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Standard Guide for Testing Systems for Measuring Dynamic Responses of Carbon Monoxide Detectors to Gases and Vapors[1]

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1. Scope

1.1 This guide describes testing systems used for measuring responses of carbon monoxide (CO) alarms or detectors subjected to gases, vapors, and their mixtures.

1.2 The systems are used to evaluate responses of CO detectors to various CO concentrations, to verify that the detectors alarm at certain specified CO concentrations, and to verify that CO detectors do not alarm at certain other specified CO concentrations.

1.3 The systems are used for evaluating CO detector responses to gases and vapors that may interfere with the ability of detectors to respond to CO.

1.4 Major components of such a testing system include a chamber, clean air supply module, humidification module, gas and vapor delivery module, and verification and control instrumentation.

1.5 For each component, this guide provides a comparison of different approaches and discusses their advantages and disadvantages.

1.6 The guide also presents recommendations for a minimum configuration of a testing system.

1.7 *This guide does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For more specific safety precautionary information, see 6.2.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1193 Specification For Reagent Water[2]

D 1356 Terminology Relating to Sampling and Analysis of Atmospheres[3]

D 1945 Test Method for Analysis of Natural Gas by Gas Chromatography[4]

D 3162 Test Method for Carbon Monoxide in the Atmosphere (Continuous Measurement by Nondispersive Infrared Spectrometry)[3]

D 3195 Practice for Rotameter Calibration[3]

D 3249 Practice for General Ambient Air Analyzer Procedures[3]

D 3687 Practice for Analysis of Organic Compound Vapors Collected by the Activated Charcoal Tube Adsorption Method[3]

2.2 *Other Standards:*

BS 7860 Specification for Carbon Monoxide Detectors (Electrical) For Domestic Use[5]

UL 2034 Single and Multiple Station Carbon Monoxide Detectors[6]

CFR 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories[7]

3. Terminology

3.1 *Definitions*:

For definitions of terms used in this guide, refer to Terminology D 1356.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air change rate*—the volume of clean, humidified air plus contaminants that enters the chamber in 1 h, divided by the internal volume of the chamber, expressed as air changes per hour (h^{-1}).

3.2.2 *chamber*—an enclosed test volume composed of chemically inert materials supplied with a mixture of air, gases, or vapors, or combination thereof, having known compositions.

3.2.3 *CO alarm/detector*—an alarm device consisting of an assembly of electrical and mechanical components with chemical, electrochemical, solid-state electronic, or other types of sensors to detect the presence of CO gas in specified ranges of concentrations.

3.2.4 *sensor*—the component included in the CO alarm/detector that senses CO gas.

[1] This guide is under the jurisdiction of ASTM Committee D-22 on Sampling and Analysis of Atmospheres and is the direct responsibility of Subcommittee D22.05 on Indoor Air.

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[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] *Annual Book of ASTM Standards*, Vol 11.03.

[4] *Annual Book of ASTM Standards*, Vol 05.05.

[5] Available from British Standards Institute, 2 Park St., London, England W1A2B5.

[6] Available from Underwriter Laboratories, Inc., Northbrook, IL.

[7] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20036.

4. Summary of Guide

4.1 This guide describes components of systems for testing CO detectors with mixtures of air and CO at different concentrations of CO. The systems are also used for evaluating the responses of CO detectors to mixtures of air and various gases or vapors, or both. Such systems require clean air with a preselected level of relative humidity supplied to an environmental chamber. Gases and vapors are introduced in the clean air supply or placed directly in the chamber to achieve desired chamber concentration. The components of such systems include devices or modules for supplying pure air, humidifying air, supplying gases or vapors, or both, to be tested, reference instruments for verifying concentrations of gases and vapors, and a chamber for placing and exposing CO detectors. The guide describes various options for each component: chamber (Section 6), clean air supply module (Section 7), humidification module (Section 8), gas/vapor delivery module (Section 9), and verification and control module (Section 10). The guide further provides recommendations on a minimum configuration for the testing system (Section 11) and reporting results (Section 12).

5. Significance and Use

5.1 This guide provides information on testing systems and their components used for measuring responses of CO alarms or detectors subjected to gases, vapors, and their mixtures. Components of a testing system include a chamber, clean air supply module, humidification module, gas and vapor delivery module, and verification and control instrumentation.

5.2 The CO detector is tested by sequential exposure to CO and interference gases at the specified challenge concentrations. A properly functioning alarm/detector will sound upon sufficient exposure to CO but will not sound upon any exposure to interference gases consistent with applicable standards (for example, IAS 6-96 (**1**)[8], BS 7860, UL 2034).

6. Chamber

6.1 *Types of Chamber*— There are two types of chambers—static and dynamic. In a static chamber, air and known quantities of gases are introduced and then the chamber is sealed. In a dynamic chamber, a characterized air-gas mixture is continually introduced at a rate sufficient to maintain target concentrations.

6.2 *Hazards*—In a dynamic chamber, the air exiting chamber will contain CO and interference gases or vapors that may be toxic. To avoid undue exposures of toxic gases and vapors to occupants of the laboratory (where the chamber is located), the chamber should be properly vented to outside with an appropriate stack. For a static chamber, exposures to test gases should be avoided in operating (for example, opening) the chamber.

6.3 *Size of the Chamber*—The chamber size can be large (that is, room-size) or small and depends on the number of detectors to be tested. Detectors should be placed on a wire rack or similar supporting structure. Detectors should be placed at least 0.1-m (4-in.) away from the chamber walls. If multiple detectors are undergoing simultaneous testing, they should be spaced at least 0.05 m (2 in.) from each other. The chamber size required by UL 2034 is a $0.9 \times 0.9 \times 0.9$-m ($3 \times 3 \times 3$-ft) box, which has been found to be practical for testing several detectors at a time.

6.4 *Material of Construction*—The chamber should be made of relatively inert materials, such as glass, stainless steel, or certain types of polymers/plastics. Materials, such as wood or gypsum board, may not be appropriate because of their absorption, adsorption, and leakage characteristics. Joints should be well-sealed using inert caulking/sealing materials. Gaskets should be used around doors and other closable openings to achieve a good seal when closed.

6.5 *Air Change Rate*— The air change rate of a dynamic chamber should be sufficient (for example, 1 h^{-1} or higher) to overcome loss of chamber air through leakage and the depletion of test gases and vapors due to factors, such as consumption through a chemical reaction or deposition.

6.6 *Mixing*—To provide a uniform concentration for testing, the chamber air should be well mixed. With an adequate air change rate (for example, 1 h^{-1} or higher), mixing can be achieved through proper placement and design of inlet and outlet ports. The design and placement should be such that any short-circuiting of flow from inlet to outlet ports is avoided. A better alternative to promote mixing is to use a fan that is appropriately sized for the chamber volume. For example, mixing within a large chamber having 23-m^3 (800-ft^3) volume can be achieved by an 378 $l\text{-}s^{-1}$ (800-cfm) fan. Ideally, the fan should be mounted on a shaft through the chamber wall, and the fan motor should be external to the chamber to prevent contamination and heat load in the chamber. If a fan is used, the sensor ports should be shielded from direct air impingement. In addition to providing a uniform air concentration, the combination of air change rate and mixing should be such that it provides sufficient face velocity (for example, over 1 m s^{-1} or 3.3 ft s^{-1}) at sensor head(s) through the detector housing.

6.7 The chamber should be able to provide accurate control of temperature and relative humidity at ambient pressure as indicated in Table 1. The chamber should be airtight to minimize any leakage of ambient air into or chamber air out of the system. The range of environmental conditions cited in Table 1 cover ranges specified in standards listed in 2.2 and in the literature (**1**). Also, UL 2034 prescribes certain time period(s) to achieve target concentrations that should be adhered to so that undue exposures are avoided.

6.8 *Discussion*—The advantage of the static chamber is that the setup is simple, basically requiring only a sealable box. The major disadvantage of the static chamber is that the gases may be consumed or generated in the chamber, resulting in an environment that is different than originally specified. For this reason, the composition of the atmosphere should be monitored

TABLE 1 General Specifications for Test Chamber

Specification	Control Range	Control Precision
Temperature	–10 to 52°C (14 to 126°F)	± 0.5°C (± 0.9°F)
Relative humidity	15 % to 95 % (noncondensing)	± 5.0 %

[8] The boldface numbers in parentheses refer to references at the end of this standard.