

CAN/ULC-S588:2017

**STANDARD FOR GAS AND VAPOUR DETECTORS AND
SENSORS, INCLUDING ACCESSORIES**

Prepared and Published by:



Approved by:



Standards Council of Canada
Conseil canadien des normes

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**STANDARD FOR GAS AND VAPOUR DETECTORS AND SENSORS,
INCLUDING ACCESSORIES**

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STANDARD FOR GAS AND VAPOUR DETECTORS AND SENSORS, INCLUDING ACCESSORIES

PREFACE

This is the First Edition of the Standard for Standard for Gas and Vapour Detectors and Sensors, Including Accessories, CAN/ULC-S588.

This Edition of the Standard has been formally approved by the ULC Standards Committee on Fire Alarm and Life Safety Equipment and Systems.

This Standard has been developed in compliance with the requirements of SCC for accreditation of a Standards Development Organization.

Only metric SI units of measurement are used in this Standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

Appendices A, B and C, identified as Informative, are for informational purposes only.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the fact that some Canadian authorities may require markings and/or installation instructions to be in both official languages.

Attention is drawn to the possibility that some of the elements of this Canadian standard may be the subject of patents rights. ULC Standards shall not be held responsible for identifying any or all such patents rights.

Requests for interpretation of this Standard should be sent to ULC Standards. The requests should be worded in such a manner as to permit a “yes” or “no” answer based on the literal text of the requirement concerned.

The review and action to revise or reaffirm this Standard will not exceed 5 years from the date of publication, unless the Standard is identified as fitting within a stabilized category, whereby the review will commence within the appropriate time frame set out by ULC Standards.

This Standard is intended to be used for conformity assessment.

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1 SCOPE

1.1 This Standard covers requirements for permanently installed, portable and transportable toxic and combustible gas and vapour detectors and *sensors*, including accessories, intended to be employed in indoor locations or *outdoor locations/unconditioned locations* in accordance with manufacturer's recommendations.

1.2 A detector and/or *sensor*, as covered by these requirements, consists of an assembly of electrical components coupled with a sensing means inside a chamber, or by separate components to detect toxic and/or combustible gases or vapours. The detector includes provision for the connection to a source of power and signaling circuits and optional remote control circuits. Additional functionality, such as a heat detector, heat *sensor*, smoke detector, smoke *sensor*, or audible signaling appliance/device, is permitted to be incorporated as part of the toxic combustible gas and vapour detector assembly and are to be evaluated to the applicable standard(s).

1.3 This Standard covers the following types of detectors and *sensors*:

- A Those intended for monitoring the environment, areas inside ventilation ductwork, and detectors and *sensors* intended for open area protection which are connected to a compatible power supply or control unit for operation as part of gas detection or emergency signaling systems;
- B Those intended solely for control of ventilation or shut off devices such as fans or control valves;
- C Those intended for both of the above applications;
- D *Sensors* and sensing circuits intended for use with or in gas detectors or gas detection circuits within fuel cell systems;
- E *Portable detectors* and *sensors*;
- F *Transportable detectors* and *sensors*;
- G Multi-gas gas and vapour detectors; and
- H Multi-gas gas and vapour *sensors*.

1.4 This Standard also covers all remote accessories that are intended to be connected to a gas or vapour detector and/or *sensor*.

1.5 This standard does not cover the following:

- A Control units to which the detectors are intended to be connected that are covered by CAN/ULC-S527, Standard for Control Units for Fire Alarm Systems; and CAN/ULC-S545, Standard for Residential Fire Warning System Control Units;
- B Self-contained single and multiple station carbon monoxide alarms that are covered by the Standard for Residential CO Alarming Devices, CAN/CSA 6.19;
- C Automatic flammable vapour sensor systems and components covered by the Standard for Automatic Flammable Vapor *Sensor* Systems and Components, Z21.94/CSA 6.3, or CSA C22.2 No. 152, Combustible gas detection instruments;

- D A *sensor* used solely as part of a multi-criteria smoke detector, covered by CAN/ULC-S529, Standard for Smoke Detectors for Fire Alarm Systems;
- E A heat detector or *sensor* incorporated as a part of a carbon monoxide detector assembly, and covered by CAN/ULC-S530, Standard For Heat Actuated Fire Detectors for Fire Alarm Systems; and
- F Devices that are part of a manufacturing process interface or control.

2 GENERAL

2.1 COMPONENTS

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

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

- A Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- B Is superseded by a requirement in this standard.

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

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

2.2 UNITS OF MEASUREMENT

2.2.1 The metric unit shall be designated as the official unit for purposes of this standard. Where values of measurement are specified in both SI and English units, either unit is used. In cases of dispute, the metric unit shall be used. Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.3 REFERENCE PUBLICATIONS

2.3.1 The documents shown below are referenced in the text of this Standard. Unless otherwise stated elsewhere in this Standard such reference shall be considered to indicate the edition and/or revisions of the document available at the date on which this standard was approved. All undated references shall be interpreted as referring to the latest edition of that document.

Documents Published by ULC Standards
171 Nepean Street, Suite 400, Ottawa, ON K2P 0B4 Canada
Telephone: (613) 755-2729
www.ulc.ca/ulcstandards

- CAN/ULC-S524, Standard for Installation of Fire Alarm Systems
- CAN/ULC-S527, Control Units for Fire Alarm Systems
- CAN/ULC-S529, Smoke Detectors for Fire Alarm

- CAN/ULC-S536, Inspection and Testing of Fire Alarm Systems
 - CAN/ULC-S537, Verification of Fire Alarm Systems
 - CAN/ULC-S545, Standard for Residential Fire Warning System Control Units
-

Documents Published by the CSA Group
178 Rexdale Blvd., Toronto, ON, Canada M9W 1R3
Telephone: (416) 747-4000 or 1-800-463-6727
www.csa.ca

- CAN/CSA-C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials
 - CAN/CSA 6.19-01, Residential Carbon Monoxide Alarming Devices
 - CAN/CSA-C22.2 No. 0.17-00 (R2013), Evaluation of Properties of Polymeric Materials
 - CSA C22.1-15, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations
 - CAN/CSA C22.2 No. 65-03 (R2008), Wire Connectors
 - CSA C22.2 No. 77-95, Motors with Inherent Overheating Protections
 - CSA C22.2 No. 153, Electrical Quick-Connect Terminals;
 - CSA C22.2 No. 158, Terminal Blocks
 - Z21.94/CSA 6.3, Standard for Automatic Flammable Vapor Sensor Systems and Components,
 - CSA C22.2 No. 152-M1984, Combustible Gas Detection Instruments
 - CSA C22.2 No. 0.15-01, Adhesive Labels
 - CAN/CSA-C22.2 NO. 60950-1-07 (R2012) – Information Technology Equipment – Safety – Part 1: General Requirements (Bi-National standard, with UL 60950-1)
-

Standards Published by the International Electrotechnical Commission (IEC) available from:
IEC Central Office
3, rue de Varembé P.O. Box 131 CH - 1211 GENEVA 20 Switzerland
Phone: +41 22 919 02 11 Fax: +41 22 919 03 00
www.iec.ch

Standards Council of Canada (SCC)
55 Metcalfe Street, Suite 600
Ottawa, ON, K1P 6L5
Telephone: (613) 238-3222; Fax (613) 569-7808
www.scc.ca

- IEC 61000-4-5 Electromagnetic Compatibility (EMC) Part 4-5: Testing and Measurements Techniques – Surge Immunity Test

- IEC 60079-2-1 ed. 1.0 Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases

Documents Published by the National Research Council Canada (NRC)
1200 Montreal Road, Bldg. M-58, Ottawa, ON K1A 0R6 Canada
Telephone: (613) 993-9101 or 1-877-672-2672
www.nrc-cnrc.gc.ca

- National Building Code of Canada, 2015
- National Fire Code of Canada, 2015

Other Standards

- MIL-HDBK-217-F(2) – February 2, 1995
Military Handbook, Reliability Prediction of Electronic Equipment
- ANSI/IEEE C62.41, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
- NIOSH Pocket Guide to Chemical Hazards, 2004 published by the National Institute for Occupational Safety and Health (NIOSH).

3 GLOSSARY

NOTE: Terms used in this Standard that are in *italic* print are defined as follows:

3.1 **ALARM SIGNAL** – A signal transmitted throughout a zone or zones or throughout a building to advise occupants that a fire emergency exists.

3.2 **ASPIRATED GAS AND VAPOUR DETECTORS AND SENSORS** – Detectors and *sensors* that sample the gas or vapour by drawing it to the *sensor*.

3.3 **CONFORMAL COATING** – A protective covering applied on a printed-wiring board capable of conforming to the configuration of objects coated, used to increase the dielectric voltage-withstand capability between conductors and/or to protect against environmental conditions. *Conformal coatings* may be used on printed circuit boards where electrical spacing's are insufficient between uninsulated live parts of opposite polarity or between such parts and accessible dead-metal parts.

3.4 **DAMP LOCATION** – An exterior or interior location that is normally or periodically subject of condensation of moisture in, on, or adjacent to electrical equipment and includes partially protected location under canopies, marquees, roofed open porches, and similar locations.

3.5 **DRY LOCATION** – A location not normally subject to dampness, but that may include a location subject of temporary dampness as in the case of a building under construction, provided that ventilation is adequate to prevent an accumulation of moisture.

3.6 **END-OF-LIFE SIGNAL** – A signal at the control panel or remote display, differing from the *alarm signal* and *trouble signal*, intended to indicate that the device has reached the end of its useful life and shall be replaced.

3.7 EXTRA-LOW-VOLTAGE CIRCUIT – A circuit that has an AC voltage of not more than 30 V alternating current (AC) (42.4 V peak) and maximum power of 100 VA, such as supplied by a Class 2 transformer; or a circuit of not more than 30 V direct current (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 V by connecting resistance or impedance, or both, in series with the supply circuit to limit the voltage and current, is not identified as an *extra-low-voltage circuit*.

3.8 GAS OR VAPOUR DETECTOR – A device that consists of an assembly of electrical components coupled with a sensing means to detect toxic and/or combustible gases or vapours. For the purpose of this Standard, this term is also referred as “detector”.

3.9 HAZARDOUS LOCATION – premises, buildings, or parts thereof in which:

- A An explosive gas atmosphere is present, or may be present, in the air in quantities that require special precaution of the construction, installation, and use of electrical equipment;
- B Combustible dusts are present, or may be present, in the form of clouds or layers in quantities to require special precaution of the construction, installation, and operation of electrical equipment; or

3.10 HAZARDOUS-VOLTAGE CIRCUIT – A circuit having characteristics in excess of those of an extra low-voltage circuit.

3.11 LATCHING ALARM – An alarm that, once activated, requires deliberate action to be deactivated.

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

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

3.14 MULTI-CRITERIA DETECTOR – A device that contains multiple *sensors* that separately respond to physical stimulus such as combustible and/or toxic gases, or employs more than one *sensor* to sense the same stimulus. This device generates only one alarm output.

3.15 MULTI-SENSOR DETECTOR – A device that contains multiple *sensors* that separately respond to physical stimulus such as combustible and/or toxic gases, or employs more than one *sensor* to sense the same stimulus. This device is capable of generating multiple alarm outputs either independently or in combination.

3.16 ORDINARY LOCATION – A dry location in which, at normal atmospheric pressure and under normal conditions or use, electrical equipment is not unduly exposed to damage from mechanical causes, excessive dust, moisture or extreme temperatures, and in which electrical equipment is entirely free from the possibility of damage through corrosive, flammable, or explosive atmospheres.

3.17 OUTDOOR LOCATION – A location exposed to the weather.

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

3.19 PORTABLE DETECTORS AND SENSORS – Detectors and *sensors* that have been designed to be readily carried from place to place and to be used while it is being carried. A portable detector and *sensor* is battery powered and includes, but is not limited to:

- A a hand-held detectors and *sensors*, typically less than 1 kg, suitable for single-handed operation;
- B personal monitors, similar in size and mass to the hand-held detector and *sensor*, that are continuously operating (but not necessarily continuously sensing) while they are attached to the user;
- C larger detector and *sensors* that can be operated by the user while it is suspended by hand, by a shoulder strap or by a carrying harness; it may or may not have a hand directed probe;
- D detectors and *sensors* capable of producing visual and audible signals.

3.20 PRINTED CIRCUIT BOARD – A printed board produced from rigid industrial laminate material that provides point-to-point connections and printed components in a predetermined arrangement.

3.21 PRODUCTION GAS SENSITIVITY – A gas *sensitivity* range equal to or less than the *sensitivity* limits determined by the applicable tests required in this Standard. This range is used to verify *sensitivity* calibration in Subsection 9.4.2, *Sensitivity Calibration*.

3.22 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 2.5 or less failures per million hours as determined for "Ground Fixed" (GF) environment by MIL-HDBK-217-F, or equivalent.

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

- A The potential between the part and earth ground or any other accessible part is more than 42.4 V peak, and
- B The continuous current flow through a 1500 Ω resistor connected across the potential exceeds 0.5 milliampere.

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

- A The open circuit voltage is more than 42.4 V peak and the energy available to the circuit under any condition of load, including short circuit, results in a current of 8 A or more after 1 min of operation, or
- B A power of more than 15 W is deliverable into an external resistor connected between the two points.

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

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

3.27 SPECIFIED LIFETIME – For purposes of this standard, “*specified lifetime*” will be referred to as “lifetime.” A continuous period of time specified by the manufacturer, during which the alarm meets the requirements of the standard. The manufacturer will specify the start date of the period as either the date of manufacturer or the fully assembled unit in its final enclosure, or the date the unit is placed into service.

3.28 TIME OF RESPONSE $t(x)$ – The time interval between the start of a test and when the detector or *sensor* reaches a stated percentage (x) of the final indication.

3.29 TRANSPORTABLE DETECTORS AND SENSORS – Detectors and *sensors* intended to be permanently installed and readily moved from one place to another.

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

3.31 UNCONDITIONED LOCATION – Enclosed spaces without continuous climate control.

3.32 WET LOCATION – A location in which liquids may drip, splash, or flow on or against electrical equipment.

4 DETECTOR OR SENSOR RELIABILITY PREDICTION

4.1 GENERAL

4.1.1 Detectors, *sensors* and components, shall be subjected to a reliability prediction as calculated by a full part stress analysis prediction as described in the appropriate Section of MIL-HDBK-217-F See Appendix A (Informative), Reliability Prediction and Criteria for Acceptance. A “Ground Fixed” (GF) environment is to be used for all calculations. When actual equivalent data is available from the manufacturer, it is permissible that it be used in lieu of the projected data for the purpose of determining reliability.

4.2 DETECTORS

4.2.1 The maximum failure rate for a detector shall not be greater than 4.0 failures per million hours as calculated by a full part stress analysis prediction as described in Section 2.0 of MIL-HDBK-217-F, or shall not be greater than 3.5 failures per million h as calculated by a simplified parts count reliability prediction as described in Section 3.0 of MIL-HDBK-217-F, or equivalent.

4.3 SENSORS

4.3.1 The maximum failure rate for a *sensor* or sensing component shall not be greater than 2.5 failures per million hours as calculated by a full part stress analysis prediction as described in Section 3.4 of MIL-HDBK-217-F, or equivalent.

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

- A 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 determine if the *sensor* is unresponsive to the gas concentrations identified in Subsection 9.4, *Sensitivity Limits* 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, Subsection 9.9. All predicted failure modes shall result in a *trouble signal*; or

- B Reliability data developed to predict the *sensor* drifting beyond 5% of the operating range.

4.3.3 If the *sensor* or component is automatically and periodically tested for its performance response to the target gas (acceptable proxy gas), and results in a *trouble signal* when the *sensor* or component drifts out of specification, then the *sensor* or component can be excluded from the reliability calculation.

4.4 COMPONENT

4.4.1 Data on detector components, for example, capacitors, resistors, solid-state devices and the like, shall be provided for evaluation of the components for the intended application. When a Mil-Spec. is referenced, a copy of the specification is to be provided for review.

4.4.2 The data required by Clause 4.4.1 shall include the following or equivalent information:

- A Component Fault Analysis. Effect of failure, open and short, of capacitors and *limited-life components* on operation of a detector.
- B Maximum supplier's ratings for each component as well as the actual maximum operating values (voltage and current) in the detectors.
- C A description of component screening and burn-in test data for solid-state devices (including, but not limited to, relays, semiconductor, integrated circuit) that operate at greater than the limits described in note d of Table 1, Maximum Temperature Rises.
- D General description of the detector manufacturer's quality assurance (QA) program. This data shall include incoming inspection and screening, in-process quality assurance, burn-in data, and testing. This applies to complete and partial assemblies as well as individual components.
- E A general description of the circuit operation under standby, alarm, and trouble conditions.
- F General calibration procedure of test instruments employed by the manufacturer in the calibration of a detector.
- G Amount of derating of components under normal standby and alarm conditions.
- H Component failure rate data at rated values and derated values.

4.4.3 Any component whose failure:

- A Results in energization of an audible *trouble signal*
- B Results in energization of a separate visual indication (separate and distinct from an *alarm signal*); or
- C Results in de-energization of a power-on light;
- D Does not affect the normal operation or *sensitivity*; or
- E Is evaluated by specific performance tests included in the standard;

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

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

4.4.5 A custom integrated circuit (CHIP) employed in a detector 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-h burn-in test, or equivalent.

4.4.6 Integral transmitters/receivers and related components used for non-supervised, wireless interconnected detectors are required to be included in the reliability prediction.

4.4.7 Fan motors, airflow monitoring, and related components used for aspirating detectors are required to be included in the reliability prediction.

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 a reference in the examination and test of the detector

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

6 COMPATIBILITY

6.1 GENERAL

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

6.1.2 The requirements in Clause 6.1.1 apply to:

- A Separate products connected to any circuit and by which the operating parts of the product are actuated for signaling and/or action; and
- B Separate or incorporated appliances or units by which signals are indicated or actions carried out.

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

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

6.1.5 Compatibility between a two-wire detector that receives its power from the initiating device circuit of a system control unit is dependent upon the interaction between the circuit parameters, such as voltage, current, frequency, and impedance, of the detector and the initiating device circuit.

6.1.6 As a two-wire detector obtains its power from the initiating device circuit of a system control unit, its operation is dependent on the characteristics of the circuit to which it is connected as the detector imposes a resistive and capacitive load on the circuit. Similarly, the load imposed upon the initiating circuit by a connected detector shall not prevent alarm response by a control unit to a detector in alarm, nor prevent a trouble response to an open circuit after the last detector.

6.1.7 The connection of a two-wire detector is restricted to the specific control units with which a compatibility evaluation has been made.

6.1.8 It is permissible for a detector that does not receive its power from the initiating device circuit of a control unit (conventionally a detector having four or more wires for field connection) to be employed with any electrically compatible system control unit without the requirement for compatibility consideration as its connection does not impose any load on the initiating circuit. Under an alarm condition, the four-wire detector acts as a switch (similar to a manual station or heat detector) to place the system in alarm.

6.1.9 A supplementary signaling device – such as an audible appliance, relay, or annunciator lamp (LED) – that is integral with a two-wire detector and that is also powered from an initiating device circuit of a system control unit shall not be used when its operation, including level of audibility and light output, is inhibited by the operation limitation of the initiating device circuit.

6.1.10 A detector incorporating circuitry for functional interfacing with a control unit for functions such as, but not limited to supervision, point addressing, and multiplexing, shall be tested for compatibility with the applicable functional requirements of the control unit.

6.1.11 To determine whether any combination of a fire alarm control unit and detector or detectors is compatible (whether the detectors are the same model or a mixture of one or more models or types), the Two-Wire Detector Compatibility Tests shall be conducted in accordance with the following standards:

- A CAN/ULC-S527, Standard for Control Units for Fire Alarm Systems; and
- B CAN/ULC-S545, Standard for Residential Fire Warning System Control Units.

6.2 CHANGES AFFECTING COMPATIBILITY

6.2.1 In the event of modifications to either detectors or control units which result in the possibility of incompatibility with previously installed compatible combinations, the modified product shall be assigned a different model number or the compatibility identification marking of the product shall be changed.

7 CONSTRUCTION: ASSEMBLY

7.1 ASSEMBLY

7.1.1 A detector/*sensor* shall be so constructed that it will be reliable and sufficiently durable for its intended installation and use.

7.1.2 A component of a detector/*sensor* shall comply with the requirements for that component, except that such requirements may be modified for the particular application

7.2 REMOTE ACCESS

7.2.1 Unless specifically indicated otherwise the construction requirements specified for a gas or vapour detector/*sensor* shall also apply for any remote accessories with which it is to be employed.

7.3 SENSITIVITY INDICATING MEANS

7.3.1 Each detector/*sensor* shall be provided with a means for measuring or indicating the nominal *sensitivity* or *sensitivity* range of the detector as described in Clause 7.3.2, or a *sensitivity* test feature as described in Clause 7.3.3, after it has been installed as intended. Removal of a snap-on cover to gain access to the *sensitivity* control is permissible only when no hazardous-voltage parts are exposed or able to be contacted by the user.

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

7.3.3 Measuring or indicating means may include the use of jacks or terminals for connection of a meter, visual indicators (such as a change in frequency of a pulsing light visible with the detector/sensor installed), operation of a mechanical device (such as described in Clause 7.3.4), or any arrangement determined to be equivalent. An instrument used for measuring *sensitivity* of a detector/sensor shall be provided with the following information and features:

- A The instrument shall have a measurement capability to determine if the detector is within its production *sensitivity* range. If the instrument contains a numerical readout that does not clearly provide gas or vapour *sensitivity* units, a chart shall be provided with the instrument to indicate the acceptable production gas or vapour *sensitivity* range of each model of detector/sensor that it is capable of testing;
- B Instructions shall clearly state the operating temperature range of the instrument;
- C If a warm-up period is required, the instrument shall clearly state this period;
- D The instrument shall include the description of the method used to confirm the calibration of the instrument and the period at which re-calibration is required;
- E The instrument shall have provision to identify its date of last calibration; and
- F The instrument shall have a method of identifying to the user that it is not calibrated, if low batteries, dirty filters, or the like, affect the instrument.

7.3.4 The use of a plug-in type detector/sensor assembly that is removed readily for insertion of an adapter connected to metering equipment is permissible. A plug-in type detector/sensor that is removed readily and connected to metering equipment is also permissible.

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

7.4 MAINTENANCE (FIELD CLEANING)

7.4.1 If a detector/sensor is capable of being cleaned, it shall be done so without;

- A Degradation of performance, when tested in accordance with Subsection 9.16, *Sensitivity Test*; and
- B Disturbance of field wiring.

The procedures shall be described in the manufacturer's instructions.

7.5 SERVICING AND MAINTENANCE PROTECTION

7.5.1 An uninsulated live part of a hazardous voltage circuit and hazardous moving parts that present a risk of injury to persons within the enclosure shall be located, guarded, or enclosed to reduce the risk of unintentional contact by persons performing service functions performed with the equipment energized.

7.5.2 Manual switching devices may be located or oriented with respect to uninsulated live parts or hazardous moving parts so that manipulation of the mechanism can be accomplished in the normal direction of access if uninsulated live parts or hazardous moving parts are not located in front (in the direction of access) of the mechanism, or not located within 150 mm of any side or behind the mechanism, unless guarded.

7.5.3 In determining compliance with Clause 7.5.2 only uninsulated live parts in circuits above 30 Vrms shall be considered.

7.5.4 An electrical control component, which may require examination, adjustment, servicing, or maintenance while energized (excluding voltage measurements except for jacks or terminals specifically intended for that purpose), shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for electrical service functions without subjecting persons to the likelihood of shock hazard from adjacent uninsulated live parts or to accidental hazard from adjacent hazardous moving parts.

7.5.5 Other arrangements of location of components and/or guarding shall be also acceptable where electrical components are accessible for service as indicated by Clause 7.5.4.

7.5.6 The following are not identified as uninsulated live parts:

- A Coils of controllers, relays, and solenoids, and transformer windings, when the coils and windings are provided with appropriate insulating overwraps;
- B Enclosed motor windings;
- C Terminals and splices with insulation appropriate to the application; and
- D Insulated wire.

7.5.7 An assembled part intended to be removed during installation shall be protected against damage from normal handling.

8 CONSTRUCTION: ALL PRODUCTS

8.1 GENERAL

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

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

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

8.1.4 The requirement in Clause 8.1.3 also applies to those positions of a part adjacent to a moving part identified to involve a risk of injury to persons.

8.2 ENCLOSURE

8.2.1 General

8.2.1.1 The enclosure of a detector/sensor shall be constructed to resist the abuses encountered in service. The degree of resistance to abuse inherent in the detector/sensor shall preclude total or partial collapse with the attendant reduction of spacings, loosening or displacement of parts, and other serious defects, which alone or in combination result in an increase in the *risk of fire*, electric shock, or injury to persons.

8.2.1.2 Enclosures for individual electrical components, outer enclosures, and combinations of the two shall be evaluated in determining compliance with the requirement specified in Clause 8.2.1.1.

8.2.1.3 All electrical parts of a detector/sensor shall be enclosed to reduce the risk of contact with uninsulated live parts. A separate enclosure for field-wiring terminals that are intended to be enclosed by a back box is not required. An electrical part of a sampling chamber may be exposed if contact with such part does not result in a hazard or affect the operation of the detector/sensor or system supervision.

8.2.1.4 There shall be no rear openings in a detector/sensor through which debris or air currents can pass that would adversely affect product's intended operation.

8.2.1.5 Following installation as intended there shall not be any openings between the intended mounting surface and the rear of the detector/sensor which allow for sufficient passage of air to affect detector/sensor response from test gas.

8.2.1.6 Representative samples shall be subjected to Subsection 9.16.6, Gas or Vapour Entry (Stack Effect) Test.

8.2.1.7 The enclosure of a detector/sensor shall be provided with means for mounting in the intended manner. Any fittings, such as brackets or hangers, required for mounting shall be furnished with the sample. The mounting means shall be accessible without disassembling any operating part of the sample. The removal of a completely assembled panel, cover, or equivalent, to mount the detector/sensor is not identified as disassembly of an operating part.

8.2.1.8 An enclosure shall have provision for the connection of metal-clad cable, non-metallic sheathed cable, or conduit. A detector/sensor intended for permanent connection only to a wiring system other than metal-clad cable or conduit shall be marked to indicate the system or systems for which it is suitable. The marking shall be so located that it will be visible when power-supply connections to the detector/sensor are made, or may appear on the installation wiring diagram.

NOTE: An enclosure without provision for such connection may be acceptable if the unit is intended for mounting on an outlet box.

8.2.2 Cast Metal Enclosures

8.2.2.1 The thickness of cast metal used for an enclosure shall be as indicated in Table 2, Cast Metal Enclosures. Cast metal having a thickness 0.8 mm (1/32 in) less than that indicated in Table 2, Cast Metal Enclosures, shall be employed only when the surface under consideration is curved, ribbed, or otherwise reinforced, or when the shape of the surface, size of the surface, or both, are such that equivalent mechanical strength is determined to be provided.

8.2.2.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall be not less than 3.5 nor more than 5 threads in the metal, and the construction shall be such that a standard conduit bushing can be properly attached.

8.2.2.3 When threads for the connection of conduit are tapped only part of the way through a hole in an enclosure wall, there shall 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.

8.2.3 Sheet Metal Enclosures

8.2.3.1 The thickness of sheet metal employed for the enclosure of a detector/*sensor* shall not be less than that indicated in Table 3, Sheet Metal Enclosures, except that sheet metal of two gage sizes lesser thickness shall be employed only when the surface under consideration is curved, ribbed, or otherwise reinforced, or when the shape of the surface, the size of the surface, or both, are such that equivalent mechanical strength is determined to be provided.

8.2.3.2 At any point where conduit or metal clad cable is to be attached, sheet metal shall be of such thickness or shall be 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 1.6 mm (1/16 in).

8.2.3.3 A ferrous plate or plug closure for an unused conduit opening or other hole in the enclosure shall have a thickness not less than 0.69 mm (0.027 in) or 0.81 mm (0.032 in) nonferrous metal for a hole having a 35 mm (1-3/8 in) diameter maximum dimension.

8.2.3.4 A closure for a hole larger than 35 mm (1-3/8 in) 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. See Subsection 8.6.1, Mounting of Components.

8.2.3.5 A knockout in a sheet metal enclosure shall be secured and shall be capable of being removed without excessive deformation of the enclosure.

8.2.3.6 A knockout shall be provided with a surrounding surface for seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout used during installation does not result in spacings between uninsulated live parts and the bushing of less than those indicated in Subsection 8.6.12, Spacings.

8.2.4 Nonmetallic Enclosures

8.2.4.1 An enclosure or parts of an enclosure of nonmetallic material shall be formed so 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 3, Sheet Metal Enclosures. See also Subsection 9.50, Tests on Polymeric Materials.

8.2.4.2 The continuity of any grounding system intended for a detector/*sensor* connection shall not rely on the dimensional integrity of the nonmetallic material.

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

- A Enclosures containing parts including a *risk of fire* – minimum flammability rating of 5VA or V-0 and compliance with Subsection 9.50.4, Flame Test, 127-mm (5-in);
- B Enclosures containing power limited circuits with a voltage not exceeding 30 V AC, 42.4 V-peak, or 60 V DC – minimum flammability rating of V-2 or HB and successful completion of Subsection 9.50.3, Flame Test 19 mm (3/4 in); and
- C Enclosures containing circuits powered by sources with energy limited to 15 watts – minimum flammability rating of HB.

8.2.4.4 Flammability ratings for nonmetallic enclosures are defined in CAN/CSA-C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials.

8.2.5 Sensitivity Adjustment

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

8.2.6 Sharp Edges

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

8.2.7 Ventilating Openings

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

8.2.7.2 Perforated sheet metal employed for expanded metal mesh shall not be less than 1.0 mm (0.042 in) in average thickness, 1.2 mm (0.046 in) when zinc coated.

8.2.7.3 When the indentation of the guard enclosure does not alter the clearance between uninsulated live parts and grounded metal so as to reduce spacings below the minimum values required, it is permissible for 0.5 mm (0.021 in) expanded metal mesh 0.5 mm (0.021 in) thick, or zinc coated perforated sheet metal, 0.6 mm (0.024 in) thick, shall be used only when the following conditions are met:

- A The exposed mesh on any one side or surface of the product has an area of not more than 465 cm² (72 in²) with no dimension greater than 305 mm (12 in); and
- B The width of an opening so protected is not more than 89 mm (3-1/2 in).

8.2.7.4 The wires forming a screen protecting current-carrying parts shall not be smaller than 1.3 mm² (16 AWG) and the screen openings shall not be greater than 3. cm² (0.465 in²).

8.2.7.5 The wires forming a screen employed as a detector/*sensor* chamber cover shall be not less than 0.33 mm² (22 AWG) for steel and not less than 0.52 mm² (20 AWG) for aluminum.

8.2.8 Covers

8.2.8.1 An enclosure cover of a detector/*sensor* shall be hinged, sliding, pivoted, or similarly attached when:

- A It provides ready access to fuses or any other overcurrent protective device requiring renewal;
or

- B It is necessary to open the cover periodically in connection with the intended operation of the product.

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

8.2.8.2 A cover that is intended to be removed only for periodic maintenance of the sensing chamber, *sensitivity* measurement/calibration, or replacement of a lamp or battery 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.

8.2.8.3 When a cover is not intended to be removed for cleaning or maintenance, and the device is intended to be returned to the factory for servicing, the cover shall be secured so that it is not readily removed. Exposed screw slots or nuts, other than a tamper-proof type, shall be sealed or covered. See Clause 10.1.1, Item (O) for marking.

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

8.2.8.4 A hinged cover is not required where the only fuse(s) enclosed is intended to provide protection to portions of internal circuits, such as may be employed on a separate printed-wiring board or circuit subassembly, to prevent circuit damage resulting from a fault. Such a fuse(s) shall only be used when the following marking is located on the cover of a device employing *hazardous-voltage circuits*:

“Caution/Mise en Garde” and/or symbol indicated in Table 4, Safety Warnings: “Circuit Fuse(s) Inside - Disconnect Power Prior to Servicing/Circuit fusible (s) à l’intérieur– Débranchez l’alimentation pour effectuer une réparation”.

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

8.2.9 Battery Removal Indicator

8.2.9.1 Removal of a battery from a battery-operated detector/sensor (or AC with battery back-up) shall result in a readily apparent and prominent indication. The indication shall consist of one of the following:

- 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 A swing-out or pull-out battery compartment shall resist a push and/or pull force of 11 N $\pm$ 0.5 N (2 $\pm$ 0.1 force pounds) being closed unless it has a battery in place; or
- D An audible *trouble signal* on an AC powered detector/sensor with battery back-up; or
- E An arrangement that prohibits the detector/sensor to be reinstalled; or
- F A trouble indication at the control unit; or
- G An equivalent arrangement.

8.2.9.2 If a warning flag, or equivalent, is employed to comply with the requirement of 8.2.9.1, it shall be marked as required in Clause 10.1.1, Item (K).

8.2.10 Transparent Panels

8.2.10.1 Glass covering an enclosure opening shall be held securely in place so that it does not displace in service and shall provide mechanical protection of the enclosed parts. The thickness of a glass cover shall not be less than that indicated in Table 5, Thickness of Glass Covers.

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

- A Be mechanically equivalent to glass,
- B Not become a fire hazard or distort, and
- C Not become less transparent at the temperature to which it is subjected under normal service conditions.

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

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

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

8.2.11.2 The probe mentioned in Clause 8.2.11.1 shall be applied to any depth that the opening will permit. The probe shall be rotated or angled before, during, and after insertion through the opening to any position that is required in order to examine the enclosure. The probe illustrated in Figure 1, Articulated Probe, shall be applied in any possible configuration and, when necessary, the configuration shall be changed after insertion through the opening.

8.2.11.3 The probe mentioned in Clause 8.2.11.1 shall be used as a measuring instrument to evaluate the accessibility provided by an opening, and not as an instrument to evaluate the strength of a material. It shall be applied with the minimum force required to determine accessibility.

8.2.11.4 During the examination of a product to determine whether it complies with the requirement in Clause 8.2.11.1, a part of the enclosure that is to be opened or removed by the operator without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) shall be opened or removed.

8.2.12 Corrosion Protection

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

Exception: Parts made of stainless steel, polished or treated when required, do not require additional protection.

8.2.12.2 The requirement of Clause 8.2.12.1 applies to all enclosures, whether of sheet steel or cast iron, and to all springs and other parts upon which proper operation depends. It does not apply to minor parts such as washers, screws, and bolts, when the deterioration of such unprotected parts does not result in noncompliance with this standard, result in a hazardous condition, or impair the operation of the product.

8.2.12.3 Bearing surfaces shall be of such materials that reduce the risk of binding due to corrosion.

8.2.12.4 Iron and steel parts, except bearings, and the like, where such protection is impracticable, shall be suitably protected against corrosion by enamelling, galvanizing, sherardizing, plating, or other equivalent means.

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

8.2.12.6 Hinges and other attachments shall be resistant to corrosion.

8.2.12.7 Nonferrous cabinets and enclosures require no special corrosion protection.

8.3 FIELD WIRING CONNECTIONS

8.3.1 General

8.3.1.1 A detector/*sensor* shall be provided with wiring terminals or leads for the connection of conductors corresponding to the electrical rating of the detector/*sensor* and sized in accordance with CSA C22.1, Canadian Electrical Code, Part I, Safety Standard for Electrical Installations.

8.3.1.2 Duplicate terminals or leads, or an equivalent arrangement, shall be provided for circuits supplying operating power to the detector/*sensor* (where the operating power is monitored by an end-of-line device) and for circuits transmitting *alarm signals* from the detector/*sensor* to the control unit, one for each incoming and one for each outgoing wire. It is permissible that a common terminal be used in lieu of duplicate terminals when it is intended to prevent the looping of an unbroken wire around or under a terminal screw in a manner that permits the looped wire to remain unbroken during installation, thereby precluding monitoring in the event the wire becomes dislodged from under the terminal. A notched clamping plate under a single securing screw, where separate conductors are intended to be inserted in each notch, is an equivalent arrangement.

8.3.2 Field Wiring Compartment

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

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

8.3.2.3 The location of an outlet box or compartment in which field wiring connections are to be made shall be such that these connections may be inspected after the detector/*sensor* is installed as intended. The removal of not more than two mounting screws, or equivalent arrangement, to view the field wiring connections, is considered to comply with this requirement.

8.3.3 Field-Wiring Terminals (General)

8.3.3.1 A field-wiring terminal to which field-wiring connections are made shall comply with the following requirements:

- A Clauses 8.3.3.2 – 8.3.3.5;
- B CSA C22.2 No. 153, Quick-Connect;
- C CSA C22.2 No. 65, Standard for Wire Connectors;
- D UL 486E, Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors; or
- E CSA C22.2 No. 158, Terminal Blocks, rated for field-wiring (FW) Code 2 applications and also suitable for the voltage, current, wire range, and wire type of the intended application.

8.3.3.2 Nonferrous soldering lugs or solderless (pressure) wire connectors shall be used for 5.3 mm² (10 AWG) and larger wires. When the connectors or lugs are secured to a plate, the plate thickness shall not be less than 1.3 mm (0.050 in) thick. Securing screws of plated steel have been determined to meet the requirements.

8.3.3.3 A wire-binding screw used at a wiring terminal shall not be smaller than 4.2 mm (No. 8) diameter. Plated screws are not prohibited.

Exception: A 3.5 mm (No. 6) diameter screw is appropriate for use for the connection of a 2.1 mm² (14 AWG) and a 2.8 mm (No. 4) diameter screw is appropriate for use for the connection of a 0.65 mm² (19 AWG) or smaller conductor.

8.3.3.4 Terminal plates tapped for wire-binding screws shall:

- A Have not less than two full threads in the metal (the terminal plate metal may be extruded to provide the two full threads) and shall have upturned lugs, clamps, or the equivalent, to hold the wires in position. Other constructions may be used if they provide equivalent thread security of the wire-binding screw;
- B Be of a nonferrous metal not less than 1.3 mm (0.050 in) thick when used with a 4.2 mm (No. 8) diameter or larger screw, and not less than 0.76 mm (0.030 in) thick when used with a 3.5 mm (No. 6) diameter or smaller screw.

8.3.3.5 When two or more conductors are intended to be connected by wrapping under the same screw, a nonferrous intervening metal washer shall be used for each additional conductor. A separator washer is not required when two conductors are separated and intended to be secured under a common clamping plate. When the wires protrude above terminal barriers, the nonferrous separator shall include means, such as upturned tabs or sides, to retain the wire.

8.3.4 Special Field-Wiring Terminals (Qualified Application)

8.3.4.1 Any of the following terminal configurations are suitable for connection of field wiring when all of the conditions in Clause 8.3.4.2 are met:

- A Quick-Connect Terminals – Nonferrous, quick-connect (push-type) terminals consisting of male posts permanently secured to the device and provided with compatible, female connectors for connection to field wiring. These require a special tool for crimping of field wires. Mating terminals shall be shipped with the control unit with instructions for their installation;

- B Push-In Terminals – Nonferrous (screwless), push-in terminals of the type used on some switches and receptacles. Solid conductors are pushed into slots containing spring-type contacts. The leads are removable by means of a tool inserted to relieve the spring tension on the conductor. Push-in terminals are not to be used with aluminum conductors. The marking adjacent to the terminal shall indicate that copper conductors only are to be used; and
- C Other Terminals – Other terminal connections are not prohibited when determined to be equivalent to item A and B and are limited to the same restrictions.

8.3.4.2 Any of the terminal configurations listed in Clause 8.3.4.1 are appropriate for connection of field wiring provided all of the following indicated conditions are met.

- A When a special tool is required for connection, it shall be provided and its use indicated on the installation wiring diagram by name of the manufacturer and the model number or equivalent;
- B The range of wire sizes shall be indicated on the installation wiring diagram. The minimum permissible wire size to be used shall not be less than 0.13 mm^2 (26 AWG) for a jacketed, multi-conductor cable or 0.82 mm^2 (18 AWG) for a single conductor wire;
- C The wire size to be used shall be rated for the current-carrying capacity of the circuit application; and
- D The special field-wiring terminal assembly shall comply with the strain relief test as outlined in Subsection 9.46.2, Strain Relief (Special Field-Wiring Terminals).

8.3.5 Field Wiring Leads

8.3.5.1 Leads provided for field connections shall not be less than 152 mm (6 in) long; shall be provided with strain relief; shall not be smaller than 0.82 mm^2 (18 AWG); and the insulation, when of rubber or thermoplastic, shall not be less than 0.8 mm (1/32 in) thick. Wire shall be of stranded copper.

8.3.6 Grounded Supply Terminals and Leads

8.3.6.1 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. It shall be readily distinguishable from the other terminals or proper identification of the terminal for the connection of the neutral conductor shall be clearly shown in another manner, such as on an attached wiring diagram.

8.3.6.2 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 leads other than neutral conductors shall be so identified.

8.3.6.3 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 which has an OFF position or to a single-pole over-current (not thermal) protective device.

8.3.7 Grounded Terminals and Leads

8.3.7.1 A hazardous-voltage detector/sensor which is provided with an overall nonmetallic enclosure and cover, is intended to be serviced internally, and employs internal dead metal parts which become energized under fault conditions, requires an equipment grounding terminal or lead, or the equivalent.

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

- A An extra-low voltage detector/sensor;
- B A hazardous-voltage detector/sensor provided with an overall nonmetallic enclosure and cover and that is not intended to be internally serviced; or
- C A hazardous-voltage detector/sensor provided with an overall nonmetallic enclosure and cover, and:
 - i) That does not employ internal dead-metal parts which are energized under a fault condition and be contacted during servicing, or
 - ii) Having internal dead metal parts that are insulated; or
- D A hazardous-voltage detector/sensor provided with an overall nonmetallic enclosure and cover that includes internal dead metal parts which are contacted during servicing, and employs a 2-pole disconnect switch which de-energizes both legs of the supply circuit upon removal of the cover.

8.3.7.3 The grounding means shall be connected to all exposed dead metal parts that become energized and all dead metal parts within the enclosure that are exposed to contact during servicing and maintenance. See Subsection 8.5, Bonding for Grounding.

8.3.7.4 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, and 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 by being marked "G," "GR," "Ground," "Grounding," or the equivalent, or by a marking on a wiring diagram provided on the detector/sensor. The field wiring terminal shall be located so that it won't to be removed during servicing of the product.

8.3.8 Isolated (nongrounded) detectors/sensors

8.3.8.1 When a detector/sensor is constructed such that the exposed metal enclosure serves as a current-carrying part of the circuit, an insulated (nonmetallic) mounting plate, or a metal mounting plate with insulated bushed holes through which metal mounting screws are employed, or an equivalent arrangement shall be provided for installation between the detector current-carrying parts and metal back box.

8.3.8.2 The arrangement described in Clause 8.3.8.1 is permitted only on a detector/sensor intended for connection to a low-voltage circuit. In addition, the following or equivalent marking is to be displayed in letters at least 3.2 mm (1/8 in) high adjacent to the detector wiring area:

- A "CAUTION/MISE EN GARDE" and/or symbol indicated in Table 4, Safety Warnings:
- B "Install enclosure isolated from ground per manufacturer's instructions and hardware provided. Grounding could result in a false alarm." and
- C «Installer le boîtier sans mise à la terre selon les instructions et avec le matériel fourni par le fabricant. La mise à la terre du boîtier pourrait entraîner une fausse alarme »

8.3.9 Internal Wiring

8.3.9.1 General

8.3.9.1.1 The internal wiring of a detector/sensor shall consist of conductors having:

- A Insulation rated for the potential involved;
- B Insulation rated for the temperatures to which it may be subjected; and
- C The current-carrying capacity of the service.

The wiring shall be routed away from moving parts and sharp projections and held in place with clamps, string ties, or the equivalent, unless of sufficient rigidity to retain a shaped form.

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

8.3.9.1.3 When the use of a short length of insulated conductor is not feasible, e.g., a short coil lead or the like, electrical insulating tubing may be employed. The tubing is not to be subjected to sharp bends, tension, compression, or repeated flexing, and is not to contact sharp edges, projections, or corners. The wall thickness is to conform to the requirements for such tubing, except that the thickness at any point for the smaller sizes of polyvinyl chloride tubing is to be not less than 0.43 mm (0.017 in). For insulating tubing of other types, the thickness is to be not less than that providing mechanical strength, dielectric properties, heat- and moisture-resistant characteristics, and the like at least equal to those of 0.43 mm (0.017 in) thick polyvinyl chloride tubing.

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

8.3.9.2 Wireways

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

8.3.9.3 Splices

8.3.9.3.1 All splices and connections shall be mechanically secured and bonded electrically. Tack soldering of components or electrical leads is permitted where the construction precludes mechanical security only when 5 samples resist a pull-force of 8.9 N (2 lbs) applied for 3 s and the connection is subjected to 100 % inspection and testing with the same pull force by the manufacturer.

8.3.9.3.2 A splice shall be provided with insulation determined to be equivalent to that of the wires involved when permanence of electrical spacings between the splice and uninsulated metal parts is not provided.

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

8.3.9.4 Barriers

8.3.9.4.1 A metal barrier shall have a thickness at least equal to that required by Table 3, Sheet Metal Enclosures, as determined by the size of the barrier. A barrier of insulating material shall not be less than 0.71 mm (0.028 in) thick and shall be thicker when it is possible for deformation which defeats its purpose to be easily accomplished. Any clearance between the edge of a barrier and a compartment wall shall not be more than 1.6 mm (1/16 in).

8.3.9.5 Strain Relief

8.3.9.5.1 A strain relief means shall be provided for the field supply leads and all internally connected wires or cords that are subject to movement in conjunction with the installation, operation, or servicing of a detector/sensor to reduce the risk of any mechanical stress being transmitted to internal connections and terminals. Inward movement of the cord or leads provided with a ring-type cord grip shall not damage internal connections or components, or result in a reduction of the electrical spacings required. See Subsection 9.45, Strain Relief Test.

8.4 SERVICING PROTECTION

8.4.1 General

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

8.4.2 Trained Service Personnel

8.4.2.1 The requirements in Clauses 8.4.2.2 and 8.4.2.3 apply for non-household products intended to be serviced by trained service personnel.

Exception: Any part that is exposed only during operator servicing and complies with Subsection 9.39, Electric Shock Current Test, is not required to comply with the requirements in Clause 8.4.2.2 or 8.4.2.3.

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

8.4.2.3 In lieu of the minimum 152 mm (6 in) requirement in Clause 8.4.2.2:

- A An interlock shall be provided on the cover to de-energize all live parts in the enclosure; or
- B The following wording shall be permanently and prominently marked on the cover front:

“CAUTION/MISE EN GARDE” and/or symbol indicated in Table 4, French/English Markings:

“Disconnect Power Prior to Servicing.”

«Déconnecter avant de procéder à L'entretien.»

8.5 BONDING FOR GROUNDING

8.5.1 An exposed non-current-carrying metal part of a detector/sensor operating at more than 30 Vrms that is liable to become energized, shall be reliably 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. This requirement also applies to a product equipped with auxiliary function contacts rated at more than 30 Vrms.

8.5.2 Except as indicated in Clause 8.5.3, uninsulated metal parts of electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors, and other electrical components shall be bonded for grounding when it is possible that they be contacted by the user or by a serviceman in servicing or operating the equipment.

8.5.3 Metal parts as described below are not required to comply with the requirement specified in Clause 8.5.2:

- A Adhesive attached metal foil markings, screws, and handles that are located on the outside of the detector/sensor enclosure and isolated from electrical components or wiring by grounded metal parts so that they shall not become energized;
- B Isolated metal parts, such as small assembly screws, that are separated from wiring and uninsulated live parts;
- C Panels and covers which do not enclose uninsulated live parts, when wiring is positively separated from the panel or cover so that it shall not become energized; and
- D Panels and covers which are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 0.8 mm (1/32 in) thick and secured in place.

8.5.4 A bonding conductor shall be of material determined to be capable for use as an electrical conductor. When of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The conductor shall not be smaller than the maximum size wire employed in the circuit wiring of the component or part. A separate bonding conductor or strap shall be installed in such a manner that it is protected from mechanical damage.

8.5.5 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, brazing, or welding. 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.

NOTE 1: A bolted or screwed connection that incorporates a star washer under the screw head is considered acceptable for penetrating non-conductive coatings.

NOTE 2: Where the bonding means depend upon screw threads, two or more screws or two full threads of a single screw engaging metal are considered acceptable. Metal-to-metal hinge-bearing members for doors or covers may be considered as a means for bonding the door or cover for grounding providing that a multiple bearing, pin-type hinge is employed.

8.5.6 Splices shall not be employed in conductors used to bond electrical enclosures or components.

8.6 COMPONENTS

8.6.1 Mounting of Components

8.6.1.1 All parts of a detector/sensor shall be securely mounted in position and prevented from loosening or turning if such motion may adversely affect the normal performance of the unit, or may affect the fire and accident hazard incident to the operation of the product.

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 of a plunger or other type that does not tend to rotate when operated. A toggle switch is 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 loosens it.*
- C The spacings are not reduced below the minimum required values when the switch rotates.*
- D The operation of the switch is by mechanical means rather than by the 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, are not required to be prevented from turning when rotation does not reduce spacings below the minimum values required.

8.6.1.2 Uninsulated live parts shall be secured to the base or mounting surface so that they shall not turn or shift in position, when it is possible that such motion results in a reduction of spacings, below the acceptable values. Friction between surfaces shall not be used as a means to prevent shifting or turning of live parts, a lock washer applied as intended is permissible.

8.6.1.3 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 shall not turn or shift in position when such motion results in reduction of spacings below the minimum values required. This is to 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 any method determined to be equivalent.

8.6.2 Operating Components

8.6.2.1 Operating components and assemblies, such as switches, relays, and similar devices, shall be protected by individual protection (i.e. dust covers) or dust tight cabinets against fouling by dust or by other material which affect their operation.

8.6.2.2 Adjusting screws and similar adjustable parts shall not loosen under the conditions of actual use. The use of a lock washer, applied as intended, to reduce the risk of loosening is permissible.

8.6.2.3 Moving parts shall have sufficient play at bearing surfaces to prevent binding.

8.6.2.4 Manually operated parts shall have sufficient strength to withstand the stresses to which they will be subjected in operation.

8.6.2.5 An electromagnetic device shall be reliable and ensure positive electrical and mechanical performance under all conditions of normal operation.

8.6.3 Current-Carrying Parts

8.6.3.1 A current-carrying capacity for the service shall be a metal such as silver, copper, copper alloy, or other material that will provide equivalent performance.

8.6.3.2 Bearings, hinges, and the like shall not be acceptable for carrying current between interrelated fixed and moving parts.

8.6.4 Bushings

8.6.4.1 When 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 to provide support for the wire.

8.6.4.2 When the opening is in a phenolic composition or other nonconducting material or in metal of thickness greater than 1.07 mm (0.042 in) at the opening, a smooth surface having rounded edges is identified as the equivalent of a bushing.

8.6.4.3 Ceramic materials and some molded compositions are permissible for insulating bushings, separate bushings of wood and of hot-molded shellac are prohibited.

8.6.4.4 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 1.6 mm (1/16 in) thick, with a minus tolerance of 0.4 mm (1/64 in) for manufacturing variations; and
- C It does not deteriorate in normal ambient humidity conditions.

8.6.4.5 When 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, projections, and other anomalies which cut into the bushing and wire insulation.

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

8.6.5 Electrical Insulating Material

8.6.5.1 Material for the mounting of current-carrying parts shall be porcelain, phenolic composition, cold-molded composition, or equivalent material which is suitable for the particular application.

8.6.5.2 Polymeric materials shall be used for the sole support of uninsulated live parts only when determined to be equivalent to the materials indicated in Clause 8.6.5.1.

8.6.5.3 When vulcanized fiber is used for insulating bushings, washers, separators, and barriers, it shall not be the sole support for uninsulated current-carrying parts of other than *extra-low-voltage circuits*.

8.6.5.4 The thickness of a flat sheet of insulating material, such as impregnated asbestos-cement composition or phenolic composition employed for panel mounting of parts, shall not be less than the applicable value indicated in Table 6, Thickness of Flat Sheets of Insulating Material.

8.6.5.5 A terminal block mounted on a metal surface which is capable of being grounded shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base to reduce the risk of the parts and the ends of replaceable terminal screws from reducing spacings below the minimum thickness specified in Table 6, Thickness of Flat Sheets of Insulating Material.

Exception: Such insulation is not required when the parts are staked, upset, sealed, or equivalently kept from loosening.

8.6.5.6 A countersunk sealed part shall be covered with a waterproof insulating compound which does not melt at a temperature 15 °C (27°F) higher than the maximum intended 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 3.2 mm (1/8 in).

8.6.6 Visual Indicators

8.6.6.1 Lampholders and visual indicators shall be rated for the circuit in which they are employed when the detector/sensor is operated under any condition of normal service.

8.6.6.2 A lampholder shall be installed so that uninsulated live parts other than a screw shell will not be exposed to contact by persons removing or replacing lamps in normal service.

8.6.6.3 A lampholder employing a metal shell, such as a screw shell, used in a circuit rated at 30 Vrms or greater shall be wired so that the metal shell is connected to an identified (grounded circuit) conductor.

8.6.6.4 When more than one lampholder employing a metal shell is provided, the metal shells of all such lampholders shall be connected to the same grounded circuit conductor.

8.6.6.5 A visual indicator or equivalent means shall be provided on a detector/sensor head or base to identify it as the unit from which the alarm was initiated.

8.6.6.6 When a detector/sensor has more than one visual indicator, indicator colours are required as follows:

- A A white or green "power-on" indicator;
- B A red alarm indicator; and
- C An amber or yellow trouble indicator.

8.6.6.7 Use of alternate colors or indication flash rates shall be permitted and shall be marked to identify the function. If flashing is used, the flash rate shall be no less than 12 flashes per min.

8.6.7 Protective Devices

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

8.6.8 Printed Circuit Boards

8.6.8.1 The components of a printed circuit board shall be attached securely and the spacings between circuits shall comply with the spacing requirements of Subsection 8.6.12, Spacings, for rigidly clamped assemblies [see Table 7, Minimum Spacings; and Table 8, Minimum Over Surface Spacings on Printed Circuit Boards. The board shall be mounted so that deflection of the board during servicing shall not result in damage to the board or in a reduction of electrical spacings below those required in this standard.

8.6.9 Switches

8.6.9.1 A switch provided as part of a unit shall have a current and voltage rating not less than that of the circuit which it controls when the device is operated under any condition of normal service.

8.6.9.2 When a reset switch is provided, it shall be of a self-restoring type.

8.6.9.3 When a nonself-restoring switch is in the "off-normal" position, a *trouble signal* is to be communicated to the control unit.

8.6.10 Transformers and Coils

8.6.10.1 A transformer shall meet the requirements of CSA C22.2 No. 66, Specialty Transformers.

Exception: An autotransformer shall be used only when the terminal or lead connected to the autotransformer winding that is common to both input and output circuits is identified and the output circuits are located only within the enclosure containing the autotransformer.

8.6.10.2 The insulation of coil windings of relays, transformers, and other insulation, shall resist the absorption of moisture.

8.6.10.3 Film-coated or equivalently insulated wire does not require additional treatment to stop moisture absorption.

8.6.11 Dropping Resistors

8.6.11.1 A carbon composition resistor shall not be used as a dropping resistor in the *hazardous-voltage circuit* of a detector/sensor.

8.6.12 Spacings

8.6.12.1 General

8.6.12.1.1 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 7, Minimum Spacings, or Table 8, Minimum Over Surface Spacings on Printed Circuit Boards.

8.6.12.1.2 The spacings between an uninsulated live part and:

- A A wall or cover of a metal enclosure;
- B A fitting for conduit or metal-clad cable; and
- C Any dead-metal part

shall not be less than that indicated in Table 7, Minimum Spacings.

8.6.12.1.3 The "Through Air" and "Over Surface" spacings of Table 7, Minimum Spacings, measured at an individual component part shall be judged on the basis of the volt-amperes used and controlled by the individual component. However, the spacing 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-ampere ratings of all components in the enclosure.

8.6.12.1.4 The spacing requirements specified in Table 7, Minimum Spacings, do not apply to the inherent spacings inside motors, except at wiring terminals, nor to inherent spacings for a component provided as part of the detector/sensor. 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 as indicated in Table 7, Minimum Spacings.

8.6.12.1.5 The "To Walls of Enclosure" spacings of Table 7, Minimum Spacings, are not to be applied to an individual enclosure of a component part within an outer enclosure.

8.6.12.1.6 Film-coated or equivalently insulated wire is identified as an uninsulated live part. Enamel is capable of being used as turn-to-turn insulation in coils.

8.6.12.2 PCBA Clearance A (Equivalency)

8.6.12.2.1 Other than as noted in Clause 8.6.12.1.1, the requirements of this section may be used to evaluate clearances less than those specified for the end product while maintaining the same overvoltage withstand capability for the equipment.

8.6.12.2.2 A clearance, less than the specified minimum through air spacing, may be suitable if acceptable results are obtained when tested in accordance with Subsection 9.40, Dielectric Voltage-Withstand Test, using a voltage with a value in accordance with Table 9, Test Voltages for Verifying Through Air Spacings (Clearances). For specified minimum clearances between the values in Table 9, Test Voltages for Verifying Through Air Spacings (Clearances), interpolation may be used to determine the test voltage.

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

8.6.12.3 PCBA Clearance B (Controlled Overvoltage)

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

8.6.12.3.2 Control of overvoltages may be achieved by either:

- A Providing overvoltage devices or systems as an integral part of the product; or
- B Marking the product with the rating of overvoltage control to which the product is to be connected, and the energy handling capability of the overvoltage device, if appropriate.

8.6.12.3.3 With reference to the marking in Clause 8.6.12.3.2, the users of this standard must determine the appropriate method to state that the overvoltage control device or system should comply with the requirements in Clause 8.6.12.3.4. One of the alternatives to marking the product would be to provide the information in published documentation.

8.6.12.3.4 Devices or systems, including filters or air gaps, used to control overvoltages in accordance with this section shall be evaluated using the requirements within this Standard and/or within the standards listed below, as applicable. If used in products having short circuit withstand ratings, the suppressors shall also withstand the available current when tested in accordance with the standards listed below, as applicable:

- A C22.2 No. 269.1-14 Surge Protective Devices – Type 1 – Permanently Connected;

- B C22.2 No. 269.2-13 Surge Protective Devices – Type 2 – Permanently Connected; and
- C C22.2 No. 269.3-14 Surge Protective Devices – Type 3 – Cord Connected, Direct Plug-in, and Receptacle Type.

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

8.6.12.3.6 Line connected devices and circuits shall be assigned both a phase-to-ground rated system voltage and an overvoltage category as specified in Table 10, Minimum Clearances for Equipment. Circuits, line connected or secondary, employing the clearances of Table 10, Minimum Clearances for Equipment, shall be protected for the rated impulse withstand voltage peak identified in Table 10, Minimum Clearances for Equipment. The switching test detailed in Subsection 8.6.12.5, Switching Test, should be conducted unless circuit analysis reveals that the appropriate protection is provided wherever Table 10, Minimum Clearances for Equipment, clearances are used.

8.6.12.3.7 Clearances are to be:

- A Evaluated by the dielectric voltage-withstand test in Clause 8.6.12.2.2; or
- B Selected and measured in accordance with the dimensions in Table 10, Minimum Clearances for Equipment.

8.6.12.3.8 Clearances selected and measured in accordance with the dimensions in Table 10, Minimum Clearances for Equipment, do not require testing.

8.6.12.4 Pollution degree

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

- A Pollution Degree 1 – No pollution or only dry, nonconductive pollution. The pollution has no influence.
- B Pollution Degree 2 – Normally, only nonconductive pollution. However, a temporary conductivity caused by condensation may be expected.
- C Pollution Degree 3 – Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation that is expected.
- D Pollution Degree 4 – Pollution that generates persistent conductivity through conductive dust or rain and snow.

8.6.12.5 Switching test

8.6.12.5.1 Where required by Clauses 8.6.12.1.1 – 8.6.12.4.1, Clearance B (Controlled Overvoltage), line and load terminals of a device are to be monitored for generated voltages during normal operation, including adjusting switches and controls, at rated operational voltage under load and no-load conditions. Generated voltages shall not be greater than the rated impulse withstand voltage peak specified in Table 10, Minimum Clearances for Equipment, for the device. This monitoring is to be done using an oscillographic study during a suitable test such as an overload test.

8.6.13 Batteries

8.6.13.1 General

8.6.13.1.1 When a battery or set of batteries is employed as the main source of power for a gas or vapour detector/sensor, it shall comply with the requirements of Subsection 9.29, Battery Tests.

8.6.13.1.2 Batteries included as part of a detector/sensor shall be located and mounted to reduce the likelihood of terminals of cells coming in contact with uninsulated live parts, terminals or adjacent cells, or metal parts of the enclosure as a result of shifting.

8.6.13.1.3 A battery compartment intended for use with rechargeable batteries that emit gases during charging shall be provided with vent holes and a coating that is resistant to the corrosive action of the electrolyte.

8.6.13.1.4 Ready access shall be available to the battery compartment to facilitate battery replacement, without damage to the product components, field wiring, or disassembly of any part of the detector/sensor, except for a cover or the equivalent.

8.6.13.1.5 Connections of external wiring to a battery-operated gas or vapour detector/sensor, or to a portable accessory, shall not be subjected to stress or motion during battery replacement, servicing, or both. Removal of the detector/sensor or accessory from the mounting support to replace a battery or to service the unit is permitted only when the connected wiring is not subjected to flexing or stress.

8.6.13.2 Battery Connections

8.6.13.2.1 A lead or terminal assembly connection to a battery shall be provided with strain relief and shall be identified with the proper polarity (plus or minus signs) unless the intended connection is determined by the terminal configuration. It is permissible for polarity to be indicated on the unit adjacent to the battery terminals or leads.

8.6.13.2.2 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 that applies a minimum of 6.6 N (1.5 lbs) force to each battery contact, or equivalent. The connection shall consist of an unplated or plated metal that is resistant to the corrosive action of the electrolyte.

8.6.13.2.3 Each lead of a clip-lead assembly employed as a part of a battery operated detector/sensor shall not be smaller than 0.21 mm² (26 AWG) stranded wire, and the insulation shall not be less than 0.4 mm (1/64 in) thick.

9 PERFORMANCE

9.1 GENERAL

9.1.1 The performance of gas and vapour detectors and sensors shall be investigated by subjecting samples of each rating that is representative of production to the tests specified in Section 9, Performance, as applicable. Refer to Table 15, Gas & Vapour Detector Performance Tests and Analysis Table. Refer to Appendix B, Test Sample Sequence Flowchart, for test sequence.

NOTE: Variation to the test sequence are permissible when agreed upon between the testing organization and manufacturer prior to the start of the tests, unless a test sequence is specifically defined in the applicable requirements.

9.2 TEST VOLTAGES

9.2.1 Except as otherwise indicated, the performance of a product shall be investigated by subjecting three representative samples, in commercial form, to the applicable tests described in Subsections 9.8, Normal Operation Test, through 9.54, Corrosion Test.

9.2.2 Unless otherwise specified, the test voltages for each test of a product are to be at the rated frequency of the product as noted in Table 11, Test Voltages.

9.3 TEST SAMPLES AND DATA

9.3.1 Detectors and *sensors* that are fully representative of production units shall be used for the tests specified in Subsections 9.8, Normal Operation Test, through 9.54, Corrosion Test, unless otherwise specified. The *sensitivity* setting or range of sensitivities of the sample under test will define the *production gas sensitivity*.

9.3.2 The devices employed for testing shall be those specified by the wiring diagram of the sample under test. When substitute devices are used, they shall produce functions and load conditions equivalent to those obtained with the sample under test in service including devices intended to be used with the detector or *sensor*.

9.4 SENSITIVITY LIMITS

9.4.1 General

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

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

9.4.1.3 A gas and vapour detector or *sensor* shall operate within the *sensitivity* parameters defined by the manufacturer but must not exceed the *sensitivity* limits defined in Table 12, Allowable Gas and Vapour Limits, and:

- A The limits specified by the applicable Time Weighted Average (TWA) concentration as specified by regulations of the *authority having jurisdiction*;

NOTE: Refer to the provincial or territorial Occupational Health and Safety Act or, for federal jurisdictions, the Canadian Occupational Health and Safety Regulations.

- B Standards such as the Instrument Society of America Standard, Performance Requirements for Combustible Gas Detectors, ANSI ISA 12.13.01. A detector can produce an *alarm signal* up to and above the LEL. This performance requirement applies to industrial applications for detectors and/or their control assemblies that are intended for use in *hazardous locations*; or
- C Residential and commercial and industrial detectors and/or their control assemblies intended for use in *ordinary locations* (non-hazardous) shall produce an *alarm signal* at or below 25% of the LEL; or
- D For carbon monoxide detectors:

- (i) A carbon monoxide detector shall operate at or below the test points specified in Part A of Table 13, Carbon Monoxide Concentration Versus Time for Alarm Test Points Based on 10% Carboxyhemoglobin (COHb), when using the test equipment described in Subsection 9.4.3, Test Chamber. These test points are based on plotted limits for the 10% COHb curve Figure 2, Carbon Monoxide Concentration (*ppm* CO) Versus Time (Minutes). If the detector employs a variable *sensitivity* setting, test measurements are to be made at maximum and minimum settings. For this test, three carbon monoxide concentrations (70, 150, and 400 *ppm*) are to be used as specified in Part A of Table 13, Carbon Monoxide Concentration Versus Time for Alarm Test Points Based on 10% Carboxyhemoglobin (COHb); and
- (ii) A carbon monoxide detector shall not operate below the test points specified in Part B of Table 13, Carbon Monoxide Concentration Versus Time for Alarm Test Points Based on 10% Carboxyhemoglobin (COHb), when using the test equipment described in Subsection 9.4.3, Test Chamber. If the detector employs a variable *sensitivity* setting, test measurements are to be made at maximum and minimum settings. For this test, at least two carbon monoxide concentrations (70 and 30 *ppm*) are to be used as specified in Part B of Table 13, Carbon Monoxide Concentration Versus Time for Alarm Test Points Based on 10% Carboxyhemoglobin (COHb).

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

9.4.1.5 Where a test gas is to be used, it shall be an appropriate mixture of the gas under investigation with clean air. This mixture shall be used for the initial and all subsequent tests.

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

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

9.4.1.8 If a detector or sensor has two or more alarm set points, the lower set point may be non-latching. The higher alarm set point shall remain latched in the alarm condition.

9.4.1.9 If a gas detector is intended to operate when a potentially hazardous gas concentration is detected, it shall be of a latching type requiring a deliberate manual action to reset.

9.4.1.10 For detector(s) or sensor(s) that result in a latching alarm condition, the manufacturer's field sensitivity test shall be conducted or the sample shall result in a trouble signal as defined in Subsection 4.3.

9.4.2 Sensitivity Calibration

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

9.4.3 Test Chamber

9.4.3.1 The detector or *sensor* may be installed in a chamber, having a volume of at least 0.0283 m³ (1 ft³), constructed so as to permit accurate monitoring and control of chamber air temperature and humidity and oxygen and gas concentrations. The following conditions shall be established within the test chamber and maintained throughout the test, unless otherwise specified by the instruction manual:

- A Ambient temperature at 23 ± 3 °C (73.4 ± 5 °F) or a higher temperature if specified by the manufacturer;
- B Relative humidity at 50 ± 20 %;
- C Oxygen concentration at 20.9 ± 1 %; and
- D Supply voltage, if applicable, adjusted to 100 % of rated input voltage.

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

9.4.4 Carbon Monoxide Sensitivity

9.4.4.1 The carbon monoxide detector or *sensor* shall not produce an alarm or *alarm signal* when exposed sequentially, as described in Clauses 9.4.4.4 through 9.4.4.6, to the concentrations of gases and vapours shown in Table 14, Carbon Monoxide Detector Immunity Concentrations. Alternatively, for combustible and toxic gas detectors other than carbon monoxide alarms intended for residential or commercial applications, the cross *sensitivity* and contamination gases and gas concentrations are to be specified by the manufacturer and outlined in the User's Manual. The gases and concentrations identified in the User's Manual shall constitute the list of gases to be used for selectivity testing.

9.4.4.2 Calculate the interior volume of the test chamber used in Subsection 9.4.3, Test Chamber. Deduct the volume of the device under test (as provided by the manufacturer). From this volume, calculate the amount of each test substance necessary to supply the concentrations identified in Table 14, Carbon Monoxide Detector Immunity Concentrations.

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

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

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

9.4.4.6 Purge the chamber with clean air to remove all of the test atmosphere. Maintain clean air in the chamber for a recovery time of 16 h or as specified by the manufacturer. In no case shall recovery time exceed 16 h. Reseal the chamber and repeat the test using another substance from Table 14, Carbon Monoxide Detector Immunity Concentrations, until the detector has been exposed to all substances. It is not required that exposure to the substances be in any particular order.

9.4.4.7 Following this test, the *sensitivity* test, see Clauses 9.4.1.1 – 9.4.1.7, using the target gas concentration, is to be performed on the detector or *sensor*. All samples used for and tested to the requirements of this Subsection (Subsection 9.4.4, Carbon Monoxide *Sensitivity*), shall comply with these requirements.