half the specified spacing through-air, may be less than 0.028 in (0.71 mm) but not less than 0.013 in (0.33 mm) thick, provided the barrier or liner is (1) of good quality of suitable insulating material resistant to moisture, (2) capable of adequate mechanical strength if exposed or otherwise likely to be subjected to mechanical injury, (3) reliably held in place, and (4) located so it will not be adversely affected by operation of the equipment in service - particularly arcing.

Insulating material having a thickness less than that specified in the preceding paragraph may be used if found acceptable for the purpose or if listed or certified for the purpose by a nationally recognized testing agency.

Mica may be less than 0.028 in (0.71 mm) thick but not less than 0.013 in (0.33 mm) thick when the mica is used in lieu of the through-air spacing specified in Table III, Minimum Spacings - Millivoltage Circuits Intended for Access After the Control Manufactured and for Class 2 Low Voltage Safety Circuits (0-30 Volts), provided the mica is tightly held in a fixed position by the parts between which the spacing is involved.

- b. A barrier used to provide separation between the wiring of different circuits shall have adequate mechanical strength and shall be reliably held in place.

A barrier between uninsulated live-metal parts connected to different circuits, and a barrier between uninsulated live-metal parts of one circuit and the wiring of another circuit shall also comply with 1.4.4-a.

Openings in a barrier for the passage of conductors shall not be larger than $\frac{1}{4}$ in (6.4 mm) in diameter and shall not exceed in number, the number of wires that pass through the barrier.

1.5 Electrical Components

1.5.1 Mounting of Components:

- a. An electrical component that may require examination, replacement, adjustment, servicing, or maintenance with the sensor and system 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 qualified technician to an electric shock from adjacent, uninsulated line voltage live parts.
- b. 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. The following exceptions apply:
 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 is of 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 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, and
 - (d) The operation of the switch is by mechanical means rather than by direct contact by persons.
 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 non-removable jewel, need not be prevented from turning if rotation cannot reduce spacings below the minimum values required in [1.5.2](#).
- c. 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 is acceptable.
- d. Uninsulated live parts (e.g., 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 may result in reduction of spacings below the minimum values required. This may 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.

1.5.2

Electrical spacings shall comply with the following specifications, except for spacings that comply with [1.5.3](#).

- a. The electrical clearance resulting from the assembly of line-voltage parts into the complete component, except for thermoelectric circuits, shall comply with the spacings specified in Table IV, Minimum Spacings Line Voltage Safety Circuits, or Table V, Minimum Spacings Line Voltage Circuits For Other Than Safety Circuits, as applicable.

Film-insulated wire is considered to be equivalent to an uninsulated live-metal part in determining compliance of a device with the spacing specification in this standard.

- b. For parts connected to Class 2 low-voltage circuits and millivoltage circuits intended for access after the control is manufactured (e.g., field or factory-wiring terminals), the spacings shall not be less than those indicated in Table III, Minimum Spacings - Millivoltage Circuits Intended for Access After the Control Manufactured and for Class 2 Low Voltage Safety Circuits (0-30 Volts), if a short circuit or ground between those parts could result in unsafe operation.

For millivoltage circuits not intended for access after the control is manufactured, if shorting of the circuit can result in unsafe operation, the construction of the control shall be such that the spacings are permanently maintained.

- c. For parts connected to an isolated limited secondary circuit (other than Class 2), the spacings shall not be less than those indicated in Table VI, Minimum Spacings - Isolated Limited Secondary Circuits for Safety Controls, if a short circuit or ground between those parts could result in unsafe operation.

For an isolated-limited-secondary circuit, other than a safety circuit, the spacings between uninsulated live parts of opposite polarity and between uninsulated live parts and dead metal that may be grounded in service are not specified. The minimum spacings are based on acceptable performance of specified dielectric voltage withstand and other normal and abnormal operation tests.

1.5.3

As an alternative to the spacing specifications in 1.5.1 and 1.5.2, spacings may be evaluated in accordance with the requirements specified in the Standard for *Insulation Coordination Including Clearance and Creepage Distance for Electrical Equipment*, ANSI/UL 840, or *Insulation Coordination*, CSA 22.2 No. 0.2. This alternative does not apply to spacings for field wiring terminals or spacings between uninsulated live parts and a metal enclosure, including fittings for conduit or armored cable.

In conducting this evaluation, the following guidelines shall be used.

- a. Evaluation of clearances shall be conducted in accordance with the following sections of ANSI/UL 840, as applicable, Section 4, Clearance A (Equivalency); Section 5, Clearance B (Controlled Overvoltage), and Section 6, Creepage Distances.

Pollution Degree 1 is considered to exist on printed wiring boards having the requirements for conformal coatings in the Standard for *Polymeric Materials - Use in Electrical Equipment Evaluations*, ANSI/UL 746C.

Pollution Degree 1 may also be achieved at a specific printed wiring board location by application of at least a $\frac{1}{32}$ in (0.8 mm) layer of silicone rubber which has been separately tested and recognized or certified for the intended usage by a nationally recognized testing agency or for a group printed wiring boards through potting, without air bubbles, in epoxy or a potting material which has been separately tested and recognized or certified for the intended usage by a nationally recognized testing agency.