



Member of the FM Global Group

Approval Standard for Combustible Gas Detectors

Class Number 6310/6320

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Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for FM Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

- a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and
- b) must be readily identifiable.

Continuance of Approval and listing depends on compliance with the Master Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

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1 INTRODUCTION

1.1 Purpose

1.1.1 This standard states Approval requirements for combustible gas detection instruments.

1.1.2 Approval criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a follow-up program.

1.2 Scope

1.2.1 This standard is concerned with the details of construction, performance and testing of portable, mobile and stationary electrical instruments that sense the presence of combustible gas or vapor concentrations in air. This standard considers the suitability of the instruments or parts thereof for use in Class I, hazardous (classified) locations as defined by the National Electrical Code® (ANSI/NFPA 70).

NOTE: IT IS STRESSED THAT ALTHOUGH COMBUSTIBLE GAS DETECTORS WARN OF COMBUSTIBLE ATMOSPHERES THAT MAY LEAD TO AN EXPLOSION, THEY DO NOT NECESSARILY WARN OF TOXIC GAS RELEASES. IT IS ALSO STRESSED THAT FINAL AND LONG-TERM EFFECTIVENESS OF ANY COMBUSTIBLE GAS DETECTION EQUIPMENT DEPENDS HEAVILY UPON THE USER, WHO MUST BE RESPONSIBLE FOR ITS PROPER APPLICATION, INSTALLATION, USE, AND REGULAR MAINTENANCE.

1.2.2 This standard contains requirements for combustible gas detectors of the fixed, portable and transportable types. The following product categories and class numbers are included in the scope of this standard.

Table 1.2.2 – *Product Categories and Class Numbers*

<i>Class</i>	<i>Product Category</i>
6310	Portable and Transportable Gas Detectors
6320	Fixed Gas Detectors

1.2.3 This standard applies to line-voltage operated instruments rated at 250V nominal or less, and to portable, mobile, or stationary-type instruments supplied by battery of a non-rechargeable (primary) type or a rechargeable (secondary) type.

1.2.4 For intrinsically safe instruments, this standard applies only to systems which utilize defined associated intrinsically safe apparatus (protective barrier assemblies). “Entity” concept does not apply to the performance Approval of combustible gas detectors.

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

1.2.6 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.

1.2.7 This standard is written for gas detection instruments that are intended to detect gas concentrations in air in the range from zero up to the lower flammable limit (LFL), since this is the most commonly used range for instruments intended to measure or monitor the degree of explosion hazard. This does

not preclude instruments intended for higher concentration ranges, such as those intended to warn of a drop in concentration from a high value down to the upper flammable limit (UFL).

- 1.2.8** For instruments used for sensing the presence of oxygen, non-flammable toxic gases, and flammable gases or vapor concentrations in air, this standard applies only to the portion of the instrument sensing the flammable gases or vapor concentrations in air.

1.3 Basis for Requirements

- 1.3.1** The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, and loss control specialists was also considered.
- 1.3.2** The construction, testing and marking required by this standard correspond, in general, to ANSI/ISA-60079-29-1.
- 1.3.3** The requirements of this standard reflect tests and practices used to examine characteristics of combustible gas detectors for the purpose of obtaining FM Approval. These requirements are intended primarily as guides, and strict conformity is not always mandatory. Combustible gas detectors having characteristics not anticipated by this standard may be Approved if performance equal or superior to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, gas detectors which do meet all the requirements identified in this standard may not be Approved if other conditions which adversely affect performance exist or if the intent of this standard is not met.

1.4 Basis for Approval

Approval is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

- 1.4.1** Examination and tests on production samples shall be performed to evaluate
- the suitability of the product;
 - the performance of the product as specified by the manufacturer and required by FM Approvals; and
 - as far as practical, the durability and reliability of the product.
- 1.4.2** An examination of the manufacturing facilities and audit of quality control procedures is made to evaluate the manufacturer's ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. These examinations may be repeated as part of FM Approvals' Surveillance Audit program.

1.5 Basis for Continued Approval

Continued Approval is based upon:

- production or availability of the product as currently FM Approved;
- the continued use of acceptable quality assurance procedures;
- satisfactory field experience;
- compliance with the terms stipulated in the Approval report;
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory Surveillance Audits conducted as part of FM Approvals' product follow-up program.

Also, as a condition of retaining Approval, manufacturers may not change a product or service without prior authorization by FM Approvals.

1.6 Effective Date

The effective date of an Approval standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products FM Approved under a previous edition shall comply with the new version by the effective date or else forfeit Approval.

The effective date of this Standard is January 1, 2020 for compliance with all requirements.

1.7 System of Units

Units of measurement used in this Standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10.

1.8 Normative References

The following referenced documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For undated references, the latest edition of the referenced document (including any amendments) applies. For dated references, only the cited edition applies.

ANSI/ISA-60079-29-1, “*Explosive Atmospheres – Part 29-1: Gas Detectors – Performance requirements of detectors for flammable gases*”

ANSI/IEEE/ASTM SI 10 “*American National Standard for Metric Practice*”

FM 3600, *Electrical Equipment for Use in Hazardous (Classified) Locations – General Requirements*

EN 50270 “*Electromagnetic compatibility. Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen*”

ANSI/ISA-61010-1 *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General requirements*

Any portion of a gas detection instrument that is intended for installation or use in a location where gas or vapor concentration is to be detected shall be suitable for use in Class I, Division 1 or 2 or Class I, Zone 0, 1 or 2 hazardous locations in accordance with the group classification of the gas. See FM Approval Standard 3600.

NOTE 1: IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE® (ANSI/NFPA 70), ONLY INSTRUMENTS WHICH UTILIZE INTRINSIC SAFETY (ia) CAN BE APPROVED FOR USE IN CLASS I, ZONE 0. INSTRUMENTS WHICH UTILIZE FLAMEPROOF (d) EITHER ENTIRELY OR IN CONJUNCTION WITH INTRINSIC SAFETY, CANNOT BE APPROVED FOR USE IN CLASS I, ZONE 0.

1.9 Definitions

For purposes of this standard, the definitions within ANSI/ISA-60079-29-1 apply, including the following additional terms:

Alarm

An audible, visual or physical presentation designed to alert the instrument user that a specific level of combustible gas concentration has been reached or exceeded.

Calibration

The act of adjusting an instrument to “zero” and setting the desired “span”. This procedure is repeated frequently by the instrument user and included in certain tests called for in this standard. It verifies that the response of an instrument to a known gas concentration is within performance requirements of this standard. This may necessitate adjustment of zero, span, and alarm set point.

Calibration gas concentration

The concentration of the combustible gas in ambient air used to set the instrument span or alarm set point.

Combustible gas

Any flammable gas or vapor that, in sufficient concentration by volume in air, can become the fuel for an explosion or fire hazard. 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 OR VAPOR” WITHIN THIS DOCUMENT.

Control unit

That portion of a gas detection instrument that is not directly responsive to the combustible gas, but which responds to the electrical signal obtained from one or more detector heads. This unit produces the output function when such gas is present at the detector head location.

Dead space

An actual or potential area within a chamber where the gas is stagnant (not mixing and/or still).

Detector head

The gas responsive portion of a gas detection instrument located in the area where sensing the presence of gas is desired. It may be integral with or removed from its control unit.

NOTE: THE DETECTOR HEAD MAY INCORPORATE, IN THE SAME HOUSING, CIRCUITRY SUCH AS SIGNAL PROCESSING AND AMPLIFYING COMPONENTS IN ADDITION TO THE GAS SENSING ELEMENT (SENSOR).

Fault signal

Audible, visible or other type of output, different from the alarm signal, permitting, directly or indirectly, a warning or indication that the apparatus is not working satisfactorily, Fault Signals and Trouble Signals are synonymous.

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 1: THE TERMS “LOWER FLAMMABLE LIMIT (LFL)” AND “LOWER EXPLOSIVE LIMIT (LEL)” ARE DEEMED TO BE SYNONYMOUS. 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” ARE USED HEREINAFTER TO DENOTE THESE TWO SETS OF TERMS. IT SHOULD BE RECOGNIZED THAT PARTICULAR AUTHORITIES HAVING JURISDICTION MAY PREFER THE USE OF ONE OF THE SETS OF TERMS AND NOT THE OTHER.

NOTE 2: THE ACTUAL GAS CONCENTRATION CORRESPONDING TO THE LOWER FLAMMABLE LIMIT OF THE SPECIFIC GAS SHALL BE THE VALUE SHOWN FOR THAT GAS IN THE LATEST EDITION OF NATIONALLY RECOGNIZED DOCUMENTS, FOR EXAMPLE, NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) 325 GUIDE TO FIRE HAZARD

PROPERTIES OF FLAMMABLE LIQUIDS, GASES, AND VOLATILE SOLIDS (FORMERLY NFPA 325M).

Full-scale gas concentration

The gas concentration that equals maximum scale indication.

Gas detection instrument

An assembly of electrical and mechanical components (either a single integrated unit or a system comprised of two or more physically separate but interconnected component parts) which senses the presence of combustible gas and responds by providing an indication, alarm, or other output function.

NOTE: FOR CONVENIENCE, THE TERM “INSTRUMENT” IS USED AS AN ABBREVIATION FOR “GAS DETECTION INSTRUMENT” WITHIN THIS DOCUMENT.

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.

Mobile instrument

A continuously monitoring instrument mounted on a vehicle such as, but not limited to, a mining machine or fork lift truck.

Portable, continuous-duty instrument

A battery-operated portable or transportable instrument intended to operate continuously for 8 hours or more.

Portable, continuous-duty, personal instrument

Gas detection instrument refers to a battery operated, alarm only instrument intended to be operator-worn and to operate continuously for 8 hours or more.

Range

The operable concentration region of the instrument or a selected subdivision of that region.

Response conversion data

Information, supplied and explained in the instrument instruction manual, enabling the instrument user to determine the concentration of the gas to be monitored that will produce the same response as a known concentration of another gas used for calibration.

Sample draw

Method by which the atmosphere being monitored is made to flow to the gas sensing element. This may involve a manual aspirator, an electrical pump or some other means.

Span

The algebraic difference between the upper and lower values of a range.

Stationary instrument

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

Transmitter

Stand-alone gas detection apparatus for use with separate control units includes apparatus that provide a conditioned electronic signal or output indication intended to be used with stand-alone control units, separate signal processing, data acquisition, central monitoring or other similar systems which typically process information from various locations and sources including, but not limited to, gas detection instrumentation.

Zero

The lower calibration value, normally clean air.

2 GENERAL INFORMATION

2.1 Approval Application Requirements

To apply for an Approval examination, the manufacturer, or its authorized representative, should submit a request to information@fmapprovals.com.

The manufacturer shall provide the following preliminary information with any request for Approval consideration:

- a) A completed Application/Request for Quote form.
- b) A complete list of all models, types, sizes, and options for the products or services being submitted for Approval consideration;
- c) General assembly drawings, complete set of manufacturing drawings, materials list, anticipated marking format, electrical schematics, nameplate format, brochures, sales literature, spec. sheets, installation, operation and maintenance manuals, and
- d) the number and location of manufacturing facilities.
- e) All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.2 Requirements for Samples for Examination

- 2.2.1** Following authorization of an Approval examination, the manufacturer shall submit samples for examination and testing based on the review of the preliminary information.
- 2.2.2** The test samples will typically be a complete assembly with all components mounted in a manner consistent with the manufacturer's instructions and intended application; but the exact sample requirements will be specified by FM Approvals as part of the proposal.
- 2.2.3** Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.
- 2.2.4** The manufacturer shall submit samples representative of production. Any decision to use data generated using prototypes is at the discretion of FM Approvals.
- 2.2.5** It is the manufacturer's responsibility to provide any necessary test fixtures required to test their specific design.
- 2.2.6** Additional tests may be required, at the discretion of FM Approvals, depending on design features and results of any foregoing tests.
- 2.2.7** Any test following a failure shall be acceptable only at the discretion of FM Approvals and with a technical justification of the conditions or reasons for failure.

3 GENERAL REQUIREMENTS

3.1 General

The apparatus shall comply with the requirements of this standard and ANSI/ISA-60079-29-1.

3.2 Review of Documentation

During the initial investigation and prior to physical testing, the manufacturer's specifications and details shall be reviewed to assess the ease and practicality of installation and use.

All claims not tested and verified by FM Approvals as part of the Approval investigation must be clearly identified as such in the product's installation and operation manual. Alternatively, the manufacturer may include a section or appendix in the manual which clearly itemizes the specifications, features, functions and restrictions included in the FM Approval.

3.3 Markings

3.3.1 In addition to the marking information required in accordance with FM 3600, combustible gas detection equipment shall be marked with the following information:

- a) Manufacturer's name or trademark and address (minimum of city and country);
- b) Specific model designation and serial number;
- c) Apparatus electrical ratings (voltage, frequency, current or power);
- d) Apparatus operating ambient temperature range (see clause 3.3.3 i) j) and k);
- e) "ANSI/ISA-60079-29-1";
- f) Hazardous location information;
- g) Approval Mark. The word "APPROVED" associated with the Mark may be supplemented as follows:

**APPROVED
FOR PERFORMANCE
or
APPROVED
FOR PERFORMANCE AND
HAZARDOUS (CLASSIFIED) LOCATIONS**

3.3.2 The model or type identification shall correspond to the manufacturer's catalog designation and shall uniquely identify the product.

3.3.3 The marking shall appear legibly and indelibly (markings shall be durable as defined by FM 3600 clause 4.2) on each gas detection apparatus 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 later obscures the required markings.

- b) For stationary apparatus, the marking shall appear in a location where it will be visible after installation and in direct sight during the routine periodic re-calibration and adjustment of set point(s).
- c) 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.
- d) 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 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.
- e) for gas detectors with external sensor housings that are interchangeable, gas type and unit of measurement shall be marked on the sensor housing.
- f) for gas detectors with external sensor housings that are not interchangeable but which have internal sensors that are interchangeable, gas type and unit of measurement shall be marked on the sensor housing and a replacement label and instructions shall be included with each replacement sensor.
- g) for gas detectors with internal sensors that are interchangeable, gas type and unit of measurement shall be marked on the gas detector and replacement labels and instructions shall be included with each replacement sensor.
- h) Fixed apparatus with remote sensors shall carry a label on each sensor indicating the gas to be detected.
- i) for gas detectors with certification for hazardous locations, the temperature range marked on the gas detector shall not exceed the temperature range of the hazardous location certification.
- j) If multiple or interchangeable gas-sensing elements are provided in a common housing, the most restrictive temperature range shall be used.
- k) for gas detectors with remote sensors, both the detector and the sensor shall be marked with a temperature range.

3.3.4 Instruments that are not intrinsically safe shall be marked:

“CAUTION — THIS AREA MUST BE KNOWN TO BE FREE OF FLAMMABLE CONCENTRATIONS PRIOR TO OPENING THE ENCLOSURE”

3.3.5 Where the design of special features of the apparatus requires additional markings or a change in marking requirements, the additions or revisions are allowed, but the safety and instructional intent of this clause shall be met.

3.3.6 The manufacturer shall not use this Mark on any other product unless such product is covered by separate agreement with FM Approvals.

NOTE 1: For gas detection instruments that comprise a control unit and remote detector head(s), it is sufficient that this marking appear on the control unit only, except if routine re-calibration 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.

3.4 Manufacturer's Installation and Operation Instruction

3.4.1 In addition to the Manufacturer's Installation and Operation Instructions required in accordance with ANSI/ISA-60079-29-1, combustible gas detection equipment shall include the following information:

3.4.2 Where the design or special nature of the instrument requires additional instructions that are in contradiction of, or in addition to, the requirements of this section, this consideration may take precedence over these requirements. Instructions shall be consistent with the marking requirements.

3.4.3 A list of desensitizing or contaminating gases or substances known to the instrument manufacturer which may adversely affect proper operation of the instrument. Warning as to the effects, if any, of oxygen-enriched or oxygen-deficient atmospheres shall also be included.

3.4.4 Instructions of maintenance and calibration on a routine basis, following exposure of any of the contaminants referred to above and following exposure to concentrations causing operation of any alarm.

3.4.5 Details of accuracy limitations.

3.4.6 A list of operational limitations which include, as applicable, maximum length of lines, loop resistance, and minimum wire size for wiring between the control unit and remote detector heads(s) needed for shielding of wiring, air velocity limitations, battery charging, battery life and temperature limitations, sensor life.

3.4.7 A statement to the user to be aware that extended exposure of a sensor to certain concentrations of combustible gases in air may introduce stress to the sensor that could seriously affect its performance and that calibration should be carried out and/or the sensor replaced after an alarm due to indication of a high concentration.

3.4.8 For stationary and mobile sample-draw instruments, wording to provide for a clear indication that suitable flow proving devices must be provided at the time of installation, if applicable.

3.4.9 For sample-draw continuous-duty portable instruments that are not provided with integral flow indicating devices, detailed instructions regarding one or more suitable techniques, not requiring special instruments.

3.4.10 The type of calibration gas or vapor mixture to be used. If the instrument is designated to monitor gases other than the one for which it is calibrated, include response conversion data with specific instructions as to its use.

- 3.4.11** An evaluation procedure to determine the possible sources of malfunction and the corrective action to be taken.
- 3.4.12** A listing of consumable parts, and recommendation of the storage type, environment and installation instructions.
- 3.4.13** If more than one type of sensor is supplied by the manufacturer, include a list stating the specific gas family or chemically similar gases for each sensor.
- 3.4.14** For instruments which provide measurement outputs (e.g., 4-20 mA signal), the instruction manual shall provide graphs or other means to indicate the relationship between the input and the output.
- 3.4.15** For stand-alone detector heads, specifications shall be supplied with the instrument that describe the relationship of the gas concentration detected by the instrument, to the corresponding output signal or indication. Such specifications shall be detailed to the extent that the accuracy of the output or signal indication can be verified. As a minimum, the manufacturer shall provide data showing the relationship between the output signal or indication of the instrument and gas concentrations corresponding to 0, 10, 25, 50, 75 and 100% of full-scale indication. Full-scale output shall be as specified by the manufacturer.
- 3.4.16** For stand-alone detector heads and instruments that provide measurement and/or alarm outputs (e.g., 4-20 mA signal, relay contacts), the following shall appear in the instruction manual:
- “This Approval does not include or imply Approval of apparatus to which the subject instrumentation may be connected. In order to maintain an FM Approved system, the apparatus to which this instrument is connected, must also be Approved by FM Approvals.”
- 3.4.17** For stand-alone control units, the following shall appear in the instruction manual:
- “This Approval does not include or imply Approval of gas detector heads or other apparatus to which the subject instrument may be connected. In order to maintain an FM Approved system, the measurement input signal to which this instrument is connected must also be FM Approved.”
- 3.4.18** Communication options:
- For instruments providing communications options that are not included in the Approval examination but which comply with ANSI/ISA-60079-29-1, the following shall appear in the instruction manual:
- “As part of this Approval, it was verified that optional communication functions of this gas detection instrument while operating at the maximum transaction rate do not adversely affect the gas detection operation and functions of the instrument. This Approval, however, does not include or imply Approval of the communications protocol or functions provided by the software of this instrument or of the communications apparatus or software connected to this instrument.”

3.5 Calibration

- 3.5.1** Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage. A copy of the calibration certificate for each piece of test equipment is required for FM Approvals records. The certificate shall indicate that the calibration was performed against working standards whose calibration is certified as traceable to the National Institute of Standards and Technology (NIST) or traceable to other acceptable reference standards and certified by an ISO/IEC 17025 accredited calibration laboratory.

The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service provider's accreditation certificate as an ISO/IEC 17025 accredited calibration laboratory is required for FM Approvals' records.

- 3.5.2** The calibration of new equipment is also required. Documentation indicating either the date of purchase or date of shipment, equipment description, model and serial number is required for identification. The new test equipment shall be clearly identified by label or sticker showing the date of initial calibration and the next due date.
- 3.5.3** When the inspection equipment and/or environment is not suitable for labels or stickers, other methods such as etching of control numbers on the measuring device are allowed, provided documentation is maintained on the calibration status of thus equipment.

3.6 Test apparatus

3.6.1 Mask for calibration and tests

When a mask is used for calibration or for the injection of test gas into the sensor, the design and operation of the mask used by the testing laboratory – in particular the pressure and velocity inside the mask – shall not inadmissibly influence the response of the apparatus or the results obtained.

- 3.6.2** Accuracy tests shall be performed within a sealed chamber. The chamber shall be of a size where the portion of the gas detector entering the chamber does not occupy more than 30% of its total volume. The gas inlet tube(s) shall be situated so as to not directly flow the gas across the sensor. The inlet flow rate shall be at a rate no greater than one test volume exchange per minute for a minimum of five volume exchanges. The gas outlet(s) shall be sized so not to increase the pressure within the chamber by more than 0.10 inches water. The inlet and outlet tubes shall be positioned as to prevent dead spaces within the chamber.

V_c = total internal volume of empty chamber

V_d = volume of the detector that will be placed inside the chamber

V_t = test volume = $V_c - V_d$

NOTE: It is common practice to consider five air exchanges to completely purge a chamber; therefore, based on an air flow of one air exchange per minute, gas stabilization should not be considered to occur in less than 5 minutes of the start of the gas flow.

- 3.6.3** Step response tests shall be performed within a chamber which will create a uniform airflow at a rate of 0.5m/s. The flow rate is to be measured at the point where the sensing element is to be inserted into the airstream but, measured without the sensor in place. The chamber shall be of a size to allow the air to flow around all portions of the detector including any junction boxes supplied with the detector or remote sensor head. The detector or remote sensor head shall be mounted in the worse case intended orientation.

NOTE: To create the step change from clean air to the test gas the test unit may either be plunged into the test chamber or tested by installing a protective cover over the sensing element and quickly removing the cover to create the step change.

3.7 Construction Requirements

3.7.1 General

For the purposes of this standard, the construction requirements within ANSI/ISA-60079-29-1 apply, including the following additional requirements:

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

3.7.3 Stationary and continuous-duty portable gas detection instruments having an integral meter or indicator to indicate gas concentrations shall employ a meter having sufficient resolution to permit measurement with the precision required for the tests within ANSI/ISA-60079-29-1.

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

3.7.5 For apparatus with more than one measuring range, the range selected shall be clearly identified and continuously displayed.

3.7.6 When latching and non-latching alarm settings are available, the following shall be included:

The latching requirement may be omitted or a defeating option permitted only when a clear and prominent statement in the instruction manual specifies that the instrument shall be connected to an auxiliary system which accomplishes the same purposes as latching.

3.7.7 A stationary or mobile gas detection instrument with signal outputs shall provide for a remotely monitored output to produce a fault signal if there is loss of continuity of any gas-sensing element.

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

3.7.9 Enclosures

3.7.9.1 Instrument enclosures, including associated accessories, intended for outdoor use as specified by the manufacturer shall be tested for such locations.

3.7.9.2 All parts of the instrument subjected to the combustible gas atmosphere to be monitored shall be suitable for that location.

3.7.9.3 The effects of the tests required to verify the instrument's suitability for specified locations (dust, rain, hosedown, corrosion tests, etc.) shall be considered as part of performance tests in Section 4.

3.8 Electromagnetic Immunity

Gas-detection apparatus, their components, and remote detector heads must be constructed to be resistant to, or protected against, electromagnetic interference. Testing shall be verified and documented in accordance with EN 50270 by an ISO/IEC 17025 accredited test laboratory.

4 PERFORMANCE REQUIREMENTS

4.1 General

For purposes of this standard, the test methods within ANSI/ISA-60079-29-1 apply, including the following additional requirements:

- a) The tests required in this section are in *addition* to the requirements of FM 3600.

NOTE: Examination and tests required under FM 3600 shall be satisfactorily completed prior to the start of tests required in this section and any modifications or changes resulting from those requirements shall be incorporated in the instruments under test.

- b) The instruments tested shall be fully representative of instruments intended for commercial production.
c) Unwarranted or false alarms shall be considered failure of the tests described below.
d) Tests shall be conducted with all equipment installed as intended for use.
e) For multiple gas sensing instruments, all unwarranted (false) alarms which require re-setting, re-adjusting, etc., to continue combustible gas detection tests shall be considered a failure.

4.2 Room air circulation

The test conditions of ANSI/ISA-60079-29-1 shall include:

Except as otherwise indicated herein, tests are to be performed in relatively still air (not more than 1 meter per second [m/s]) 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.

4.3 Sample with selectable range

4.3.1 ANSI/ISA-60079-29-1 shall include:

For instruments having more than one selectable range or scale for the same gas, the following tests shall be performed with the instrument operating at both the least and most sensitive ranges:

vibration, accuracy, temperature, step response, humidity variation, air velocity variation, supply voltage variation, EMI, long term stability, flooding.

The above shall be completed except that if the most sensitive range has a full scale equal to or less than 25% of the LFL, the performance shall be that specified by the manufacturer in the instruction manual. If the manufacturer does not state the performance characteristics of the most sensitive scale where it is 25% of LFL or less, the performance shall be the same as for the least sensitive range.

NOTE: Sensitivity is a direct relation to the range. A range of 0 – 100% LEL is less sensitive than a range of 0 – 10% LEL.

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

4.3.3 For instruments having specific ranges or scales for different gases: After only one vibration test performed per ANSI/ISA-60079-29-1, the tests in ANSI/ISA-60079-29-1 (exposure to clean air and the standard test gas) shall be repeated at each selectable range for each gas.

4.4 Accuracy

The accuracy for ANSI/ISA-60079-29-1 at 10% of range shall be within $\pm 3\%$ of the applied gas.

4.5 Alarms

ANSI/ISA-60079-29-1, the alarms shall operate when tested within $\pm 5\%$ LEL of their setpoint.

4.6 Temperature Test

The temperature test for ANSI/ISA-60079-29-1 shall include:

For fixed apparatus with remote sensors or detector heads, where the control unit and the detector head or sensor are not used in the same general environment, the following temperatures shall be applied:

1) Sensors or detector heads

With the control unit under normal ambient test conditions, the sensor or detector head shall be tested in air and in the standard test gas at -25°C and $+55^{\circ}\text{C}$.

2) Control units

With the sensor or detector head under normal ambient test conditions, the control unit shall be tested at 5°C and $+55^{\circ}\text{C}$ with the sensor or detector head exposed to air and the standard test gas.

4.7 Humidity

ANSI/ISA-60079-29-1, for instruments incorporating alarms only, the alarm shall not be actuated by 14 to 16% LFL test gas, but shall be actuated by 24 to 26% LFL test gas while exposed to both humidity extremes.

4.8 Air Velocity

ANSI/ISA-60079-29-10, for instruments incorporating alarms only, the alarm shall not be actuated by 14 to 16% LFL test gas, but shall be actuated by 24 to 26% LFL test gas while exposed to the mixture in motion in all orientations.

4.9 Vibration

4.9.1 ANSI/ISA-60079-29-1.

4.9.2 For procedure 1, the test shall be 10 Hz to 150 Hz and for procedure 2, the test shall be 10 Hz to 100 Hz.

4.9.3 In lieu of the test criteria in ANSI/ISA-60079-29-1, instruments incorporating alarms only shall be actuated by a 24- to 26-% LFL test gas mixture but not be actuated by a 14- to 16-% LFL test gas mixture after this test.

4.9.4 Signal outputs including current and alarm relays shall be continuously monitored throughout the test.

4.10 Drop test for portable and transportable apparatus

ANSI/ISA-60079-29-1, any loss of function after the test including any change of state is considered a failure since there is continued dependency on the life safety device even under adverse affects such as an accidental drop of the device during use. Automatic or manual re-starting is not acceptable.

4.11 Time of response

When instruments incorporating alarms only are tested, the following clause shall be substituted for ANSI/ISA-60079-29-1:

Beginning in clean air, the gas-sensing element shall be suddenly exposed to the standard test gas. An alarm set to 20% LFL of the mixture shall respond within 10 s of exposure to the step change.

4.12 Flooding with undiluted gas

4.12.1 The gas-sensing element of instruments other than the manually aspirated type shall be subjected to a step change in gas concentration from 0% (clean air) to 100% gas-by-volume. The instrument shall produce an output indication corresponding to a concentration of at least 60% of the lower flammable limit or to full-scale concentration, whichever is lower, within 10 s of exposure to the 100% gas-by volume.

4.12.2 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% gas by volume. During this test, the instrument shall produce an output indication corresponding to at least 60% of the lower flammable limit or to full scale, whichever is lower, within 10 seconds.

NOTE 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.

NOTE 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 Sections 4.12.1 and 4.12.2.

4.12.3 During the tests of Sections 4.12.1 and 4.12.2, if the instrument is provided with audible or visible alarm signal devices or alarm contacts, these shall be set to the maximum alarm setpoint limit set point or to the highest adjustable set point, whichever is lower, and shall be actuated as a result of these tests.

4.12.4 When instruments incorporating alarms only (without an optional readout capability) are tested, the following shall be substituted:

- a) 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% gas-by-volume.
- b) An alarm set to 20% LFL of the mixture shall respond within 10 s of exposure to the undiluted flooding condition.

4.13 Power supply interruptions, voltage transients and step changes of voltage

The apparatus shall be tested in both clean air and 90%LEL gas

4.14 Electromagnetic Immunity

The apparatus shall meet the construction requirements of clause 3.8.

4.15 Dielectric Test

Following completion of all of the applicable tests of Clause 4, the equipment shall be subjected to dielectric strength tests as required by ANSI/ISA-61010-1, with satisfactory results. This test may be run prior to the completion of the long-term stability test.

4.16 Test Methods

For the purpose of type testing, the tests shall be carried out on one apparatus. Another apparatus may be used for the long term stability test however the sample used for long term stability shall have the unpowered storage, vibration and accuracy tests completed prior to the start of the long term stability test.

5 OPERATIONS REQUIREMENTS

A quality assurance program is required to assure that subsequent gas detector(s) produced by the manufacturer shall present the same quality and reliability as the specific gas detector(s) examined. Design quality, conformance to design, and performance are the areas of primary concern.

Design quality is determined during the examination and tests, and is documented in the Approval Report.

Continued conformance to this standard is verified by the Surveillance Audit.

Quality of performance is determined by field performance and by periodic re-examination and testing.

5.1 Demonstrated Quality Control Program

5.1.1 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- existence of corporate quality assurance guidelines;
- incoming quality assurance, including testing;
- in-process quality assurance, including testing;
- final inspection and tests;
- equipment calibration;
- drawing and change control;
- packaging and shipping; and
- handling and disposition of non-conforming materials.

5.1.2 Documentation/Manual

There should be an authoritative collection of procedures/policies. It should provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.3 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of two years from the date of manufacture.

5.1.4 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the Approval Report, must be reported to, and authorized by, FM Approvals prior to implementation for production.
- The manufacturer shall assign an appropriate person or group to be responsible for, and require that, proposed changes to FM Approved or Listed products be reported to FM Approvals before implementation. The manufacturer shall notify FM Approvals of changes in the product or of persons responsible for keeping FM Approvals advised by means of FM Approvals' Revision Request Form, FM Approved Product/Specification-Tested Revision Report or Address/Main Contact Change Report.
- Records of all revisions to all FM Approved products shall be maintained.

5.2 Surveillance Audit

5.2.1 An audit of the manufacturing facility is part of the Approval investigation to verify implementation of the quality assurance program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to insure a uniform product consistent with that which was tested and FM Approved.

5.2.2 These audits shall be conducted periodically but at least annually by FM Approvals or its representatives.

5.2.3 FM Approved products or services shall be produced or provided at or from the location(s) audited by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the Approval Mark is not permitted at any other location without prior written authorization by FM Approvals.

5.3 Installation Inspections

Field inspections may be conducted to review an installation. The inspections are conducted to assess ease of application, and conformance to written specifications. When more than one application technique is used, one or all may be inspected at the discretion of FM Approvals.

5.4 Manufacturer's Responsibilities

The manufacturer shall notify FM Approvals of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation.

6 BIBLIOGRAPHY

NFPA 325 *Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.*

ANSI/NFPA 70 *National Electrical Code*

ISO/IEC 17025: 2017 *General Requirements for the Competence of Testing and Calibration Laboratories.*