

Standard

Performance Requirements, Combustible Gas Detectors



ISA-S12.13, Part I, Performance Requirements, Combustible Gas Detectors

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Preface

This preface, as well as all footnotes and annexes, is included for informational purposes and is not part of ISA-S12.13, Part I.

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Foreword

This standard is based primarily on the initiative of the Canadian Standards Association, which resulted in Standard C22.2 No. 152-1976.¹ The preface to that document, written by James E. Duncan of the Canadian Standards Association, is reprinted below for clarification of the concepts involved.²

This standard was initiated through industry effort in order to uphold and improve the level of electrical safety and safety-oriented performance of combustible gas detection instruments.

Throughout the development of the Standard the basic Subcommittee was augmented at several of its meetings by a substantial number of expert representatives from the oil and gas producing and transporting industries, the oil refining industry, the petro-chemical industry, the mining industry and other similar interests, representing "users" of this type of equipment. This included people responsible for the selection, application, installation, and maintenance of combustible gas detection instruments in this Standard have been designed to answer many of the expressed needs of such "users" based on their collective experience in the application and use of such instruments in actual service in the Canadian industrial environment.

This Standard establishes a minimum level of safety-oriented performance capability by requiring that:

- a) All such equipment pass certain tests, devised to measure the instrument's capability to properly respond to a variety of exposures simulating conditions and occurrences which may reasonably be expected to occur in actual service;
- b) All such equipment be provided with certain minimum features of construction deemed necessary to permit proper safe operation, ease of necessary adjustments and reliability;
- c) Each unit be provided with a comprehensive set of installation and operating instructions to permit the user to properly install, operate, and adjust the equipment, and to properly acquaint him with the capabilities and limitations of the equipment.

Moreover, this Standard provides that, if claims are made for performance levels or construction features in excess of the minimum levels in the Standard's basic requirements, the testing procedures and requirements be modified to verify all such superior claims. This is intended to encourage further advancements in the state of the art, and to give free rein to natural competitive development in this field, while still ensuring that any instrument he obtains is capable of performing at least to this minimum level.

Instrument capability alone cannot ensure that the use of these instruments will properly safeguard areas or locations where combustible gases or vapors may be or are present. The level of safety obtained depends heavily not only upon the

¹This standard was revised in 1984. See Annex A for reference information.

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user having a full knowledge of the limitations of the instrument, but also upon proper selection for the particular situation, proper installation and especially upon frequent periodic maintenance and adjustment.

To properly safeguard any particular area, the user must also have a basic knowledge of gas/vapor properties and phenomena (how gases and vapors propagate, whether the gases are heavier or lighter than air, etc.), and the conditions which may prevail in the areas being protected (direction and velocity of gas movement, humidity and temperature variation, presence of particulates or detrimental contaminants, ease of gaining access for periodic maintenance and adjustment, etc.), in order to select an instrument suitable for these conditions and locate it where it will be effective for its intended function.

Anyone using this Standard as an aid in selecting or applying combustible gas detection instruments should review the conditions described for the various tests (both in the body of the Standard and in the Appendix A³) and compare them to the actual conditions which may prevail in the locations to be protected. If actual conditions are likely to be more severe than the minimum test conditions in any respect, the user should seek an instrument having superior properties.

It is stressed that the final and long-term effectiveness of any combustible gas detection equipment depends heavily upon the user himself, who must be responsible for its proper application, installation, proper use and regular maintenance.

The reader's attention is particularly directed to the fact that, in developing the test requirements and acceptance criteria contained in this Standard, the Subcommittee which took part in its preparation had in mind the specific test apparatus and test technique then in use or being developed by one specific testing agency, as described in Appendix A³ of this Standard.

It is most important, therefore, in relating the test requirements of this Standard to conditions likely to arise in actual service, or in attempting to establish correlations with tests performed by different testing agencies, to realize and appreciate that the significance of the test results obtained is subject to interpretation based on the actual test apparatus and technique used. To ensure that the original intent of this Standard is met, therefore, the test technique and apparatus used must be as nearly as possible identical to that described in Appendix A.³

³ The following ISA Standard does not include the appendix from the Canadian document; therefore, references to Appendix A are not applicable.

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1 Scope

1.1 This standard addresses the details of construction, performance, and testing of portable, mobile, and stationary electrical instruments used for sensing the presence of combustible gas or vapor concentrations in ambient air. Parts of such instruments may be installed or operated in Class I hazardous (classified) locations and gaseous mines in accordance with codes and standards specified by authorities having jurisdiction. ([See Annex A.](#))

1.2 This standard applies to line-voltage operated instruments rated at 600 V nominal or less, and to portable, mobile, or stationary-type instruments utilizing a battery of a nonrechargeable (primary) type or a rechargeable (secondary) type.

1.3 This standard addresses combustible gas detection instruments intended to provide an indication or alarm, the purpose of which is to give a warning of potential hazard.

1.4 This standard does not address gas detection instruments of the laboratory or scientific type used for analysis or measurement, instruments used for process control and process monitoring purposes, open path (line of sight) area monitors, or instruments used for residential purposes.

1.5 This standard is written for gas detection instruments that are intended to measure gas concentrations in air in the range from zero up to the lower flammable (explosive) limit.

1.6 For instruments used for sensing the presence of multiple gases, this standard applies only to the portion sensing the presence of combustible gas or vapor.

2 Purpose

2.1 Part I of this standard provides minimum requirements for the performance of combustible gas detection instruments and thereby enhances the safety of operations employing these instruments.

2.2 Part II of this standard* establishes user criteria for the installation, operation, and maintenance of combustible gas detection instruments.

*ISA-RP12.13, Part II, 1987, *"Installation, Operation, and Maintenance of Combustible Gas Detection Instruments"*

3 Definitions

3.1 alarm set point: The selected gas concentration level(s) at which an indication, alarm, or other output function is initiated.

3.2 calibration: The act of adjusting an instrument to "zero" and setting the desired "span."

3.3 clean air: Air that is free of combustible gases and contaminating substances.

3.4 combustible gas: Any substance that exists in the gaseous or vapor state at normal atmospheric temperature and pressure and that is capable of being ignited and rapidly oxidizing when mixed with proper proportions of air or oxygen.

Materials that cannot produce sufficient gas or vapor to form a flammable mixture at ambient or operating temperatures and mists formed by the mechanical atomization of combustible liquids are NOT considered to be combustible gases.

NOTE—For convenience, the shorter term "gas" may be used as an abbreviation for "combustible gas" within this standard.

3.5 control unit: That portion of a multipart gas detection instrument that is not directly responsive to the combustible gas, but that responds to the electrical signal obtained from one or more detector heads to produce an indication, alarm, or other output function if gas is present at the detector head location.

3.6 detector head: That gas-responsive portion of a multipart gas detection instrument that is located in the area where sensing the presence of combustible gases is desired. Its location may be integral with or remote from its control unit.

NOTE—The detector head may incorporate additional circuitry such as signal-processing or signal-amplifying components or circuits in addition to the gas-sensing element in the same housing.

3.7 diffusion: A method by which the atmosphere being monitored gains access to the gas-sensing element by natural molecular movement.

3.8 flammable range: The range of flammable vapor concentrations or gas-air mixtures in which propagation of flame will occur on contact with a source of ignition.

NOTE—For purposes of this standard, the terms "lower flammable limit (LFL)" and "lower explosive limit (LEL)" are deemed to be synonymous, and likewise the terms "upper flammable limit (UFL)" and "upper explosive limit (UEL)" are deemed to be synonymous. For ease of reference, the two abbreviations "LFL" and "UFL" may be used hereafter to denote these two sets of terms. It should be recognized that particular authorities having jurisdiction may have overriding requirements that dictate the use of one of these sets of terms and not the other.

3.9 full-scale gas concentration: 100 percent of the actual marked full-scale concentration value.

NOTE—For purposes of this standard, the actual gas concentration corresponding to the lower and upper flammable limits shall be the values shown in the latest edition of nationally recognized documents. See Annex A.

3.10 gas detection instrument: An assembly of electrical and mechanical components (either a single integrated unit, or a system comprising two or more physically separate but interconnected component parts) that senses the presence of combustible gas and provides an indication, alarm, or other output function.

NOTE—For convenience, the shorter term "instrument" may be used as an abbreviation for "gas detection instrument" within this standard.

3.11 gas-sensing element (sensor): The primary element in the gas detection system that responds to the presence of a combustible gas—including any reference or compensating unit, where applicable.

3.12 mobile instrument: A continuous-monitoring instrument mounted on a vehicle such as, but not limited to, a mining machine or an industrial truck.

3.13 portable, continuous-duty instrument: A battery-operated portable or transportable instrument intended to operate continuously for 8 hours (h) or more.

3.14 portable, continuous-duty personal instrument: A battery-operated portable instrument intended to be operator-worn, and to operate continuously for 8 h or more.

3.15 portable, intermittent-duty instrument: A battery-operated portable or transportable instrument intended to operate for periods of only a few minutes at irregular intervals.

3.16 sample draw: A method to cause flow of the atmosphere being monitored to be directed to a gas-sensing element.

3.17 stationary instrument: A gas detection instrument intended for permanent installation in a fixed location.

4 General requirements

4.1 Gas detection instruments shall meet the applicable electrical and electronic measuring instrument requirements as they apply to personnel or property protection. [See Annex A.](#)

4.2 Any portion of a gas detection instrument that is intended for installation in a location where gas or vapor concentration may be present shall be suitable for use in hazardous classified locations or gaseous mines in accordance with the group classification of the gas, and shall be marked accordingly.

Portable instruments shall be suitable for use in Class I, Division 2 hazardous locations, as a minimum, and shall be marked accordingly.

4.3 All gas detection instruments shall meet the minimum construction and test requirements contained in this standard. If the manufacturer makes performance claims that exceed these requirements, all such claims shall be verified.

5 Construction

5.1 General

5.1.1 Gas detection instruments, their components, or remote detector heads specifically intended for use in the presence of corrosive vapors or gases, or that may produce corrosive by-products as a result of catalytic oxidation or other chemical process, shall be constructed of materials resistant to corrosion or of materials suitably protected against corrosion. For additional information, [see Annex A](#).

5.1.2 Portable instruments of the sample-draw type shall include the necessary sample-pumping mechanism.

5.2 Meters and indicators

5.2.1 Stationary and continuous-duty portable gas detection instruments having an integral meter to indicate gas concentrations shall employ a meter having sufficient resolution to permit measurement with the precision required for the tests of Clause 7.

5.2.2 Operational characteristics of nonlinear meters or indicators, when used, shall be stated in the instruction manual.

5.2.3 Continuous-duty portable instruments of the sample-draw type shall incorporate a device to indicate adequate flow, except that such an indicating device may be omitted provided that the instruction manual contains detailed instructions as required by [6.3.1\(i\)](#).

5.2.4 A means shall be provided to alert the user that a gas concentration in excess of the measuring range of the instrument has been detected.

5.3 Alarm or output function

5.3.1 Alarm devices, output contacts, or signal outputs (if provided as part of stationary instruments or continuous-duty portable instruments and intended to indicate a potentially hazardous gas concentration) shall be of a latching-type requiring a deliberate manual action to reset. If two or more set or alarm positions are provided, the lower may be nonlatching.

5.3.2 Alarm devices or signals provided as part of intermittent-duty or continuous-duty personal-type portable instruments, if of the nonadjustable alarm set point type, shall be set to operate at a gas concentration not higher than 60 percent of the lower flammable limit. If of the adjustable alarm set point type, the means for adjustment shall not be capable of being set higher than 60 percent of the lower flammable limit.

5.4 Trouble signals

5.4.1 A stationary or mobile gas detection instrument shall provide for a signal transfer or contact transfer to produce a trouble signal if any of the following conditions occur:

- a) instrument power failure;
- b) loss of continuity in any one or more conductors to any remote detector head;
- c) loss of continuity of any gas-sensing element; or
- d) downscale indication (below zero) equivalent to 10 percent nominal LFL or more.

Such signal or contact transfer shall be independent of any other alarm or shutdown signal or contact transfer.

5.4.2 Stationary and mobile sample-draw-type gas detection instruments shall be provided with flow-proving devices (either integral or nonintegral), which shall produce a trouble signal in the form of a contact transfer or signal transfer if a loss of flow occurs.

5.4.3 Continuous-duty, portable gas detection instruments shall be provided with an audible or visible indication of low battery condition, and the nature and purpose of either shall be clearly explained in the instruction manual.

5.4.4 If the manufacturer provides a mechanism that will disable alarm outputs for maintenance or calibration purposes, that mechanism shall either trip the fault signal and produce a visual indication or provide a similar independent set of signals.

5.5 Controls and adjustments

5.5.1 All portable gas detection instruments shall be provided with means for facilitating calibration checks and adjustments as required.

5.5.2 Calibration and alarm(s) setting shall be designed to discourage unauthorized or inadvertent interference with the setting(s). Examples of acceptable methods include mechanical devices (such as a cover requiring the use of a tool) and passwords (input by authorized users).

5.5.3 Fixed instruments housed in explosionproof or pressurized enclosures ([see Annex A](#)) shall have all controls for normal operation accessible from outside the enclosures. The controls for routine calibration may be inside the enclosure, provided all of the following requirements are met:

- a) The enclosure has a cover that can be readily opened or closed and that does not require removal and replacement of bolts or other securing devices in order to open and reclose the enclosure.
- b) All adjustments, switches, or controls that may be deliberately or accidentally operated during the calibration procedure shall involve only circuits meeting requirements for nonincendive circuits.
- c) All uninsulated parts of circuits exceeding 30 V RMS or 42.4 V peak and of circuits 30 V RMS or less that are not Class 2 power-limited (as defined by Article 725 of the *National Electrical Code*®) shall be protected from accidental contact by appropriate mechanical guards or partitions.
- d) The enclosure shall be marked as described in [6.2.4](#).

5.6 Batteries

5.6.1 Continuous-duty portable gas detection instruments with fresh or fully charged batteries shall be capable of continuous nonalarming operation for a period of at least 8 h without replacing or recharging batteries.

5.6.2 Intermittent-duty portable gas detection instruments with fresh or fully charged batteries shall be capable of nonalarming operation at a duty cycle of 10 minutes (min) "On" and 10 min "Off" for a period of 8 h (total cumulative "On" time of 4 hours) without replacing or recharging the batteries. If the instrument is provided with a switch that must be manually held in the "On" position for the duration of the measurement, the duty cycle shall be reduced to 2 min "On" and 18 min "Off" for a period of 8 h (total cumulative "On" time of 48 min).

6 Marking and documentation

6.1 General

The marking required in 6.2 and 6.3 is in addition to the marking requirement contained in 4.2.

6.2 Marking on instruments

6.2.1 The marking required in 6.2.2 and 6.2.3 shall appear in a clearly legible, visible, and permanent manner on each gas detection instrument in the following manner, as applicable:

- a) For portable instruments, the marking shall appear both on the outside surface of the instrument and on its carrying case, if the latter obscures the marking as required in 6.2.2. and 6.2.3.
- b) For stationary instruments, the marking required in 6.2.2 shall appear in a location where it will be visible after installation and in direct sight during the routine periodic recalibration and adjustment of set point(s).

NOTES:

- 1) For gas detection instruments that comprise a control unit and a remote detector head, it is sufficient that this marking appear on the control unit only, except that if routine recalibration can be accomplished entirely by adjustments at the remote detector locations alone, this marking shall appear both on the control unit and on the remote detector head.
- 2) For modular control units comprising one or more control modules in a common enclosure or mounting assembly, the marking need not be repeated on each module, but may appear as a single marking on the common portion of the assembly.
- 3) Where the design of a stationary control unit is such that there is insufficient space for this marking to appear on the portion of the unit that is visible after installation (e.g., compact designs for close panel mounting), the marking required by 6.2.2 is

permitted to appear elsewhere on the control unit, provided that a second duplicate label (with an acceptable adhesive) bearing such marking is supplied with each such control unit (or assembly of control units), together with the instructions that it is to be attached by the user in a conspicuous location after installation, as close as possible to the control unit.

6.2.2 All gas detection instruments shall be marked "CAUTION—READ AND UNDERSTAND INSTRUCTION MANUAL BEFORE OPERATING OR SERVICING." The word "CAUTION" of the foregoing shall be in capital letters at least 3.0 mm high. The balance of the wording shall be in capital letters at least 2.5 mm (0.10 in) high.

6.2.3 Portable gas detection instruments having scales that indicate gas concentrations only below the flammable range shall be marked "CAUTION—OFF-SCALE READINGS MAY INDICATE EXPLOSIVE CONCENTRATION." The word "CAUTION" of the preceding marking shall be in capital letters at least 3.0 mm (0.12 in) high. The balance of the wording shall be in capital letters at least 2.5 mm (0.10 in) high.

6.2.4 Instruments of the type referred to in 5.5.3 that are not intrinsically safe shall be marked "CAUTION—THIS AREA MUST BE KNOWN TO BE NONHAZARDOUS PRIOR TO OPENING THE ENCLOSURE" in capital letters at least 5.0 mm (0.20 in) high and marked in a permanent manner. The marking shall be conspicuously visible prior to removal of the cover.

6.2.5 Where the design of special features of the instrument requires additional markings or a change in marking requirements, the additions or revisions are allowed, but the safety and instructional intent of 6.2 must be met.

6.3 Instruction manual

6.3.1 Each gas detection instrument shall be provided with an instruction manual, furnished by the manufacturer, that shall contain at least the following information:

- a) A list of desensitizing or contaminating gases or substances known to the instrument manufacturer that may adversely affect proper operation of the instrument, including those gases that would not be accurately detected because of adverse reactions with the reference or compensating elements. Warning of the effects of oxygen-enriched or oxygen-deficient atmospheres must be included.
- b) Instructions for checking and calibration, both on a routine basis and following exposure to any of the contaminants referred to in (a) above and following exposure to concentrations causing operation of any alarm.
- c) Complete installation and initial start-up instructions.
- d) Operating adjustments and instructions (e.g., set point, zero, and balance adjustments).
- e) Details of operational limitations (e.g., ambient temperature limits for all parts of the instrument, humidity range, voltage range, maximum loop resistance, and minimum wire size for wiring between control unit and remote detector head(s), need for shielding of wiring, battery life and temperature limitations, maximum and minimum storage temperature limits, pressure limits, and sample velocity, as applicable).
- f) A statement cautioning that electromagnetic interference (EMI) signals may cause incorrect operation.

- g) Wording to clearly indicate that suitable flow-monitoring devices must be provided at the time of installation, if applicable. (See 5.4.2.)
- h) Wording to clearly indicate the nature and significance of all alarms, trouble signals, and any provisions that may be made for silencing or resetting of such alarms, etc., as applicable.
- i) For continuous-duty portable instruments of the sample-draw-type that are not provided with an integral flow-indicating device, detailed instructions regarding one or more suitable techniques that the user may employ (that do not require special instruments or tools) to ensure that sample lines are intact and proper flow is established. (See 5.2.3.)
- j) For stationary or continuous-duty portable instruments of the sample-draw type, wording to indicate the minimum and maximum flow rate or range of flow rates, pressure, and tubing size for proper operation.
- k) For intermittent-duty portable gas detection instruments, the word "CAUTION," followed by wording such as: "Any rapid upscale reading followed by a declining or erratic reading may indicate a gas concentration beyond the upper scale limit. This may indicate a flammable concentration."
- l) For instruments provided with meters, the word "CAUTION," followed by wording such as: "Off-scale readings may indicate a flammable concentration."
- m) An operational review to determine possible sources of a malfunction and the corrective procedures.
- n) A listing of consumable or replacement components and recommendations for the storage of each item.
- o) When more than one type of gas-sensing element is supplied by the manufacturer, a list stating the specific gas or family of chemically similar gases for each sensor.

6.3.2 The instruction manual shall contain complete and accurate instructions for safe and proper operation, installation, and periodic servicing of the instrument. Instructions shall be consistent with the markings as required in 6.2. Where the design or special nature of the instrument requires additional instruction or special information that is in contradiction to, or in addition to, the requirements of 6.3.1, this consideration shall take precedence over the requirements of 6.3.1.

6.3.3 The manufacturer shall include information concerning effects of externally generated electromagnetic interference (EMI) on instrument performance. If internally generated EMI could be detrimental to other nearby instrumentation, this information shall also be included.

6.3.4 The manufacturer shall specify the type of calibration gas or vapor mixture to be used. When the calibration gas is other than that which the instrument is to detect, the manufacturer shall supply the proper relative calibration or response comparisons.

7 Performance tests

7.1 General

The tests required in this clause are in *addition* to the requirements referred to in Clause 4. The instrument tested shall be fully representative of instruments intended for commercial production. Unwarranted or false alarms shall be considered failure of the tests described below.

7.2 Sequence

The same instrument shall be subjected to all tests applicable to that type of instrument described in 7.6 through 7.19. The sequence of tests shall correspond to the order of these clauses.

EXCEPTION: The tests described in 7.11 through 7.16 (i.e., temperature, step change, humidity, air velocity, supply voltage, and EMI) may be performed at any time after the test described in 7.10, but before the test described in 7.17.

NOTE—For stationary or continuous-duty instruments of the sample-draw type, air velocity variation testing may not be applicable.

7.3 Preparation of instrument

The instrument shall be prepared as if for actual service, in accordance with the manufacturer's instruction manual.

NOTE—For instruments having remote detector heads, all tests shall be performed with resistances (with temperature coefficients similar to those of the recommended interconnecting conductors) connected in the detector circuit to simulate the maximum line resistance specified by the instrument manufacturer, except where minimum line resistance offers a more stringent test.

7.4 Conditions for test and test area

7.4.1 Voltage

Except as otherwise indicated herein, all tests shall be performed at the nominal system voltage and frequency marked on the equipment, or, if applicable, with fresh or fully charged batteries.

7.4.2 Ambient temperature

Except as otherwise indicated herein, tests may be performed at conveniently available room ambient temperatures in the range of 18 to 30°C (64 to 86°F).

7.4.3 Humidity

Except as otherwise indicated herein, tests may be performed in ambient air having a relative humidity of any convenient value in the range of 30 to 70 percent.

7.4.4 Room air circulation

Except as otherwise indicated herein, tests shall be performed in relatively still air (not more than 1 meter per second [m/s] [3.3 feet per second]) except for those currents that may be induced by convection due to the natural heating of the equipment under test or caused by air-moving devices that are part of the equipment under test. It should be noted that the output indication may differ under conditions of a stagnant sample (sample velocities of 0.1 m/s [0.3 feet per second] or less).

7.4.5 Removal of parts

For purposes of the tests in 7.7 through 7.18, where reference is made to exposing the sensing head to specified gas mixtures or to other specified conditions, in the case of remote detector heads, the entire head, including all normally attached diffusion devices or protective mechanical parts, shall be so exposed.

7.4.6 Multiple detector heads

For stationary, mobile, or continuous-duty portable gas detection instruments intended to be used with more than one remote detector head, for tests that call for the exposure of the remote detector head to a specified test gas or other specified set of conditions, only one detector head shall be so exposed. Dummy electrical loads (e.g., fixed resistors) may be substituted for additional heads; but if additional heads are used, all other heads shall be exposed to normal, clean air and normal conditions for tests as described in 7.4.2 through 7.4.4.

7.4.7 Recalibration or adjustment

The instrument under test may be adjusted or recalibrated prior to the start of each of the tests described in 7.8 and 7.10 through 7.18. However, no further adjustments or recalibration shall be carried out for the duration of that test except where specifically permitted by the particular test procedure.

7.4.8 Stabilization time

For the tests in 7.11, 7.13, 7.14, and 7.15, each time the instrument is subjected to a different test condition the instrument shall be allowed to stabilize under these new conditions (see note below) before measurements are taken for comparison purposes.

NOTE—An instrument shall be considered to be stabilized when three successive observations of the indication taken at 5-min intervals indicate no significant change.

7.4.9 Instruments having alarms only

Instruments having alarms only do not have any meter or other output indication that can be compared before and after the tests described in Clause 7. A tolerance of ± 5 percent LFL shall apply to the alarm set point(s) for all tests. However, in all cases the alarm must operate at 60 percent (or less) of the LFL of the specific gas for which the instrument is calibrated. The instruction manual shall clearly state these limits unless the manufacturer wishes to specify closer tolerances to which the instrument shall be tested.

7.5 Selectable gas/range instruments

7.5.1 For instruments having more than one selectable range or scale for the same gas, the tests in 7.8 and 7.10 through 7.18 shall be performed with the instrument operating at both the least and most sensitive ranges, except that if the most sensitive range has a full scale equal to or less than 25 percent of the LFL, the performance shall be that specified by the manufacturer in his instruction

manual. If the manufacturer does not state the performance characteristics of the most sensitive scale where it is 25 percent of LFL or less, the performance shall be the same as for the least sensitive range.

7.5.2 For instruments having selectable ranges employing different detecting means, all of these tests shall be performed on each range.

7.5.3 For instruments having specific ranges or scales for different gases:

- a) After only one vibration test performed per 7.8.2, the tests in 7.8.3 shall be repeated at each selectable range for each gas.
- b) The tests in 7.11 through 7.19 shall be repeated at each selectable range for each gas.

7.6 Unpowered preconditioning storage

Prior to tests in 7.9 through 7.19, all parts of the combustible gas detection instrument shall be exposed sequentially to the following conditions:

- a) Temperature of -35°C (-31°F) for 24 h
- b) Ambient temperature and humidity for at least 24 h
- c) Temperature of +55°C (131°F) for 24 h
- d) Ambient temperature and humidity for at least 24 h

7.7 Drop test

7.7.1 This test is applicable only to portable instruments.

7.7.2 While in the operating mode, the instrument (less any removable case) shall be released from a height of 1 m above a concrete surface and allowed to free-fall.

7.7.3 The test required in 7.7.2 shall be performed three separate times, each time released with a different surface edge or corner of the instrument facing down at the time of release.

7.7.4 The instrument shall be considered to fail this test if it is inoperative after the test.

NOTE—Failures resulting from this test may not become apparent until subsequent tests are conducted.

7.7.5 For the tests in 7.7, multi-range instruments need to be tested only on one range.

7.8 Vibration

7.8.1 Apparatus

The vibration test machine shall consist of a vibrating table, capable of producing a vibration of variable frequency and variable constant excursion (or variable constant acceleration peak) with the instrument under test mounted in place, as required by the test procedure described in 7.8.2.

7.8.2 Procedures

The remote detector head, the control unit, and all portable instruments shall be mounted on the vibration test machine and vibrated successively in each of three mutually perpendicular directions, respectively parallel to the edges of the instrument. The instrument shall be mounted on the vibration table in the same manner and position as intended for service using any resilient mounts, carrier, or holding devices that are provided as a standard part of the instrument.

The instrument shall be vibrated over a frequency range of 10 to 30 Hz at a total excursion of 0.5 mm for a period of 1 h in each of three mutually perpendicular directions. The rate of change of frequency shall not exceed 100 Hz/min. This test procedure shall apply to the remote detector head, the control unit, and all portable instruments.

7.8.3 Test criteria

The instruments shall not give any false alarms; there shall be no loose components or damage to the enclosure that could cause a hazard, and, when tested with clean air and the initial calibration mixture, the reading shall be accurate within ± 5 percent of full-scale gas concentration after this test. In lieu of the test criteria above, instruments of the personal-type incorporating alarms only shall be actuated by the 24 to 26 percent LFL test gas mixture but not be actuated by 14 to 16 percent LFL test gas mixture after this test.

7.9 Calibration

The instrument shall be calibrated for testing in accordance with this standard using manufacturer's calibration fixture and specified calibration procedures. The calibration gas shall be a nominal 50 percent of the instrument's full-scale gas concentration. For continuous-duty portable instruments of the personal-type incorporating alarms only, the alarm set point shall be adjusted to 20 percent LFL. The combustible gas to be used shall be as follows:

- a) Methane for instruments intended for sensing methane specifically, or intended for general-purpose combustible gas detection (including detection of methane)
- b) Propane for instruments intended for general-purpose combustible gas detection that excludes methane
- c) The actual specific gas or a representative gas for instruments intended for sensing a specific combustible gas or a specific family of chemically similar combustible gases

NOTES:

- 1) When instruments can be used for detecting more than one combustible gas by changing only the gas-sensing element, then only those tests as described in 7.8, 7.9, 7.10, 7.11.3, 7.12, 7.13, 7.14, 7.17, and 7.18 need to be repeated for the second and subsequent gases. "Methane" shall be tested first if a methane-sensing element is supplied by the manufacturer.
- 2) Unless otherwise indicated herein, the manufacturer's calibration device is to be used to supply the gas mixture to the gas-sensing element for the tests described in the paragraphs that follow. However, the instrument's response utilizing this method and the instrument's intended method of gas monitoring, if different, shall first be established.
- 3) Gas mixtures having the same concentrations as those used for tests in 7.9 are used for various other tests described in the paragraphs that follow. For ease of reference, such gas mixtures will hereafter be referred to simply as "the initial calibration gas mixture."

7.10 Accuracy

7.10.1 All test gas concentrations shall be known to a tolerance of ± 2 percent.

7.10.2 The sensing head shall be exposed to five gas concentrations falling in each of the following ranges: 9 to 11 percent, 24 to 26 percent, 49 to 51 percent, 74 to 76 percent, and 98 to 100 percent of the full-scale gas concentration. In each case, the concentration indicated by the meter or output signal shall not vary from the known test gas concentration by more than ± 3 percent of full-scale gas concentration or ± 10 percent of applied gas concentration, whichever is greater. (See Annex B.)

7.10.3 For instruments having alarms only, testing shall verify that each alarm actuates on exposure to gas-air mixtures whose concentrations are at the upper tolerance limit for alarm actuation and does not actuate on exposure to mixtures whose concentrations are below the lower tolerance limit. (See 7.4.9.)

7.11 Temperature variation

7.11.1 All gas detection instruments shall first be calibrated using the initial calibration test gas, with all parts of the instrument at ambient temperature (7.4.2); they then shall be exposed to the same initial calibration gas while in a test chamber at a temperature of first 0°C (32°F) and then of 50°C (122°F), as follows:

- a) For instruments having the gas-sensing element integral with or directly attached to the control unit, the entire instrument shall be placed in the test chamber containing the gas mixture, or
- b) For instruments comprising a control unit and a separate remote detector head, the control unit only shall be placed in clean air in the test chamber, while the detector head shall be exposed to the calibration gas at ambient temperature.

During this test, the meter or output indications during both 0°C (32°F) exposure and 50°C (122°F) exposure shall not vary from the indication observed during ambient exposure by more than ± 5 percent of full-scale gas concentration.

For continuous-duty portable instruments of the personal-type incorporating alarms only, the alarm shall not be actuated by 14 to 16 percent of LFL gas, but shall be actuated by 24 to 26 percent of LFL gas while exposed to each temperature extreme.

7.11.2 With all parts of the instrument at ambient temperature, calibrate the instrument to twice the normal sensitivity so that with 50 percent full-scale gas concentration at the sensor, the instrument will indicate 100 percent full-scale concentration. If a live-zero reading (capable of at least ± 10 percent full-scale deviation) is not possible, offset the zero indication to 10 percent of full scale to simulate a live zero.

- a) For instruments having the gas-sensing element integral with or directly attached to the control unit, the entire instrument shall be exposed to clean air in a test chamber at a temperature of 0°C (32°F) and then 50°C (122°F). During the test, the indication shall not vary from the initial live-zero indication by more than ± 5 percent full scale.
- b) For instruments consisting of a control unit and a separate remote detector head, the remote detection head shall be exposed to clean air at ambient temperature, with the control unit placed in the test chamber in clean air at a temperature first of 0°C (32°F)

and then 50°C (122°F). During the test the indication shall not vary from the initial live-zero indication by more than a ± 5 percent full-scale concentration.

- c) For instruments consisting of a control unit and a separate remote detector head, with the control unit at ambient temperature, the remote detector head shall be exposed to clean air in a test chamber at 75°C (167°F) and then -40°C (-40°F). During this test, the indication shall not vary from the initial live-zero indication by more than ± 10 percent full scale.

NOTE—For instruments incorporating alarms only, the alarm shall not be activated while the detector head is exposed to both temperature extremes.

7.11.3 For stationary gas detection systems comprising a control unit and a remote detector head, with the control unit at ambient temperature (7.4.2), the detector head shall be exposed to the initial calibration gas mixture at both -40°C (-40°F) and 75°C (167°F).

During this test, the meter or output indication during -40°C (-40°F) exposure or 75°C (167°F) exposure shall not vary from the indication observed during ambient exposure by more than ± 10 percent of full-scale gas concentration.

NOTES:

- 1) The gas mixture used during exposure to the extreme temperatures in 7.11.2 is to have the same percent-by-volume-in-air concentration as the gas mixture used for initial calibration at ambient temperature.
- 2) Observations of the meter or output indication shall be made 1 h after stabilization at each new temperature.
- 3) For detection of vapors whose properties are such that the concentration (due to its vapor pressure properties) cannot be obtained, another appropriate gas may be used.

7.12 Step change response to 100 percent calibration gas (Annex B)

7.12.1 Beginning with the gas-sensing element in clean air, it shall be suddenly exposed to a prepared mixture of gas-in-air having a concentration corresponding to 100 percent of full-scale gas concentration. From the instant of exposure to this gas mixture, the instrument shall respond to provide an indication as follows:

- a) 60 percent of full-scale gas concentration within 12 s.
- b) When indication has stabilized, the test gas shall be removed. The indicator shall decline below 50 percent of full scale within 20 s and below 10 percent of full scale within 45 s.

NOTE—For sample-draw-type instruments, the above times do not include the transport time required for the gas sample to reach the instrument from a remote sampling point. For manually aspirated instruments without a sampling line, the times are to be measured from the time of starting the first manual aspiration.

7.12.2 When continuous-duty portable instruments of the personal-type incorporating alarms only are tested, and when optional readout capability is not offered, the following clause shall be substituted for 7.12.1:

Beginning with the gas-sensing element in clean air, it shall be suddenly exposed to a 100 percent LFL gas-air mixture. An alarm set to 20 percent LFL of the mixture shall respond within 10 s of exposure to the step change.

7.13 Humidity variation

The instrument shall first be calibrated with the sensing element exposed to the initial calibration gas mixture at a relative humidity of 50 percent for 2 h. Then the sensing element shall be exposed for 2 h to the calibration gas mixture to which water vapor has been added to raise the relative humidity to a final value of 90 percent. The sensing head shall then be exposed for 2 h to the calibration gas mixture having a relative humidity of 10 percent. The meter or output indications during these exposures shall not vary from the 50 percent relative humidity exposure indication by more than 10 percent of full-scale concentration.

7.13.1 For continuous-duty portable instruments of the personal-type incorporating alarms only, the alarm shall not be actuated by 14 to 16 percent LFL test gas, but shall be actuated by 24 to 26 percent LFL test gas while exposed to both humidity extremes.

NOTE—Relative humidity values are to be accurate within ± 5 relative humidity percentage points.

7.14 Air velocity variation

7.14.1 The instrument shall be calibrated first with the detector head exposed to a static mixture of the initial calibration gas. It shall then be exposed to the initial calibration gas mixture in motion so as to impinge on the detector head with a velocity of 5 ± 0.5 m/s (16.4 ± 1.6 feet/s). The meter or output indication during exposures to the mixture in motion shall not vary from that observed during exposure to the static gas mixture by more than +10 percent or -5 percent of full-scale gas concentration in the orientation that causes the greatest deviation.

7.14.2 For continuous-duty portable instruments of the personal-type incorporating alarms only, the alarm shall not be actuated on 14 to 16 percent LFL test gas but shall be actuated on 24 to 26 percent LFL test gas while exposed to the mixture in motion (5 ± 0.5 m/s) in all orientations.

7.15 Supply voltage variation

7.15.1 For gas detection instruments intended for operation on ac power supply systems and with the gas-sensing element exposed to the initial calibration gas mixture ([see 7.9](#)), the supply voltage shall first be decreased to 85 percent of nominal line voltage and then increased to 110 percent of nominal line voltage.

NOTE—The method of causing these step changes in voltage shall simulate the effect of a heavy load being added to or removed from the source of supply; i.e., there shall be no actual interruption of the voltage supply during the voltage transition.

The variation in the meter or output indication from actual concentration shall not exceed ± 2 percent of full-scale gas concentration. ([See 7.4.8.](#))

7.15.2 For ac-powered instruments, incorrect functions shall not occur when the primary power is applied or removed.

NOTE—For test purposes, gas detection instruments intended for operation from an external ac power source shall be subjected to momentary power interruptions of approximately 0.5 s and 5 s.

During this test, the detector head shall be exposed to clean air (see 7.4.2 to 7.4.4), and alarms set in the same manner as for 7.15.3.

7.15.3 Gas detection instruments intended for operation from an external dc power source shall be subjected to a step-change in supply voltage from nominal to 122.5 percent of nominal voltage, and from nominal to 87.5 percent of nominal voltage. During this test, the sensing head shall be exposed to clean air. (See 7.4.2 through 7.4.4.) Adjustable alarms shall be set to operate at 10 percent of the LFL or 10 percent of full-scale concentration, whichever is lower, or at the lowest possible setting if this setting is greater. As a result of this test, there shall be no instrument malfunction or actuation of the alarms that would falsely indicate the presence of combustible gas.

NOTE—The method of causing these step changes in voltage shall be such as to simulate the effect of a heavy load being added to or removed from the source of supply; i.e., there shall be no actual interruption of the voltage supply during the voltage transition.

7.15.4 For self-contained battery-operated instruments, the voltage variation shall correspond to the maximum terminal voltage of a fresh or fully charged battery(s) and the minimum recommended operating voltage of that (those) battery(ies), as determined by a built-in battery-condition indicator. Intermittent-duty portable instruments having provision for adjustment to compensate for battery voltage decline may be so adjusted. (See 7.4.8.)

For continuous-duty portable instruments of the personal-type incorporating alarms only, the alarm shall be actuated by 24 to 26 percent LFL test gas, but not 14 to 16 percent LFL test gas, while exposed to both voltage variation extremes.

7.16 Electromagnetic Interference (EMI)

Following satisfactory completion of all the applicable tests of the preceding clauses, the stationary or mobile instrument (including sensor, electronics, and interconnecting wiring) shall be subjected (1) while in an energized (operating) mode and (2) while in the position of normal calibration, to electromagnetic energy in the frequency ranges of 150 to 170 MHz and 450 to 470 MHz, using frequency-modulated portable radio transmitters (5 W input to the final amplifier) at a distance of 1 m away from the instrument (i.e., its sensor, electronics, and interconnecting wiring).

Tests shall be conducted for both items (1) and (2) above, using a randomly selected frequency within each of the two frequency ranges and shall not cause the instrument to produce output changes of more than 10 percent of full scale or result in an incorrect instrument function.

Tests should also be conducted following the manufacturer's suggestions concerning wiring, shielding, and installation techniques as they pertain to electromagnetic interference.

7.17 Long-term stability

NOTE—Repeat applicable accuracy tests (7.10) before performing the test under this Clause.

7.17.1 Stationary instruments

The gas-sensing element shall be consecutively subjected to the following sets of conditions for the periods stated (7.4.7):

- a) Clean air at ambient temperature and humidity for six continuous days. (See 7.4.2 and 7.4.3.)
- b) At the beginning of the seventh day, expose the gas-sensing element to the initial calibration gas mixture for a period of 24 h. Within 5 min after start of the test, the indicated concentration shall be noted and shall not deviate from the actual calibration gas concentration by more than ± 10 percent of full scale for the remainder of the 24 h.
- c) Repeat (a) and (b) a total of four consecutive times (total of 28 days). Just prior to the end of the fourteenth and twenty-eighth days, while the gas-sensing element is still exposed to the initial calibration gas mixture, the indicated concentration shall be noted and shall not deviate from the actual calibration gas concentration by more than ± 10 percent of full scale.

NOTE—Following the deviation check at the end of the fourteenth and twenty-eighth days, the instrument may be zeroed and recalibrated.

- d) Expose the gas-sensing element to clean air at ambient temperature and humidity for 24 h. At the end of this period, the gas-sensing element shall be exposed to the initial calibration gas mixture, and the indicated concentration observed after 5 min shall not deviate from the actual gas concentration by more than ± 10 percent of full scale.

NOTE—Following the deviation check at the end of (d), the instrument may be zeroed and recalibrated prior to the final accuracy test of (e).

- e) Immediately after completing (d) (total elapsed time for tests (a) through (d) is 29 days), repeat the accuracy test procedure in 7.10, except that the maximum allowable deviation shall not vary from the known test gas concentration by more than ± 4 percent full-scale gas concentration or 12 percent of the applied gas concentration, whichever is greater.

7.17.2 Continuous-duty portable instruments

The instrument shall be consecutively subjected to the following sets of conditions for the periods stated (see 7.4.7):

- a) The gas-sensing element shall be exposed to clean air at ambient temperature and humidity for six cycles of operation, each cycle consisting of 8 h with the instrument "On," followed by 16 h with the instrument "Off" (total elapsed time of 24 h per cycle).
- b) At the beginning of the seventh day, the gas-sensing element shall be exposed to the initial calibration gas mixture for a period of 8 h with the instrument "On," following which it shall be exposed to clean air at ambient temperature and humidity with the instrument "Off" for a period of 16 h. The indicated concentration shall be noted over a period of 5 min and shall not deviate from the actual calibration gas concentration by more than ± 10 percent of full scale.
- c) Repeat (a) and (b) a total of four consecutive times (total elapsed time of 28 days).
- d) The gas-sensing element shall be subjected to clean air at normal ambient temperature and normal humidity for an additional period of 6 h with the instrument "On."
- e) Immediately after completing (d) (total elapsed time for test [a] through [d] is 28 days and 6 h), repeat accuracy test procedure of 7.10, except that the maximum allowable deviation shall not vary from the known test gas concentration by more than ± 4 percent of full-scale gas concentration or 12 percent of the applied gas concentration, whichever is greater.

- 1) In lieu of the accuracy tests above, instruments of the personal-type incorporating alarms only shall not be actuated by exposure to 14 to 16 percent LFL test gas mixture and shall be actuated by the 24 to 26 percent LFL test gas mixture after completing (d).
- 2) The test described in (e) shall be performed immediately after the 6 h test of (d) and shall be completed in not more than 2 h so that the total elapsed instrument "On" time for tests (d) and (e) does not total more than 8 h.

NOTES:

- 1) For instruments using replaceable (nonrechargeable) batteries, a suitable dc power supply may be used or fresh batteries may be installed at the start of each of the 8 h "On" periods, except that the actual batteries specified for the instrument shall be used for the first 8 h of (a).
- 2) For instruments using rechargeable batteries, the same rechargeable battery shall be used for the entire test sequence of (a). A suitable dc power supply may be used for the remainder of the test.
- 3) Zero and span adjustments are permitted prior to each stipulated 8 h "On" period.

7.17.3 Intermittent-duty portable instruments

Intermittent-duty portable instruments provided with a switch that must be manually held in the "On" position shall be subjected to the same test sequence and evaluation as described in [7.17.2](#), except that each 8 h "On" period shall consist of 24 cycles of 10 min "On" and 10 min "Off."

NOTES:

- 1) Manually aspirated-type instruments shall be aspirated continuously during each 10 min "On" period; alternatively, a vacuum pump having an equivalent flow may be utilized.
- 2) Instruments having provisions for voltage adjustments to compensate for battery voltage decline shall be adjusted as necessary during the above tests, including just prior to the final evaluation.

7.18 Flooding with undiluted gas

7.18.1 The gas-sensing element of instruments other than the manually aspirated type shall be subjected to a step change in gas concentration from zero percent (clean air) to 100 percent gas-by-volume. The instrument shall produce an output indication corresponding to a concentration of at least 60 percent of the lower flammable limit or to full-scale concentration, whichever is lower, within 10 s of exposure to the 100 percent gas-by-volume. ([See 6.3.1\[b\].](#))

7.18.2 Manually aspirated instruments shall be subjected to a test whereby, using the shortest possible sample tube, they are aspirated at the rate that is recommended by the manufacturer with the sample inlet connected to a source of 100 percent gas-by-volume. During this test, the instrument shall produce an output indication corresponding to at least 60 percent of the lower flammable limit or to full scale, whichever is lower, within seconds (s).

NOTES:

- 1) For sample-draw instruments of other than the manually aspirated type, the times given above do not include the transport time required for the gas sample to reach the instrument from a sampling point.
- 2) For detection of vapors whose properties are such that the concentration, due to its vapor pressure properties, cannot be obtained, another appropriate gas may be used for the tests in 7.18.1 and 7.18.2.

7.18.3 During the tests of 7.18.1 and 7.18.2, if the instrument is provided with audible or visible alarm signal devices or alarm contacts, these shall be set to the 60 percent of lower flammable limit set point or to the highest adjustable set point, whichever is lower, and shall be actuated as a result of these tests.

7.18.4 When continuous-duty portable instruments of the personal-type incorporating alarms only (without an optional readout capability) are tested, the following shall be substituted:

Beginning with the gas-sensing element in clean air, it shall be subjected to a step change in gas concentration from clean air to 100 percent gas-by-volume. An alarm set to 20 percent LFL of the mixture shall respond within 10 s of exposure to the undiluted flooding condition.

7.19 Dielectric strength

Following completion of all of the applicable tests of the preceding clauses, the equipment shall be subjected to dielectric strength tests as specified by ANSI/ISA-S82.01 or other comparable recognized standard.

Annex A — References

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

C84.1-89 Voltage Ratings for Electrical Power
Systems and Equipment (60 Hz)

Available from: ANSI

11 West 42nd Street
New York, NY 10036

Tel: (212) 642-4900

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

E681-85 Standard Test Method for Concentration Limits of Flammability of
Chemicals

Available from: ASTM

1916 Race Street
Philadelphia, PA 19103-1187

Tel: (215) 299-5585

BRITISH STANDARDS INSTITUTION (BSI)

BS6020 Parts 1, 2, and 3 Instruments for the Detection of Combustible Gases

Available from: BSI

Sales Department
Linford Wood
Milton Keynes, MK14 6LE UK

Tel: 01-837-8801

Telex: 266933

or

CENELEC

European Committee for Electrotechnical Standardization
Secretariat General
Rue Brederode
2 boîte no. 5
8-1000 Bruxelles
Belgique

CANADIAN STANDARDS ASSOCIATION (CSA)

C22.2 No. 152	Combustible Gas Detection Instruments
C22.2 No. 157	Intrinsically Safe and Nonincendive Equipment for Use in Hazardous Locations

Available from: CSA

178 Rexdale Boulevard
Etobicoke, Ontario M9W 1R3

Tel: (416) 747-4044
Telex: 06 989344

ISA

ANSI/ISA-S51.1-1993 (RA)	Process Instrumentation Terminology
ISA-S12.4-1970	Instrumentation Purging for Reduction of Hazardous Area Classification
ISA-S12.12-1994	Nonincendive Electrical Equipment for Use in Class I and II, Division 2, and Class III, Divisions 1 and 2 Hazardous (Classified) Locations
ANSI/ISA-S82.01-1994 (R)	Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment—General Requirements

Available from: ISA

67 Alexander Drive, P.O. Box 12277
Research Triangle Park, NC 27709

Tel: (919) 549-8411

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 654.1	Operating Conditions for Industrial-Process Measurement and Control Equipment. Part I: Temperature, Humidity and Barometric Pressure
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Available from: ANSI

11 West 42nd Street
New York, NY 10036

Tel: (212) 642-4900

or

IEC

Bureau Centrale de la Commission Electrotechnique International
1 rue de Varembe
Geneve, Suisse

NATIONAL FIRE PROTECTION ASSOCIATION (ANSI/NFPA)

ANSI/NFPA 70-93	<i>National Electrical Code</i> ®, Articles 500, 501, and 04
325M-91	Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids
496-93	Standard for Purged and Pressurized Enclosures for Electrical Equipment

Available from: NFPA

Batterymarch Park
Quincy, MA 02269

Tel: (708) 770-3000

NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE)

Corrosion Data Survey, Metals Section

Available from: NACE

PO Box 218340
1440 S. Creek Drive
Houston, TX 77218-8340

Tel: (713) 492-0535

US DEPARTMENT OF LABOR, OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

30 CFR	Subchapter B—Testing, Evaluation, and Approval of Mining Products
49 CFR 154	USCG Standard for Gas Detection, Sections 1345 and 1350

Available from: U.S. Department of Labor

Occupational Safety and Health Administration
Office of Information, Room N3647
200 Constitution Avenue, N.W.
Washington, D.C. 20210

Tel: (202) 523-8151

UNDERWRITERS LABORATORIES, INC. (UL)

UL 913	Intrinsically Safe Apparatus and Associated Division 1, Hazardous (Classified) Locations Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations
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Available from: UL

333 Pfingsten Road
Northbrook, IL 60062-2096

Tel: (708) 272-8800

Annex B — Explanatory notes (See 7.10.2)

This annex is included for information only and is not part of the standard.

The tolerance of 3 percent of full-scale gas concentration or 10 percent of applied gas concentration (whichever is greater) was determined on a practical basis. Consider the following:

- a) In the majority of applications, the instrument will be adjusted to cause alarm or other warning action at a gas concentration of 60 percent LFL or lower. Therefore, the possibility of a meter or output signal of 90 percent LFL when the actual concentration is 100 percent LFL is not significant.
- b) Any application that requires an alarm or other warning action at a gas concentration higher than 60 percent LFL should consider calibration at the higher alarm point setting, with resultant increases in accuracy at the higher level.
- c) If required by the application risk, the user should select instrumentation that will provide a higher level of accuracy than the minimum tolerances of this standard.

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