

Performance Requirements for Combustible Open Path Gas Monitors

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Foreword

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TABLE OF CONTENTS

1. SCOPE	1
2. DEFINITIONS	1
3. GENERAL REQUIREMENTS	4
3.1 Review of Documentation	4
3.2 Markings	5
3.3 Manufacturer's Installation and Operation Manuals	5
3.4 Construction and Functions	8
3.5 Test Equipment Calibration	10
4. PERFORMANCE REQUIREMENTS	10
4.1 General	10
4.2 Samples and Sequence	11
4.3 Preparation of Apparatus	11
4.4 Conditions for Test and Test Area	11
4.5 Un-Powered Preconditioning Storage	15
4.6 Vibration	15
4.7 Calibration	15
4.8 Accuracy	16
4.9 Trouble Signals	16
4.10 Temperature	17
4.11 Time of Response	18
4.12 Solar Radiation	19
4.13 Power Supply Variations	19
4.14 Power Supply Interruptions and Transients	20
4.15 Recovery from Power Supply Interruption	20
4.16 Electromagnetic Interference (EMI)	21
4.17 Partial Obscuration	21
4.18 Simulated Fog/Mist (Intended for Outdoor Use)	21
4.19 Water Vapor Interference	21
4.20 Beam Blockage Fault	22
4.21 Long Range Operation	22
4.22 Environmental Ratings	22
4.23 Long Term Stability	23
5. OPERATIONS REQUIREMENTS	23
5.1 Demonstrated Quality Control Program	23
5.2 Facilities and Procedures Audit	24
5.3 Installation Inspections	24
5.4 Manufacturer's Responsibilities	24
APPENDIX A: Open Path Monitor Figures	25
APPENDIX B: Units of Measurement	26

1. SCOPE

- 1.1 This standard provides minimum requirements of open path gas monitoring apparatus.
- 1.2 This standard is concerned with the details of construction, performance and testing of open path (line-of-sight) gas monitors that sense the presence of combustible gas or vapor concentrations in air. Based on associated requirements, this standard considers the suitability of the apparatus, or parts thereof, for use in Class I, hazardous (classified) locations as defined by the National Electrical Code® (ANSI/NFPA 70).
- 1.3 For apparatus used for sensing the presence of multiple gases, non-flammable toxic gases, as well as a gas that is both toxic and combustible, this document applies only to the portion sensing the presence of flammable gas or vapor.
- 1.4 This standard addresses combustible gas monitors intended to provide a broad indication or alarm, the purpose of which is to give warning of possible presence of a potential flammable concentration of gas or vapor.
- 1.5 This standard does not address gas monitoring or monitoring apparatus of the laboratory or scientific type used for analysis or measurement, apparatus used for process control and process monitoring purposes, or apparatus used for residential purposes.
- 1.6 This standard is written for gas monitoring apparatus that are intended to monitor gases or vapors in ambient air by measuring the spectral absorption by the gases or vapors over an extended optical path. The units of measurement and range of the gas monitoring apparatus are a mathematical integral of the gas concentration along the optical path. The units of measurement are expressed as full concentration of the lower flammable limit (100%LFL or 1LFL) multiplied by the distance, in meters, at that concentration (e.g., LFL·meter, %LFL(Avg)).
- 1.7 The standard is limited to instrument applications where: calibration is performed using either the gas to be monitored or another gas for which response conversion data appears in the instruction manual.

NOTE: FOR CONVENIENCE, THE SHORTER TERM “GAS” MAY BE USED AS AN ABBREVIATION FOR “COMBUSTIBLE GAS OR VAPOR” WITHIN THIS DOCUMENT.

2. DEFINITIONS

For purposes of this standard, the following terms apply:

- 2.1 **Alarm:** An audible, visual or physical presentation designed to alert the apparatus user that a specific measurement level has been reached or exceeded.
 - 2.1.1 **Alarm Set Point:** a fixed or adjustable setting of the system that is intended to pre-set the value of integral concentration at which the apparatus will automatically initiate an indication, alarm, or other output function for the selected gas concentration level(s) at which an indication, alarm, or other output function is initiated.
 - 2.1.2 **alarm signal:** an audible, visual, electronic or other signal generated by the apparatus when an integral concentration of gas in excess of a preset value is detected.
 - 2.1.3 **latching alarm:** an alarm which, once activated, requires a deliberate action to deactivate it.

- 2.2 **Alarm only apparatus:** an apparatus having an alarm but not having a meter or other indicating device that would allow measurement of the deviations permitted by the requirements of this standard.
- 2.3 **Calibration:** the act of adjusting an apparatus to “zero” and setting the desired “span”.
- 2.4 **Calibration gas concentration:** the concentration of the combustible gas in ambient air used to set the apparatus span or alarm set point.
- 2.5 **Clean air:** air that is free of combustible gases, vapors or contaminating substances.
- 2.6 **Combustible gas:** any flammable gas or vapor that, in sufficient concentration by volume in air which can become the fuel for an explosion or fire hazard.
- 2.7 **Control unit:** that portion of a gas monitoring apparatus that is not directly responsive to the combustible gas, but which responds to the electrical signal obtained from one or more detector heads and produces an indication, alarm or other output function.
- 2.8 **Diffusion:** a method by which an atmosphere being monitored gains access to the gas sensing element by nature of molecular movement or natural convection.
- 2.9 **Explosion protection:** the measures applied in the construction of electrical apparatus to prevent ignition of a surrounding combustible atmosphere by the apparatus
- 2.10 **Fixed apparatus:** an apparatus which is intended to have all its parts permanently installed
- 2.11 **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.

- 2.12 **Full-scale gas concentration:** the gas concentration that equals maximum scale indication.
- 2.13 **Gas monitoring 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 combustible gas and responds by providing a meter indication, alarm function, and/or output functions.
- NOTE:** FOR CONVENIENCE, THE TERM “APPARATUS” IS USED AS AN ABBREVIATION FOR “GAS MONITORING APPARATUS” WITHIN THIS DOCUMENT.
- 2.14 **Gas-sensing element (Transmitter/receiver):** the primary element(s) in the gas monitoring system that responds to the presence of a combustible gas — including any reference or compensating unit, where applicable.

2.15 **Gaseous atmospheres**

- 2.15.1 **Ambient air:** normal atmosphere surrounding the apparatus.
- 2.15.2 **clean air:** air which is free from gases or vapors (combustible, toxic or environmentally harmful gases) to which the apparatus is sensitive or which influence the performance of the apparatus

- 2.15.3 **combustible atmosphere:** a mixture with air, under normal atmospheric conditions, of combustible materials in the form of gas, vapor or mist, in which, after ignition, combustion spreads throughout the unconsumed mixture
- NOTE 1:** This definition specifically excludes dusts and fibers in suspension in air. Mists, though included in the definition are not covered by this Standard
- NOTE 2:** Although a mixture which has a concentration above the upper flammable limit is not a combustible atmosphere, there is a risk of creating a combustible atmosphere by dilution.
- 2.15.4 **combustible gas:** a gas, which, when mixed with air in certain volumetric ratios, forms a combustible atmosphere
- 2.15.5 **integral concentration:** the mathematical integral of the gas concentration along the optical path. It is expressed in units of concentration multiplied by distance, e.g., LFL meter for combustible gases or ppm meter for toxic gases
- NOTE:** $100\% \text{LFL} \times 1 \text{ meter} = 1 \text{ LFL meter};$
 $10\% \text{LFL} \times 10 \text{ meter} = 1 \text{ LFL meter}.$
- 2.15.6 **lower flammable limit (LFL):** the volume ratio of combustible gas or vapor in air below which a combustible gas atmosphere will not be formed
- 2.15.7 **upper flammable limit (UFL):** the volume ratio of combustible gas or vapor in air above which a combustible gas atmosphere will not be formed
- 2.16 **lower flammable limit meters (LFL·m):** a unit of measurement for the amount of gas present in the beam. The LFL·m represents the size of a gas cloud multiplied by the gas concentration within the cloud. See figure 1.1 of Appendix A.
- 2.16.1 **lower flammable limit/meters or Path Average (%LFL(Avg)):** a unit of measurement for the amount of gas present in the beam over the length of the beam. The %LFL(Avg) represents the size of a gas cloud multiplied by the gas concentration within the cloud divided by the beam length multiplied by 100. See figure 1.2 of Appendix A.
- 2.17 **Measurement range:** the operable span region of the apparatus or a selected subdivision of that region.
- 2.18 **Optical apparatus**
- 2.18.1 **gas cell:** a sealed enclosure with transparent ends which can be filled with test gases
- 2.18.2 **open path:** an optical path which traverses the area (or part of the area) in which the atmosphere is being monitored and through which gases in the atmosphere are free to move.
- 2.18.3 **optical radiation:** the ultra-violet, visible or infra-red regions of the electromagnetic spectrum.
- 2.18.4 **receiver:** an assembly in which the optical detecting element(s) are housed and which may contain associated optical and electrical components.
- 2.18.5 **retroreflector:** an individual or multiple arrangement of reflecting corners of cubes arrayed so that light is reflected back parallel to its incident path.
- 2.18.6 **transceiver:** an assembly in which the optical detecting element(s) and optical transmitting element(s) are housed and which may contain associated optical and electrical components
- 2.19 **Transmitter:** an assembly in which the optical transmitting element(s) are housed and which may contain associated optical and electrical components
- 2.20 **Response conversion data:** information, supplied and explained in the apparatus instruction manual, enabling the apparatus 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.

2.21 Signals and indications

- 2.21.1 **fault signal:** an audible, visual, or other type of output which provides, directly or indirectly, a warning or indication that the apparatus has been compromised
- 2.21.2 **beam blocked signal:** an audible, visual or other type of output which provides, directly or indirectly, a warning or indication that the optical path is obscured or that the signal detected is too weak to enable the apparatus to function normally
- 2.21.3 **inhibition signal:** an audible, visual, or other type of output which provides, directly or indirectly, a warning or indication that normal operation has been suspended
- 2.21.4 **indicating devices:** means for displaying values or states in analog or digital form
- 2.21.5 **special state:** all states of the apparatus other than those in which monitoring of gas concentration take place, for example warm-up, calibration mode or fault condition

2.22 **Span:** the algebraic difference between the upper and lower values of a range.

2.23 **Stand-alone control unit:** control unit that is utilized with unspecified stand-alone detector head(s).

2.24 **Stand-alone monitor:** a combination transmitter and receiver either integral or remote that is (are) utilized with an unspecified control apparatus. Such apparatus is intended to be interfaced to a 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 of the aforementioned type that typically process information from various locations and sources including, but not limited to, gas monitoring apparatus.

2.25 **Stationary apparatus:** a gas monitoring apparatus intended for permanent installation in a fixed location.

2.26 **Transportable apparatus:** apparatus which is not intended to be portable, but which can be moved from one place to another and used after alignment.

2.27 **Zero:** the lower calibration value, normally clean air.

3. GENERAL REQUIREMENTS

3.1 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. The certification investigation shall define the limits of the certification.

If any of the manufacturer's published claims exceed any of the test condition extremes described in Section 4, the tests shall be conducted under the conditions for which the claims apply.

All claims not tested and verified by the certification agency as part of the certification 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 certification.

3.2 Markings

3.2.1 Marking on the product or, if not possible due to size, on its packaging or label accompanying the product, shall include the following information:

- Manufacturer's name or trademark and address
- Specific model designation and serial number
- Apparatus's ratings (voltage, frequency, current or power, etc.)
- Apparatus's operating ambient temperature range

3.2.2 The model or type identification shall correspond to the manufacturer's catalog designation and shall uniquely identify the product as Listed or labeled.

3.2.3 The Certification Mark shall be displayed visibly on the product and/or packaging as appropriate. The manufacturer shall not use this mark on any other product unless such product is covered by separate agreement with the certification agency.

3.2.4 All markings shall be legible and durable.

3.2.5 The marking required in 3.2.6 shall appear in a clearly legible, visible, and permanent manner on each gas monitoring apparatus in the following manner, as applicable:

a) For stationary apparatus, the marking required in 3.2.6 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).

NOTE 1: 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.

NOTE 2: Where the design of a stationary control unit is such that there is insufficient space for this marking to appear on the portion of the unit that is visible after installation (e.g., compact designs for close panel mounting), the marking required by 3.2.6 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.

3.2.6 All open path gas monitoring apparatus shall be marked:

“CAUTION — READ AND UNDERSTAND INSTRUCTION MANUAL BEFORE OPERATING OR SERVICING.”

The word “CAUTION” of the foregoing shall be in capital letters at least 3.0 mm high. The balance of the wording shall be in capital letters at least 2.5 mm high.

3.2.7 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 section must be met.

3.3 Manufacturer's Installation and Operation Manuals

3.3.1 Each gas monitoring apparatus shall be provided with an instruction manual, furnished by the manufacturer. The instruction manual shall contain clear and precise instructions for safe and proper operation, installation and periodic servicing of the apparatus. The requirements of Sections 3.3.1 and 3.3.3 shall be included as applicable. Where the design or special nature of the apparatus requires additional instructions that are in contradiction of, or in addition to, the requirements of Sections 3.3.1 and 3.3.3, this consideration may take precedence over these requirements. Instructions shall be consistent with the markings required in Section 3.2.

3.3.2 The following requirements shall be incorporated in the manufacturer's instruction and operation manuals: Each apparatus shall be provided with an instruction manual that includes the following information:

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

3.3.2.2 operating instructions and adjustment procedures;

3.3.2.3 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.

3.3.2.4 details of operational limitations, including, where applicable, the following:

- 1) Gases for which the apparatus is suitable and the relative sensitivities of the instrument 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
- 10) Warm-up time
- 11) Stabilization time

3.3.2.5 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

3.3.2.6 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;

3.3.2.7 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;

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

3.3.2.9 a statement that alarm devices, outputs, or contacts are of the non-latching types, where applicable.

3.3.2.10 for battery-operated apparatus, installation, and maintenance instructions for the batteries;

3.3.2.11 a recommended replacement parts list;

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