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Performance Requirements for Toxic Gas Detectors

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Performance Requirements for Toxic Gas Detectors

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Preface

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CAUTION—EXPOSURE TO TOXIC GASES MAY BE HAZARDOUS TO HEALTH AND LIFE.

1 Scope

1.1 This standard provides minimum requirements for the construction, performance, and testing of portable, transportable, mobile, and stationary electrical apparatus whose purpose is for the detection, measurement and notification of toxic gas in air that are used to enhance the safety of personnel in commercial and industrial locations.

NOTE 1 — Laboratory- or scientific-type analysis or process control performance requirements are not part of this standard.

a) Residential locations are outside the scope of this standard.

NOTE 2 — Performance requirements for detection of flammable (explosive) concentrations of toxic gas(es) are not the purpose of this standard.

NOTE 3 — The user should be aware of environmental effects on both the apparatus and the toxic gas. The effects are not intended to be evaluated by this standard.

Hereafter, the term "apparatus" will refer to "gas-detection apparatus."

2 References

ANSI/ISA-12.13.01, Performance Requirements for Combustible Gas Detectors

ISA-RP92.0.02, Installation, Operation, and Maintenance of Toxic Gas-Detection Instruments: Hydrogen Sulfide (recommended practice for this standard), establishes user criteria for the installation, operation, and maintenance of toxic gas-detection instruments

ANSI/ISA-92.04.01, Performance Requirements for Instruments Used to Detect Oxygen-Deficient/Oxygen-Enriched Atmospheres

National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards, Title 29, Part 1910.1000, Occupational Safety and Health Standards

Threshold Limit Values for Chemical Substances in the Work Environment Adopted by the American Conference of Governmental Industrial Hygienists (ACGIH)

Documentation for Immediately Dangerous to Life or Health Concentrations (IDLHs) (NIOSH Taft Laboratories)

EN 50270, Electromagnetic Compatibility - Electrical Apparatus for the Detection and Measurement of Combustible Gases, Toxic Gases or Oxygen

3 Definitions

For the purposes of this standard, the following definitions apply:

3.1 alarm:
an audible, visual, or physical signal that alerts the instrument user of a dangerous gas concentration or instrument problem

3.1.1 false alarm:
any alarm that is triggered by a condition other than the one(s) that the alarm function is set for (ex: high gas alarm caused by RF interference or gas alarm caused by temperature changes)

3.2 alarm-only apparatus:
apparatus having an alarm, but not having a meter or other indicating device.

3.3 alarm setpoint:
the selected gas concentration level(s) at which an alarm is activated.

3.4 ambient air:
air to which the sensing element is normally exposed.

3.5 bump test
application of test gas or other means of obtaining a response from the sensor to check its function. This may include the generation of an alarm. This check is performed without adjustments of sensitivity.

NOTE — This is also known as a "response check" or "functional check".

3.6 calibration:
the procedure to adjust the apparatus for proper response (e.g., zero level, span, alarm, and range).

3.7 calibration gas:
the known concentration(s) of gas used to set the apparatus span or alarm level(s).

3.8 clean air:
air that is free of any substance that will adversely affect the operation of or cause a response from the apparatus.

3.9 consumables:
materials or components that are depleted or require periodic replacement through normal use of the apparatus.

3.10 control unit:
that portion of a gas detection apparatus that is not directly responsive to the gas, but which responds to the electrical signal obtained from one or more detector heads. This unit is intended to provide meter indication, alarm functions, output contacts and/or alarm signal outputs when utilized with a detector head.

3.11 detector head:
the gas responsive portion of a gas detection apparatus 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 or amplifying components or circuits in addition to the gas sensing element (sensor).

3.12 diffusion:
a process by which the atmosphere being monitored is transported by natural random molecular movement to and from the gas-sensing element.

3.13 field check with gas (response check):
application of test gas to the sensor to check the response signal or the generation of an alarm, without adjustments of zero, sensitivity, or alarm level.

3.14 full-scale:
the maximum claimed operational level of the gas-detection apparatus.

3.15 gas-detection apparatus:
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 a gas and responds by providing an alarm, indication, or other output functions.

3.16 gas-sensing element:
the particular subassembly or element in the gas-detection apparatus that, in the presence of a gas, produces a change in its electrical, chemical, or physical characteristics.

3.17 indication:
a discrete communication of a measured value or alarm condition.

3.18 IDLH (Immediately Dangerous to Life and Health):
the maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing (e.g., severe eye irritation) or irreversible health effects.

3.19 mobile apparatus:
a continuous-monitoring apparatus mounted on a vehicle, such as, but not limited to, a mining machine or industrial truck.

3.20 nominal voltage:
the voltage given by manufacturers as the recommended operating voltage of their gas detection equipment. If a range (versus a specific voltage) is given, the nominal voltage shall be considered as the midpoint of the range, unless otherwise specified.

3.21 PEL (Permissible Exposure Limit):
time-weighted average (TWA) concentration that must not be exceeded during any 8-hour work shift of a 40-hour work week, as defined by the Occupational Safety and Health Administration (OSHA).

3.22 portable apparatus:
spot-reading or continuous duty apparatus that has been designed to be readily carried from place to place and to be used while it is being carried. A portable apparatus is battery powered and includes, but is not limited to

a) a hand-held apparatus, typically less than 1 kg, suitable for single-handed operation;

b) personal monitors, similar in size and mass to the hand-held apparatus, that are continuously operating (but not necessarily continuously sensing) while they are attached to the user; and

c) larger apparatus that can be operated by the user while it is suspended by hand, by a shoulder strap or by a carrying harness; it may or may not have a hand directed probe.

3.23 REL (Recommended Exposure Limit):
exposure levels that are safe for various periods of employment, including but not limited to the exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of that work experience.

3.24 range:
the values of concentrations of toxic gas over which accuracy is ensured by calibration.

3.25 spot-reading apparatus:
apparatus intended to be used for short periods of time as required (typically 5 min or less).

3.26 sample-draw:
a method to cause deliberate flow of the atmosphere being monitored to a gas-sensing element.

3.27 signal-processing detector head:
an apparatus intended to be incorporated with separate signal processing, data acquisition, central monitoring, or other similar systems in which the apparatus provides a conditioned electronic signal or

output indication to systems of the aforementioned type that typically process information from various locations and sources including, but not limited to, gas-detection apparatus.

3.28 span:
the algebraic difference between the upper and lower values of a range.

3.29 stabilization:
state when three successive readings of an apparatus, taken at intervals equal to the maximum t(90) value defined in Annex A (Item 5), indicates no changes greater than the accuracy value defined in Annex A (Item 2).

3.30 stationary apparatus:
a gas-detection apparatus intended for permanent installation in a fixed location.

3.31 (TLV-)STEL, (Threshold Limit Value-) Short-Term Exposure Limit:
a 15-minute Time-Weighted Average (TWA) exposure that should not be exceeded at any time during a workday, even if the 8-hour TWA is within the Threshold Limit Value - Time-Weighted Average (TLV-TWA).

3.32 test gas:
toxic gas diluted with clean air or inert gas to a known concentration within the test-gas tolerance stated in Annex A, Item 1.

3.33 transportable apparatus:
apparatus not intended to be portable, but which can be moved readily from one place to another.

3.34 (TLV-)TWA, (Threshold Limit Value-) Time-Weighted Average:
the time-weighted average concentration for a normal 8-hour work day in a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

3.35 toxic gas:
toxic gases, for the purpose of this standard, are gases that may cause significant acute health effects at low concentrations. Health effects may include severe skin or eye irritation, pulmonary edema, neurotoxicity, or other potentially fatal conditions.

3.36 trouble signal:
information that alerts an apparatus user to abnormal conditions.

3.37 stand-alone gas detection apparatus:
a detector which provides a conditioned electronic signal or output indication to a system. The stand-alone detector head is intended to be interfaced to unspecified separate control unit, signal processing data acquisition, central monitoring, or other similar systems in which the apparatus provides a conditioned electronic signal or output indication to systems.

3.38 stand-alone control unit:
fixed gas detection control units intended to provide meter indication, alarm functions, output contacts and/or alarm signal outputs when utilized with stand-alone detector head.

4 General requirements

4.1 General

4.1.1 The gas detection apparatus shall be suitable for use in the intended location.

NOTE — This means that other relevant requirements (e.g. hazardous (classified) locations, environmental ratings, combustible gas detection, cross-sensitivity poisoning, etc.) must be addressed.

4.1.2 All toxic gas-detection apparatus shall meet the minimum construction and test requirements contained within this standard. When verifying a manufacturer's claimed superior performance or special features of construction, the minimum requirements of the standard must be met and the manufacturer's claimed superior performance must be verified by test. The superior performance of one criterion may result in a reduced performance in other criteria. The additional tests should be agreed upon by the manufacturer and test laboratory and identified and described in the test report.

EXAMPLES:

(1) When a manufacturer claims a sensor accuracy over a defined temperature range of – 50°C to +40°C at ±10ppm (assuming a measuring range of 0-100ppm), the sensor shall meet the manufacturer's claim from – 50°C to – 10°C and meet the specified requirements of section 5.15 for the temperature range of – 10°C to +40°C.

(2) For detectors that consist of detection and alarm capabilities for simultaneous detection of 5 or more gases, the product shall state the following, "Reference instruction manual for a list of all gases. The additional tests shall be agreed between the manufacturer and test laboratory.

4.1.3 Gas-detection apparatus, their components, and remote detector heads specifically intended for use in the presence of corrosive vapors or gases shall be constructed of materials resistant to, or protected against, corrosion.

4.1.4 Apparatus of the sample-draw type shall include the necessary sample-pumping mechanisms.

4.2 Indicating devices (audible, visual and display)

4.2.1 An indication shall be provided to show that the apparatus is energized.

NOTE — For fixed apparatus the indication may be shown at the control unit.

4.2.2 For alarm-only apparatus or apparatus where the resolution of the read-out device is inadequate to demonstrate compliance with this standard, the manufacturer shall identify suitable points for connecting indicating or recording devices for the purpose of testing the compliance of the apparatus with this standard. The indication on the readout device shall not contradict the results obtained by additional indicating or recording devices.

NOTE — If the main mode of the apparatus is "alarm only", but through a special or factory provided mode can display the gas reading in sufficient resolution, the special or factory mode may be used to determine compliance with agreement between the Testing Laboratory and Manufacturer.

4.2.3 Any under-range or over-range measurements shall be clearly indicated.

4.2.4 The audible and visual alarm settings for the apparatus shall not be ambiguous. If the apparatus has more than one measuring range per given gas, the alarm level shall not be compromised.

4.2.5 For instruments with a display to indicate gas concentrations, the Gas type, Concentration and unit of measurement shall be indicated. It is permissible to physically indicate the gas and unit of measurement outside the actual display. Display must provide sufficient concentration resolution to meet the requirements of the tests in this Standard. Nonlinear scales or indicators are permissible when their function is prominently and clearly noted in the instruction manual.

4.2.6 When an indicating light is the only means of indication and only one indicating light is provided for signaling alarms, faults and other indications, it shall be colored red. If separate indicating lights are used

or if a multi-colored indicating light is provided, the colors shall be used in the following order of priority ((a) being highest priority):

a) alarm visual indicator(s) that are used to identify the presence of a gas concentration at or above the alarm set point shall be RED in color;

b) equipment fault visual indicator(s) shall be YELLOW in color;

c) "power-on" visual indicator(s) shall be GREEN in color.

4.2.7 In addition to the color requirements referenced in clauses 4.2.6 a), b) and c), the indicator lights shall be adequately labeled to identify their function(s).

4.2.8 For portable apparatus, when an integral audible alarm is provided the output sound pressure level must be $\geq$ 90db @ 1ft. If an audible alarm is provided, but can be disabled, a visual indication must be provided and a clear warning in the manual must be provided. For portable apparatus where an audible alarm is not provided a visual indication of alarm condition must be provided.

4.3 Switches and outputs

4.3.1 Devices (such as switches) that disable alarm or trouble outputs or signals are acceptable if the following criteria are met:

a) Alarm or trouble outputs or signals are automatically enabled when the device is returned to the operating (normal) mode.

b) A distinctive visual or audible indication, or both, and a distinctive output signal or indication are provided with the device in the disable (bypass) mode.

c) Local (i.e., at the apparatus) visual alarm indications are not disabled.

EXCEPTION:

Indicators may be disabled when the apparatus is in calibration mode.

4.3.2 Apparatus of the sample-draw type shall incorporate a device to indicate either adequate or inadequate flow. In portable apparatus, the flow-indicating device may be omitted provided that the instruction manual contains detailed instructions as required by clause 4.13.

4.3.3 When auxiliary outputs from the gas-detection apparatus are provided, their malfunction shall not adversely affect apparatus alarm functions.

4.4 Alarm signal

4.4.1 Continuous-duty apparatus

If alarm devices, output contacts, or alarm signal outputs are provided as part of fixed or continuous duty portable apparatus and are intended to operate when a potentially hazardous gas concentration is detected, they shall be of a latching type requiring a deliberate manual action to reset within the gas detection system. Where the outputs are connected to an integrated or auxiliary system the means of latching and resetting may be incorporated into these systems. If two or more set or alarm positions are provided, the lower may be nonlatching - based on user preference.

NOTE — The integral or latching device may reside in software.

4.4.2 Factory default alarm settings

All gas-detection apparatus and stand-alone control units with alarm functions that are factory set at default values shall be identified by marking and/or a product document, and the factory default alarm setting shall be at or below the ACGIH TLV, NIOSH REL, OSHA PEL or specified level required by the local authority where the product will be used.

4.4.3 Stand-alone apparatus

All stand-alone gas-detection apparatus and stand-alone control units shall include alarm or indication. Signal processing heads, approvable under this standard, are designed as components of a data-acquisition, central-monitoring, or similar system in which the alarm and malfunction are inherently part of the system, and hence gas alarm functions are not separately required as part of the detecting head.

4.4.4 Portable apparatus

All portable gas-detection apparatus shall be provided with a distinguishable trouble signal indicating low-battery condition, and the nature and purpose of this indication shall be explained in the manual. This trouble signal shall operate for a minimum of 10 minutes, during which time no false alarms are permitted and the ability to accurately detect gas and generate alarm(s) shall not be compromised.

4.5 Fault signals

4.5.1 Fixed and transportable apparatus

Fixed and transportable apparatus shall provide a fault signal in the event of power failure to the apparatus, short circuit in connection to any sensor, loss of continuity in one or more of the wires to any sensor or sensing element, loss of electrical continuity of any gas-sensing system, or the manufacturers specified down-scale indication not to exceed 10% of the measuring range.

NOTE — It is desirable to provide a trouble signal for a gas-sensing element failure.

4.5.2 Sample-draw gas-detection apparatus

Sample-draw gas-detection apparatus shall be provided with flow-proving devices that produce a trouble signal in the form of a contact transfer or signal transfer in the event of flow outside the manufacturer's stated flow-rate range.

4.6 Adjustments

All gas-detection apparatus shall be provided with means for facilitating response check and adjustments as required.

All adjustment devices shall be designed so as to discourage unauthorized or inadvertent interference with the apparatus. Examples would include procedural, in the case of a keyboard apparatus, or mechanical such as a cover requiring the use of a tool.

Fixed explosion-protected apparatus housed in explosion-protected enclosures shall be designed so that, if any facilities for adjustment are necessary for routine recalibration and for resetting or like functions, they shall be externally accessible or a non-intrusive method of adjustment provided. The means for making adjustments shall not degrade the explosion protection of the apparatus.

The adjustments of the zero and signal amplification shall be so designed that adjustment of one will not affect the other when adjusted in accordance with the manufacturers instruction manual.

4.7 Construction

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.

4.8 Stand-alone gas detection apparatus for use with separate control units

4.8.1 General

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.

4.8.2 Transfer function specification

A specification shall be supplied with the apparatus that describes the relationship (transfer function) the gas concentration (detected by the apparatus) has with the corresponding output signal or indication (voltage, current, digital). Such specification shall be detailed to the extent that the accuracy of this transfer function can be verified. As a minimum, the manufacturer shall provide data showing the relationship between the output signal and the gas concentrations corresponding to 0, 5-10%, 20-30%, 40-60%, and 70-90% of the Full-scale gas concentration. Full-scale output shall also be as specified by the manufacturer.

4.8.3 Provision for transfer function verification

Where necessary, equipment shall be provided by the manufacturer to interpret the output signal or indication, which will enable the accuracy of the transfer function to be verified.

4.8.4 Tests

Stand alone gas detection apparatus shall be tested to the requirements of 5.5, 5.7 through 5.11, 5.13 through 5.19, and 5.21 using the parameters of the transfer function.

4.9 Stand-alone control units for use with stand-alone gas detection apparatus

4.9.1 General

Stand-alone control units for use with stand-alone gas detection apparatus include those apparatus to be used with stand-alone gas detection apparatus to complete a "performance evaluated" toxic gas detection system at the maximum configuration. The stand-alone control unit shall be tested with a representative stand-alone or simulated gas detection apparatus.

4.9.2 Tests

The control units shall be tested to the requirements of 5.5, 5.7 through 5.9, 5.13 through 5.15, and 5.21 using the parameters of the transfer function pertinent to the specific type of gas detector.

4.10 Communication options

For apparatus having serial or parallel communications options used during normal gas detection operation, tests in 5.8, 5.9 and 5.13 shall be performed with all communication ports connected. The maximum transaction rate, cabling characteristics and activity level specified by the apparatus's manufacturer shall be employed.

4.11 Gas detection apparatus as part of systems

For gas detection apparatus which are part of systems, tests in 5.8, 5.9, 5.13 and 5.21 shall be performed with the maximum system communications transaction rate and activity level. This shall correspond to the largest and most complex system configuration permitted by the manufacturer.

4.12 Labeling and marking

4.12.1 General

The apparatus shall be marked or documented with reference to "ANSI/ISA-92.00.01" and the manual must include reference to the gas(es) which performance has been verified.

All equipment and protective systems shall be marked legibly and indelibly with the following minimum requirements:

a) name or trademark and address of the manufacturer (minimum of city and country);

b) certification marking;

c) designation of model or type;

d) the month and year of manufacture (e.g. date code, serial number or equivalent means);

e) the specific marking describing the type of explosion protection (if any).

f) the marking "**CAUTION — READ AND UNDERSTAND INSTRUCTION MANUAL BEFORE OPERATING.**" or equivalent.

4.12.2 Marking notations

The markings required by this standard shall appear in a clearly legible, visible, and permanent manner on each gas-detection apparatus in the following manner, as applicable:

a) For portable apparatus, the required markings shall appear both on the outside surface of the apparatus and also on any removable carrying case if the case obscures the markings required.

b) For stationary apparatus, the required markings shall appear in a location where they will be visible after installation.

c) For apparatus that comprise a control unit and a remote detector head, the required markings shall appear, as a minimum, on the control unit only. If routine recalibration can be accomplished entirely by adjustments at the remote detector location(s), this marking shall appear both on the control unit and on the remote detector head.

d) For modular control units comprised of one or more control modules in a common enclosure or mounting assembly, the required markings need not be repeated on each module but may appear as a single marking on the common portion of the assembly.

e) For apparatus that lack sufficient space for required markings or for apparatus having interchangeable gas-sensing elements, the required markings shall be provided on permanent labels or tags that are attached to the apparatus by the manufacturer.

4.12.3 Special features

Where the design or special features of the apparatus require additional markings or changes in marking requirements, the additions or revisions are allowed, but the safety and instructional intent of 4.13 must be met.

4.12.4 Temperature range

The manufacturer's stated temperature range over which the apparatus will perform within specifications shall appear in a clearly legible, visible, and permanent manner on each apparatus. If multiple or interchangeable gas-sensing elements are provided in a common housing, the most restrictive temperature range shall be used. If the apparatus has interchangeable gas sensor types, the main portion of the apparatus can indicate the full temperature range, if the interchangeable sensors indicate the individual sensor operating temperature range.

4.13 Instruction manual

Each apparatus shall be provided with an instruction manual that includes the following information:

a) complete instructions, drawings and diagrams for safe and proper operation, installation and servicing of the apparatus;

b) operating instructions and adjustment procedures;

c) recommendations for initial checking and calibration of the apparatus on a routine basis, including instructions for the use of the field calibration kit, if provided;

NOTE — Users are referred to ANSI/ISA-92.00.02.

d) relationship between any outputs and toxic gas concentrations; and

e) a list of operating adjustments and instructions for setting these adjustments (e.g., alarm setpoint, zero, and span adjustments);

f) a list of available options;

g) details of operational limitations, including, where applicable, the following:

1) Gases for which the apparatus is suitable and the relative sensitivities of the apparatus to these gases

2) Information that describes the sensitivities to other gases to which the apparatus is responsive

3) Temperature limits

4) Humidity ranges

5) Supply voltage limits

6) Relevant characteristics and construction details of required interconnecting cables

7) Battery data

8) Pressure limits

9) Sample flow rate

10) Warm-up time

11) Stabilization time

h) details of storage life and limitations for apparatus, replacement parts, and accessories, including, where applicable, the following:

1) Temperature

2) Humidity

3) Time

4) Pressure

i) the bases used for converting test and calibration gas concentrations from PPM to % volume fraction;

j) a list of desensitizing, contaminating, or interfering substances or water-vapor concentrations known to the apparatus manufacturer, which may adversely affect proper operation of the apparatus (Warning as to effects of oxygen-enriched or oxygen-deficient atmospheres must be included.);

NOTE — Recognizing that it is difficult to compile a complete list of all possible desensitizing or contaminating gases or other substances, it is recommended that the manual also include either the generic description of the sensing element or a description of its properties so that the user is cautioned to either evaluate the probable effect of contaminants that are not included in the list or contact the apparatus manufacturer.

k) information on the adverse effects of poisons and interfering gases or substances and oxygen-enriched or deficient atmospheres on the proper performance (and, in the case of oxygen-enriched atmospheres, on electrical safety) of the apparatus;

l) for aspirated apparatus, indication of the minimum and maximum flow rates and pressure; also, tubing specifications, sample-draw lag times, and materials suitable for transportation lines for proper operation;

m) for aspirated apparatus, instructions for ensuring that the sample lines are intact and that proper flow is established;

n) for aspirated apparatus, adequate data/information to advise the user of inaccuracies caused by absorption/adsorption of toxic gas by sample lines and contaminants;

o) statements of the nature and significance of all alarms and fault signals, the duration of such alarms and signals (if time-limited or non-latching) and any provisions that may be made for silencing or resetting such alarms and signals, as applicable;

p) details of any method for determination of the possible sources of a malfunction and any corrective procedures (i.e. trouble-shooting procedures);

q) a statement that alarm devices, outputs, or contacts are of the non-latching types, where applicable;

r) a recommendation for external alarm latching when non-latching alarms are provided.

s) a listing of consumable and replacement components and the expected life/usage rate and recommendations for storage of each item;

t) for battery-operated apparatus, installation, recharging and maintenance instructions for the batteries;

u) a recommended replacement parts list;

v) where optional accessories (e.g. collecting cones, weather-protecting devices) are supplied, the manufacturer shall list them and state their effects on the apparatus characteristics (e.g. including response time, accuracy and repeatability) and provide means for identification of these (e.g. part numbers included in manual);

w) details of certification and marking and any special conditions of service;

x) the storage life and recommended storage conditions for replacement parts and accessories, where critical;

y) for stand alone control units and stand alone detector head the following note or equivalent shall appear within the manual: **"CAUTION: THE STAND ALONE DETECTOR HEAD HAS A RESPONSE TIME OF (AS TESTED) SECONDS. THE STAND-ALONE DETECTOR HEAD SHALL BE CONNECTED TO A STAND-ALONE CONTROL UNIT WITH A RESPONSE TIME OF LESS THAN OR EQUAL TO (REQUIREMENT-AS TESTED) SECONDS."**

z) where the special nature of the apparatus (such as non-linear responses) requires additional instructions or special information that are alternative to, or in addition to, the requirements of 4.12 and 4.13 a) to y), the instructions or information shall be provided.

5 Test methods

5.1 Introduction

The tests described in 5.5 through 5.21 are in addition to the requirements specified in Clause 4.

5.2 General requirements for test

5.2.1 Samples and sequence of tests

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 (see 5.19).

The unpowered storage (5.5), drop test (5.6), and vibration (5.7) tests must be conducted prior to all remaining tests. The test sequence on all remaining tests shall be carried out to a schedule agreed upon between the manufacturer and the test laboratory.

Where an ingress protection level is claimed for the gas detector head and/or gas detection apparatus, the ingress protection acceptance criteria must be applied in addition to a subsequent 'bump test' gas application with the acceptance criteria in accordance with Annex A, Item 2 (accuracy/repeatability). If it is necessary to apply the manufacturer's maintenance recommendation in order to comply with the accuracy acceptance criteria, the manual must clearly state that after exposure to the ingress the apparatus must undergo a maintenance application.

5.2.2 False alarms

Unwarranted (false) alarms shall be considered failure of the tests.

5.2.3 Test-gas concentration

The tolerances of the test-gas concentrations shall be included in the uncertainty of the apparatus indications.

NOTE 1 — Some toxic gas mixtures are not stable and will deteriorate over time. Therefore, it is necessary for the testing laboratory to use an independent analytical method to verify the gas concentration at the sensor location.

NOTE 2 — Some toxic gas mixtures have a longer surface residence time (commonly known as a sticky gas). This characteristic should be taken into consideration by the test laboratory during the test program.

5.3 Preparation of the apparatus

5.3.1 Interconnections and adjustments

The apparatus selected for testing shall be prepared as if for actual service, including all necessary interconnections and initial adjustments, in accordance with the manufacturer's instruction manual.

In all cases, optional parts shall be either attached or removed according to which condition will give the most unfavourable result (at the discretion of the testing laboratory) for the test being conducted.

Conditioning of the test setup is permitted prior to each test, and the conditioning shall be consistently applied and documented throughout all tests.

5.3.2 Remote detector heads

For apparatus having remote detector heads, all tests shall be performed with resistance(s) connected in the detector circuits to simulate the maximum line resistance specified by the apparatus manufacturer (except where the minimum line resistance offers a more stringent test in the judgment of the testing laboratory).

5.3.3 Signal processing detector heads

For signal processing detector heads, adequate means for interpreting the output signal shall be provided.

5.4 Conditions for test and test area

5.4.1 Voltage

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

5.4.2 Ambient temperature

The ambient air and test gas shall be held at a temperature constant to ±2 K per hour within the range of 18 °C to 30 °C, throughout the duration of each test, unless otherwise specified for the particular test.

5.4.3 Ambient atmospheric pressure

Except as otherwise indicated herein, tests shall be performed at any atmospheric pressure in the range of 86 kPa to 108 kPa.

5.4.4 Ambient humidity

The ambient air and test gas shall be held at a relative humidity (RH), controlled to within ±20 % RH, over the range 20 % to 80 % throughout each test unless otherwise specified for the particular test.

5.4.5 Air velocity

Except as otherwise indicated herein, tests are to be performed in relatively still air (velocity not more than 1.0 meter per second [m/s] [3.3 feet per second (f/s)]) other than 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.

5.4.6 Diffusion device

For purposes of the tests in 5.8 through 5.21, where reference is made to exposing the detector head to specified gas mixtures or to other specified conditions, all normally attached diffusion devices or protective mechanical parts shall remain attached.

5.4.7 Remote detector head

For apparatus intended to be used with more than one remote detector head, only one detector head shall be exposed when tests call for the exposure of the remote detector head to a specified test gas or other specified set of conditions. Dummy electrical loads (e.g., fixed resistors) may be substituted for additional detector heads, but if additional detector heads are used, all other detector heads shall be exposed to clean air and normal conditions as described in 5.4.2 through 5.4.4.

5.4.8 Adjustments

The apparatus shall be prepared and mounted as nearly as possible as for typical service, in accordance with the instruction manual including all necessary interconnections, initial adjustments, and initial calibrations. Adjustments, as specified within the manufacturer calibration procedure, may be made, where appropriate, at the beginning of each test.

The apparatus under test may be adjusted or recalibrated prior to the start of each of the tests described in 5.6 through 5.21. 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.

5.4.9 Stabilization

Unless otherwise indicated herein, the apparatus shall be allowed to stabilize under each different test condition before measurements are taken.

5.4.10 Accuracy

For the tests described in the following paragraphs of Clause 5, the tolerance specified in Annex A, Item 2, shall apply.

5.4.11 Selectable range apparatus

For selectable range apparatus using different sensory hardware, the tests of 5.5 through 5.21 shall be performed at each of the designated ranges. For selectable range apparatus using the same sensory hardware, one range shall be subjected to the tests of 5.5 through 5.21 with subsequent ranges subjected to the tests of 5.8, 5.9, 5.11, and 5.13 at each designated range.

5.4.12 Auxiliary interface

During performance testing, all auxiliary interfaces shall be in normal operating condition.

5.5 Unpowered storage

To evaluate apparatus for typical transportation environmental ranges, all parts of the gas-detection apparatus shall be exposed sequentially to the following conditions:

a) -20°C or at the manufacturer's claimed minimum if less than -20°C, for at least 24 hours;

b) ambient temperature and humidity for at least 24 hours;

c) +40°C or at the manufacturer's claimed maximum if greater than +40°C, for at least 24 hours; and

d) ambient temperature and humidity for at least 24 hours.

The above temperatures may be varied only after an agreement has been reached between the manufacturer and testing laboratory. Where temperatures other than those listed above are used, they shall be listed in the certification documents.

5.6 Drop test (portable and transportable only)

Multi-range apparatus need to be tested only on one range.

While in the operating mode, the apparatus (less any removable case, unless otherwise specified by the manufacturer) shall be released from a height of 1.0 m (3.3 ft.) above a concrete surface and allowed to free-fall.

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

The apparatus shall be considered to have failed this test if there is a loss of function (e.g. alarm, pump function, controls, display, change of state) after the test.

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

5.7 Vibration

5.7.1 Test equipment

The vibration test machine shall be capable of producing a vibration of variable frequency and adjustable constant excursion (or adjustable constant acceleration peak) with the apparatus under test mounted in place, as required by the test procedure.

5.7.2 Procedure

While in the operating mode in clean air, all apparatus 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 apparatus. The apparatus shall be mounted on the vibration test machine in the same manner and position as intended for service using any resilient mounts, carriers, or holding devices that are provided as a standard part of the apparatus. The apparatus shall be vibrated over a frequency range of 10 Hz to 30 Hz at a total excursion of 1.0 mm (0.04 in.), and 30 Hz to 100 Hz at a 2 g peak acceleration for a period of one hour in each of three mutually perpendicular directions. The rate of change of frequency shall not exceed 10 Hertz per minute (Hz/minute).

Before, and at the conclusion of the test, the apparatus shall be exposed to clean air followed by the test gas.

5.7.3 Acceptance criteria

The apparatus shall not give any false alarms; there shall be no loose components or damage to the enclosure that could cause a shock hazard. The apparatus shall be considered to fail this test if it is inoperative after the test. The output shall not vary by more than the tolerance specified in Annex A, Item 2.

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

5.8 Initial calibration and set-up

5.8.1 Procedure

The apparatus shall be calibrated for testing in accordance with this standard by using the manufacturer's recommended calibration equipment and specified calibration procedures. Unless otherwise specified by the manufacturer, at least one calibration gas shall be a minimum of 50 percent of the selected range over which the apparatus is to be calibrated not to exceed the IDLH level for that gas.

5.8.2 Acceptance criteria

The indication obtained while using the manufacturer's recommended calibration equipment shall match the indication using the intended gas application method for test purposes within the accuracy limits specified in Annex A.

5.9 Accuracy

5.9.1 Apparatus with meter or output signal

For apparatus having meters or output signals, the detector head shall be exposed to clean air and mixtures of test gas in clean air by the intended method of gas monitoring or an alternate gas presentation method verified by the tester. Compositions of the mixtures shall be 5 to 10 percent, 20 to 30 percent, 40 to 60 percent, and 70 to 90 percent of the detector's 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 the tolerance specified in Annex A, Item 2. For apparatus having selectable measuring ranges, the apparatus shall be tested on all ranges.

5.9.2 Apparatus with alarm

For apparatus with alarm or alarm-only apparatus, all alarm setpoints shall be tested, with the lowest alarm setpoint of multiple alarm setpoint units tested first.

a) Alarm(s) shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

b) Alarm(s) shall NOT be activated by a test-gas concentration lower than the alarm setpoint minus the tolerance specified in Annex A, Item 2.

c) The time of exposure to each test-gas concentration shall not be less than 5 minutes or greater than 10 minutes.

5.9.3 Sample-draw apparatus

For sample-draw apparatus, the accuracy test shall be conducted at both the minimum and the maximum sample flow rates given by the manufacturer. Unacceptable performance at either flow rate shall constitute failure of the test.

5.10 Fault signals

When the apparatus has undergone each condition separately as specified in 4.5, the apparatus shall indicate a fault signal without a false alarm indication.

5.11 Repeatability

5.11.1 For apparatus having meters or output signals, the detector head shall be exposed to clean air and mixtures of test gas in clean air by the intended method of gas monitoring or an alternate gas presentation method verified by the tester. Compositions of the mixture shall be 70 to 90 percent of range. The test gas shall be applied three separate times for a duration of 2 times the maximum t(90) value in Annex A, Item 5. The apparatus shall be exposed to clean air for a duration of 2 times the maximum t(10) value in Annex A, Item 6 after each test gas application. In each case, the concentration indicated by the meter or output signal shall not vary from the average indication by more than the tolerance specified in Annex A, Item 2. For apparatus having selectable ranges, the apparatus shall be tested on all ranges.

5.11.2 For alarm-only apparatus, the highest alarm setpoint shall be tested. The test gas shall be applied three times to the apparatus, allowing a maximum of the Recovery Time specified in Annex A, Item 6, for that gas plus 60 seconds between exposures.

a) Alarm(s) shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

b) Alarm(s) shall NOT be activated by a test-gas concentration lower than the alarm setpoint minus the tolerance specified in Annex A, Item 2.

c) The time of exposure to each gas concentration shall neither be less than 5 minutes nor greater than 10 minutes.

5.11.3 For sample-draw apparatus, the repeatability test described above shall be conducted at both the minimum and the maximum sample flow rates given by the manufacturer. Unacceptable performance at either flow rate shall constitute failure of the test.

5.12 Consumables

5.12.1 Batteries

Apparatus powered by integral batteries shall be capable of continuous operations at a temperature of -10° C (14° F) for a period of at least 8 hours, including 15 minutes of maximum load (i.e., continuous alarm, lights, etc.) without replacement or recharge of batteries.

NOTE — For Multi-Gas portable apparatus employing a combustible sensor, the battery run time requirement shall meet those requirements stated in ISA 12.13.01.

5.12.2 Consumables other than batteries

Apparatus requiring consumables shall be capable of operating a minimum of 8 hours without replacement or replenishment of such consumables.

5.13 Step-change response and recovery

5.13.1 For apparatus having meters or output signals, after initially being in clean air, the detector head, at a minimum using the worst case accessory configuration, shall be exposed suddenly to a test gas at atmospheric pressure having a concentration corresponding to 95 to 100 percent of range. From the instant of exposure to this gas mixture, the apparatus shall provide an indication within the criteria specified in Annex A, Item 3 through Item 5.

NOTE — For apparatus having multiplexed or scanned channels, the step-change response test must be conducted while scanning all channels.

5.13.1.1 When stabilization has occurred, the test gas shall be removed and the detector head exposed to clean air. From the instant of exposure to clean air, the apparatus shall respond to provide an indication as specified in Annex A, Item 6.

5.13.1.2 For sample-draw apparatus, the transportation lines should be as short as practical.

NOTE — The Step-Change Response and Recovery Test evaluates response time of the apparatus only; it does not consider transport time through sample lines.

5.13.1.3 For sample-draw apparatus, the manufacturer's stated response times for maximum sample-line length and size and lag times shall be verified.

5.13.2 For alarm-only apparatus, after initially being in clean air, the detector head shall then be suddenly exposed to gas concentrations of 500 percent of the values of the alarm setpoint concentrations. All alarms shall be tested, and all shall respond within the T_{20} time specified in Annex A, Item 3.

5.13.2.1 After two minutes, the test gas shall be removed and the detector head exposed to clean air. All alarms shall clear or be resettable within the T_{90} (recovery) time specified in Annex A, Item 6.

5.14 Supply voltage variation

5.14.1 For gas-detection apparatus intended for operation on ac power supply systems, with the detector head exposed to either clean air or test gas as noted, the supply voltage shall first be decreased to 85 percent of nominal voltage and then increased to 110 percent of nominal voltage. Adjustable alarms shall be set to operate at 50 percent of selected gas concentration range or maximum setpoint, whichever is less. As a result of this test, there shall be no apparatus malfunction or false actuation of the alarm(s). The voltage variation must occur within 100msec.

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; that is, there shall be no actual interruption of the voltage supply during the voltage transition.

5.14.1.1 For apparatus having meters or other outputs, with the detector head exposed to a concentration of 50% ± 5% of full scale, the variation in the meter or other output from the initial reading at nominal voltage shall not vary from the known test-gas concentration by more than the tolerance specified in Annex A, Item 2.

5.14.1.2 For apparatus with alarms, all alarm setpoints shall be tested, with the lowest alarm setpoint of multiple alarm setpoint units tested first.

a) Alarm(s) shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

b) Alarm(s) shall NOT be activated by a test-gas concentration lower than the alarm setpoint by the tolerance specified in Annex A, Item 2.

c) Alarm(s) shall NOT be activated when the detector head is exposed to clean air.

d) The time of exposure to each test-gas concentration shall neither be less than 5 minutes nor greater than 10 minutes.

5.14.2 For apparatus intended for operation on dc power-supply systems, with the detector head exposed to either clean air or test gas as noted, the supply voltage shall first be decreased to 87.5 percent of nominal voltage and then increased to 122.5 percent of nominal voltage. Adjustable alarms shall be set to operate at the lowest value of OSHA PEL, NIOSH REL, ACGIH TLV or 110% of STEL. As a result of this test, there shall be no apparatus malfunction or false activation of the alarm(s). The voltage variation must occur within 100msec.

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; that is, there shall be no actual interruption of the voltage supply during the voltage transition.

5.14.2.1 For apparatus having meters or other outputs, with the detector head exposed to a concentration of 50% ± 5% of full scale, the variation in the meter or other output from the initial reading at nominal voltage shall not vary from the known test-gas concentration by more than the tolerance specified in Annex A, Item 2.

5.14.2.2 For alarm-only apparatus, all alarm setpoints shall be tested, with the lowest alarm setpoint of multiple-alarm setpoint units tested first.

a) Alarm(s) shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

b) Alarm(s) shall NOT be activated by a test-gas concentration lower than the alarm setpoint minus the tolerance specified in Annex A, Item 2.

c) Alarm(s) shall NOT be activated when the detector head is exposed to clean air.

d) The time of exposure to each test-gas concentration shall neither be less than 5 minutes nor greater than 10 minutes.

5.14.3 For apparatus containing integral batteries, the voltage variation shall correspond to the maximum terminal voltage of fresh or fully charged batteries and the voltage at which the low-battery voltage alarm activates. This lower voltage must be within 5 percent of the minimum operating voltage given by the manufacturer. Apparatus having provision for adjustment to compensate for battery voltage decline may be so adjusted. During this test, the detector head shall be exposed to clean air or the test gas as noted. Adjustable alarms shall be set to operate at 110% of STEL or the lowest value of OSHA PEL, NIOSH REL, or ACGIH TLV. As a result of this test, there shall be no apparatus malfunction or false actuation of the alarm(s).

5.14.3.1 For apparatus having meters or other outputs, with the detector head exposed to a test-gas concentration of 50% ± 5% of full scale, the variation in the meter or other output from the initial reading at maximum battery voltage shall not vary by more than the tolerance specified in Annex A, Item 2.

5.14.3.2 For alarm-only apparatus, all alarm setpoints shall be tested, with the lowest alarm setpoint of multiple alarm setpoint units tested first.

a) Alarm(s) shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

b) Alarm(s) shall NOT be activated by a test-gas concentration lower than the alarm setpoint minus the tolerance specified in Annex A, Item 2.

c) Alarm(s) shall NOT be activated when the detector head is exposed to clean air.

d) The time of exposure to each gas concentration shall neither be less than 5 minutes nor greater than 10 minutes.

5.14.4 Gas-detection apparatus intended for operation from an external power source shall be subjected to five momentary power interruptions, ranging from approximately 0.1 seconds to 5 seconds, with the detector head exposed to both clean air and a test gas concentration exceeding the lowest alarm setting. Following each interruption, the apparatus shall be allowed sufficient time (not to exceed 180 seconds) to return to normal operating conditions. There shall be no apparatus malfunction when the primary power is interrupted (applied or removed), with the detector exposed to both clean air and test gas, the output shall not vary by more than the tolerance specified in Annex A, Item 2.

5.14.5 Output inhibit circuits activated upon power application are permitted, provided the status of the inhibit is visually indicated.

5.15 Temperature variation

This test shall be performed in a temperature chamber having the capability of holding the sensor or apparatus at the specified temperature within ±2°C. All gas-detection apparatus shall first be calibrated in accordance with 4.8, with all parts of the apparatus at ambient temperature. The temperature of the test chamber shall be adjusted in the sequence as specified below for 2 hours after internal chamber thermal stability or if the internal temperature of the apparatus can be measured and reported then the duration can be reduced to 1 hour after apparatus' internal thermal stability. When the apparatus (or the portion under test) has reached the temperature as specified below for the required duration, then the apparatus shall be exposed to the test gas, which shall be at the same temperature as the internal temperature of the test chamber. The dew point of the air or the test gas shall be below the temperature of the test chamber and kept constant during the test.

a) -10°C or at the manufacturer's claimed minimum if less than -10°C

b) ambient temperature

c) +40°C or at the manufacturer's claimed maximum if greater than +40°C

5.15.1 For apparatus with meters or other output signals and having the detector head integral with or directly attached to the control unit, the entire apparatus shall be placed in the test chamber. At the two temperature extremes, the meter or output indication shall not vary from the initial stabilized ambient temperature meter or output indication by more than the tolerance specified in Annex A, Item 2.

5.15.2 For apparatus with meters or other output signals and a separate (non-integral) detector head, the control unit shall be placed in the test chamber at both temperature extremes while the detector head remains at ambient temperature. Subsequently, the detector head shall be placed in a test chamber at both temperature extremes while the control unit remains at ambient temperature.

5.15.3 For alarm-only apparatus, all alarm setpoints shall be tested at the two temperature extremes, with the lowest alarm setpoint of multiple alarm setpoint units tested first.

a) Alarms shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

b) Alarms shall NOT be activated by a test-gas concentration lower than the alarm setpoint minus the tolerance specified in Annex A, Item 2.

c) The time of exposure to each gas concentration shall neither be less than 5 minutes nor greater than 10 minutes.

5.16 Humidity variation

The apparatus shall be exposed for 2 h to clean air having a relative humidity of 50% and record the results. The apparatus shall be calibrated with the standard test gas at the relative humidity of 50% and record the results. Next, the gas sensing element shall be exposed for 2 h to clean air having a relative humidity of 20%. The detector head shall then be exposed to the calibration gas mixture having a relative humidity of 20% and record the results. Next, the gas sensing element shall be exposed for 2 h to clean air having a relative humidity of 90%. The detector head shall then be exposed to the calibration gas mixture having a relative humidity of 90% and record the results.

At the two humidity extremes the indication shall not vary from the 50% RH indication by more than Annex A, Item 2.

For apparatus incorporating alarms only, the alarm setpoints shall be tested, with the lowest alarm setpoint of multiple alarm setpoint units tested first.

a) Alarms shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

b) Alarms shall NOT be activated by a test-gas concentration lower than the alarm setpoint minus the tolerance specified in Annex A, Item 2.

c) The time of exposure to each gas concentration shall neither be less than 5 minutes nor greater than 10 minutes.

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

5.17 Position sensitivity

5.17.1 For portable apparatus having meters or other outputs, with the detector head exposed to a test-gas concentration of 50% ± 5% of full scale, the variation in the meter or other output from the initial reading shall not vary from the known test-gas concentration by more than the tolerance specified in Annex A, Item 2, when the orientation of the apparatus is varied in three orthogonal planes.

5.17.2 For portable alarm-only apparatus, all alarm setpoints shall be tested when the orientation of the apparatus is varied in three orthogonal planes, with the lowest alarm setpoint of multiple alarm setpoint units tested first.

a) Alarms shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

b) Alarms shall NOT be activated by a test-gas concentration lower than the alarm setpoint minus the tolerance specified in Annex A, Item 2.

c) The time of exposure to each gas concentration shall neither be less than 5 minutes nor greater than 10 minutes.

5.18 Air velocity variation

5.18.1 The apparatus shall be calibrated with the detector head exposed to a still mixture of calibration gas. Then it shall be exposed to a flowing test gas that impinges on the detector head with a velocity of 5 ± 0.5 m/s (16.5 ± 1.7 f/s). During this test, the direction of the air velocity or the orientation of the detector head shall be varied in each of the following three orientations:

a) Sensing element oriented directly toward direction of flow.

b) Sensing element oriented away from the direction of flow.

c) Sensing element oriented at right angles to the direction of flow.

NOTE — Directions of flow which are not likely to occur in practice, due to the design of the apparatus, or which are expressly prohibited within the manufacturer's instruction manual may not be tested.

5.18.1.1 For apparatus having meters or other output signals, the meter or other output signal (during exposure to the mixture in motion) shall not vary from that observed during exposure to the still-gas mixture by more than the tolerance specified in Annex A, Item 2.

5.18.1.2 For alarm-only apparatus, all alarm setpoints shall be tested, with the lowest alarm setpoint of multiple alarm setpoint units tested first.

a) Alarms shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

b) Alarms shall NOT be activated by a test-gas concentration lower than the alarm setpoint minus the tolerance specified in Annex A, Item 2.

c) The time of exposure to each gas concentration shall neither be less than 5 minutes nor greater than 10 minutes.

5.19 Long-term stability

The apparatus shall be exposed to the clean air or test-gas mixture as noted continuously (except when batteries are being exchanged or when adjustments are being made). For battery-operated apparatus, a suitable dc power supply or fresh batteries may be used for the test of 5.19, but the actual batteries specified for the apparatus shall be used for the first 8 hours. Portable apparatus shall be ON for 8 hours minimum and OFF for 16 hours maximum. Calibration shall be performed as recommended by the manufacturer. For multi-range apparatus, the test of 5.19 needs to be performed only on the highest range unless otherwise specified.

NOTE — When the manufacturer states a required calibration cycle or bump-test cycle less than 5 weeks, a calibration or bump-test is allowed after the 3-week ambient exposure and prior to the 2-week low concentration exposure (after Clause 5.19.1.2). The calibration or bump-test can not be applied during the 2-week low concentration exposure.

5.19.1 For apparatus incorporating meters or output signals, calibrate or adjust the apparatus on a test-gas concentration of 50% ± 5% of full scale, and keep the power ON for the duration of this test.

5.19.1.1 Subject the detector head to clean air at ambient temperature and humidity for a period of 21 days.

5.19.1.2 Apply the test gas of a concentration used in 5.19.1 to the detector head. The indicated concentration shall not deviate from the initial reading observed in 5.19.1 by more than the tolerance specified in Annex A, Item 2. The reading shall be taken after stabilization, and the response time shall meet the requirements specified in Annex A, Item 3 through Item 5.

5.19.1.3 Subject the detector head to a continuous toxic gas concentration equivalent to 3% ± 1% of the current NIOSH IDLH value for a period of 14 days. For apparatus that are limited by operation at continuous low level gas concentration exposure, the time duration may be reduced under one of the following conditions:

a) For an apparatus that requires verification or calibration prior to each use, the duration may be reduced to a minimum of 24 hours or to the manufacturer's claimed duration, whichever is greater

b) For an apparatus that provides a fault signal upon sensing element failure, the duration may be reduced to the manufacturer's claimed duration and the fault signal shall be verified

c) For an apparatus that requires sensor replacement less than 14 days, the duration may be reduced to the manufacturer's claimed duration.

NOTE 1 — A precise concentration is unnecessary. This test is provided only to test the apparatus after exposure to a low-background level of toxic gas.

5.19.1.4 Remove the test gas for 5 minutes and repeat 5.19.1.2.

5.19.1.5 Subject the detector head to clean air at ambient temperature and humidity for a period of 7 days.

5.19.1.6 Apply the test gas of a concentration used in 5.19.1 to the detector head. The indicated concentration shall not deviate from the reading observed at 5.19.1.2 by more than the tolerance specified in Annex A, Item 2. The reading shall be taken after stabilization.

5.19.1.7 Calibrate the apparatus as per 5.8.

5.19.1.8 Apply a test-gas concentration between 8 and 12 percent of the current NIOSH IDLH value for 8 hours. The indicated concentration shall not deviate from the actual applied concentration by more than the tolerance specified in Annex A, Item 2. The reading shall be taken after stabilization.

5.19.1.9 Calibrate the apparatus as per 5.8.

5.19.1.10 Repeat the accuracy test as per 5.9.

5.19.2 For alarm-only apparatus, calibrate the apparatus per 5.8 and then proceed. Subject the sample inlet to clean air at ambient temperature and humidity for a period of 21 days.

5.19.2.1 Subject the sample to the following:

a) All alarm setpoints shall be tested, with the lowest alarm setpoint of multiple alarm setpoint units tested first.

b) Alarms shall be activated by a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2.

c) Alarms shall NOT be activated by a test-gas concentration lower than the alarm setpoint minus the tolerance specified in Annex A, Item 2.

d) The time of exposure to each gas concentration shall neither be less than 5 minutes nor greater than 10 minutes.

5.19.2.2 Subject the detector head to a continuous toxic gas concentration equivalent to 10 percent of the TLV-TWA for a period of 14 days. For apparatus that are limited by operation at continuous low level gas concentration exposure, the time duration may be reduced under one of the following conditions:

a) For an apparatus that requires verification or calibration prior to each use, the duration may be reduced to a minimum of 1 day or to the manufacturer's claimed duration, whichever is greater

b) For an apparatus that provides a fault signal upon sensing element failure, the duration may be reduced to the manufacturer's claimed duration

c) For an apparatus that requires sensor replacement less than 14 days, the duration may be reduced to the manufacturer's claimed duration.

NOTE — A precise concentration is unnecessary. This test is provided only to test the apparatus after exposure to a low-background level of toxic gas.

5.19.2.3 Remove the test gas for 5 minutes and repeat the tests of 5.19.2.1.

5.19.2.4 Subject the sample inlet to clean air at ambient temperature and humidity for a period of 7 days.

5.19.2.5 Repeat the tests of 5.19.2.1.

5.19.2.6 Calibrate the apparatus per 5.8, and ensure that one alarm setpoint is set to 10% of the current NIOSH IDLH value of the applicable gas.

5.19.2.7

a) Apply a test-gas concentration lower than the alarm setpoint by the tolerance specified in Annex A, Item 2, for 8 hours. The alarms shall NOT be activated during this time.

b) Apply a test-gas concentration exceeding the alarm setpoint by the tolerance specified in Annex A, Item 2, for 8 hours. The alarms shall be activated and shall not be resettable during this time.

5.19.2.8 Calibrate the apparatus per 5.8.

5.19.2.9 Repeat the tests of 5.19.2.1.

5.20 Battery and low-battery voltage alarm

5.20.1 This section is applicable only to apparatus powered by integral batteries (excluding batteries used only for memory retention). This test is intended to verify that portable apparatus will operate for specified time periods without exchanging or recharging batteries.

5.20.2 Battery-powered portable continuous duty apparatus

5.20.2.1 With fresh batteries installed at the beginning of the test, the apparatus shall be operated in clean air for a total period of

a) 8 h, if fitted with a user-operable on/off switch, or apparatus employing replaceable batteries.

b) 10 h, if not so fitted, or

c) any longer time as specified by the manufacturer.

NOTE — For disposable apparatus, a method of depleting the battery is to be agreed upon between the Test Laboratory and the manufacturer.

5.20.2.2 At the end of the specified period, the apparatus is exposed to the standard test gas in accordance with the requirements of 5.9.

5.20.2.3 The apparatus shall then continue to operate until an indication that the low battery condition has been reached. The apparatus shall continue to operate for an additional 10 min.

5.20.3 Battery-powered portable spot-reading apparatus

The apparatus shall be exposed to the test requirements of 5.13 and then operated until an indication that the low-battery condition has been reached. The apparatus shall be operated for an additional 10 minutes and then exposed to the test requirements of 5.13.

5.21 Exposure to high-concentration gas

5.21.1 The detector head of apparatus shall be subjected to a step change in gas concentration from clean air to the "high concentration" specified in Annex A, Item 7. Sample-draw apparatus shall be subjected to this test using the shortest practical sample tubing and operated within the flow-rate range recommended by the manufacturer. The apparatus shall produce an alarm output within 10 seconds of exposure to the gas. Exposure and the alarm condition shall continue for 5 minutes.

5.21.1.1 Following removal of the test gas, the detector head shall be exposed to clean air.

5.21.1.2 Apparatus incorporating meters or output signals shall produce an output of less than 10% of the current NIOSH IDLH value within the recovery time of 10 minutes.

5.21.1.3 Alarm-only apparatus, with alarm setpoint(s) adjusted to 10% of the current NIOSH IDLH value, shall not indicate an alarm condition or shall be able to be reset within the recovery time of 10 minutes.

5.21.1.4 For all apparatus except alarm-only units, 60 to 75 minutes after the removal of the test gas and exposure to clean air, the apparatus will be exposed to a test-gas concentration of 50% ± 5% of full scale. The indicated concentration shall not deviate by more than the tolerance specified in Annex A, Item 2, from the most recent reading for that same gas observed before exposure to the "high concentration." The reading shall be taken after stabilization. The apparatus must meet the requirements of 5.9.1.

5.21.1.5 For alarm-only apparatus, 60 to 75 minutes after the removal of the test gas and exposure to clean air, the apparatus shall be tested in accordance with the requirements of 5.9.2.

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Annex A —Applicability & acceptance criteria (Normative)

Item	GAS DETECTED[2]	Hydrogen Sulfide H_2S	Hydrogen Chloride HCl	Chlorine Dioxide ClO_2	Sulfur Dioxide SO_2	Nitric Oxide NO	Nitrogen Dioxide NO_2	Hydrogen Cyanide HCN	Carbon Monoxide CO	Chlorine Cl_2	Ammonia NH_3	Carbon Dioxide CO_2
1	Test-gas tolerance[1]	±1 PPM or ±5% of conc.	±0.2 PPM or ±5% of conc.	±0.1 PPM or ±5% of conc.	±0.2 PPM or ±5% of conc.	±1 PPM or ±5% of conc.	±0.2 PPM or ±5% of conc.	±0.2 PPM or ±5% of conc.	±2 PPM or ±5% of conc.	±0.1 PPM or ±5% of conc.	±0.5 PPM or ±5% of conc.	±200 PPM or ±5% of conc.
2	Accuracy / repeatability[1]	±3 PPM or ±10% of reading	±0.8 PPM or ±15% of reading	±0.4 PPM or ±15% of reading	±0.8 PPM or ±15% of reading	±3 PPM or ±10% of reading	±0.8 PPM or ±15% of reading	±0.8 PPM or ±15% of reading	±6 PPM or ±10% of reading	±0.5 PPM or ±15% of reading	±5 PPM or ±15% of reading	±600 PPM or ±10% of reading
3	Time, Response to 20% of Final Value[3]	≤20 sec	≤25 sec	≤20 sec	≤10 sec	≤10 sec	≤20 sec	≤10 sec	≤20 sec	≤25 sec	≤30 sec	≤20 sec
4	Time, Response to 50% of Final Value[3]	≤45 sec	≤75 sec	≤60 sec	≤30 sec	≤30 sec	≤45 sec	≤30 sec	≤45 sec	≤60 sec	≤90 sec	≤45 sec
5	Time, Response to 90% of Final Value[3]	≤60 sec	≤150 sec	≤120 sec	≤60 sec	N/A	≤60 sec	≤60 sec	≤60 sec	≤120 sec	≤280 sec	≤60 sec
6	Time, Recovery to 10% of Final Value[3]	≤180 sec	≤230 sec	≤180 sec	≤90 sec	≤90 sec	≤90 sec	≤90 sec	≤180 sec	≤180 sec	≤240 sec	≤180 sec
7	High Concentration	2 times measuring range										

NOTE 1 — Where two values exist (e.g., "3 PPM or 10% of reading"), the value providing the widest tolerance should be used.

NOTE 2 — Reference the current edition of OSHA Title 29 Part 1910 Subpart Z.

NOTE 3 — Response Time and Recovery Time values are based upon current technology and the reactive nature of the gas.

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