



Designation: D4490 – 23

Standard Practice for the Use of Detector Tubes in the Measurement of Toxic Gases and Vapors¹

This standard is issued under the fixed designation D4490; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the detection and measurement of concentrations of toxic gases or vapors using detector tubes (**1, 2**).² A list of some of the gases and vapors that can be detected by this practice and their measurement ranges are provided in **Annex A1**. This list is given as a guide and should be considered neither absolute nor complete.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:³

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D5337 Practice for Flow Rate Adjustment of Personal Sampling Pumps

¹ This practice is under the jurisdiction of ASTM Committee **D22** on Air Quality and is the direct responsibility of Subcommittee **D22.04** on Workplace Air Quality.

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² The boldface numbers in parentheses refer to the list of references at the end of this practice.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 Other Documents:

29 CFR 1910 Federal Occupational Safety and Health Standard Title 29⁴

ISO 13137 Workplace Atmospheres – Pumps for Personal Sampling of Chemical and Biological Agents – Requirements and Test Methods⁵

3. Terminology

3.1 For definitions of terms used in this method, refer to Terminology **D1356**.

4. Summary of Practice (3)

4.1 Detector tubes may be used for either short-term sampling (grab sampling; 1 min to 10 min typically) or long term sampling (actively or passively; 1 h to 8 h) of atmospheres containing toxic gases or vapors.

4.1.1 *Short-Term Sampling (Grab Sampling) (4-18)*—A given volume of air (specified by the manufacturer) is pulled through the tube by a pump also specified by the manufacturer in a time period on the order of 1 min to 10 min. The length-of-stain is related to the amount of air sampled and the contaminant concentration during the sample period. For most detector tubes the concentration is determined by interpreting the length of color change compared to the calibration curve affixed to the glass tube. There are some detector tubes which rely on the interpretation of the intensity of a color change compared to a color standard or standards provided by the manufacturers. The resultant color reaction may change over time and must be evaluated immediately by the user.

4.1.2 *Long-Term Active Sampling (Long-Term Tubes) (19-22)*—A sample is pulled through the detector tube at a slow, constant flow rate specified by the manufacturer by a pump over a 1 h to 8 h period. The length of color change and the sampling time are used to determine the time weighted average (TWA) concentration of the contaminant.

⁴ *Code of Federal Regulations*, Part 1910.1000 Subpart 2 and Part 1926.55 Subpart D.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

4.1.3 *Length-of-Stain Dosimeter Tubes (23)*—The contaminant molecules move into the tube according to Fick's First Law of Diffusion. The driving force is the concentration differential between the ambient air and the inside of the tube. The time-weighted average concentration of the gas or vapor is determined by dividing the indication on the tube by the number of hours sampled (typically 1 h to 10 h according to the manufacturer's instructions).

5. Significance and Use

5.1 The Federal Occupational Safety and Health Administration, in 29 CFR 1910, designates that certain gases and vapors must not be present in workplace atmospheres at concentrations above specific values.

5.2 This practice will provide a means for the determination of airborne concentrations of certain gases and vapors given in 29 CFR 1910.

5.3 A partial list of chemicals for which this practice is applicable is presented in [Annex A1](#).

5.4 This practice also provides for the sampling of gaseous atmospheres to be used for process control or other purposes ([2, 24-23](#)).

5.5 *Advantages of the Detector Tube Method:*

5.5.1 As the detector tube method requires no chemical analyzers, external reagents, etc., advance preparations are not needed; detector tubes are always ready for use.

5.5.2 The detector tube method is well-suited for use at the work site because it is small, lightweight, and needs only a small sample volume to determine the concentration of gas or vapor in a sample.

5.5.3 The operating procedures are simple.

5.5.4 The results of measurements are available in just minutes, so fast action can be taken when needed.

5.5.5 Where no electrical power source is required, detector tubes can be used even when flammable gases are present.

5.5.6 Different types of detector tubes are available for different gases and measuring ranges, from 0.01 ppm to more than 10 %, depending on analyte and tube design, making the system flexible for different sampling situations.

6. Apparatus and Operation ([26-29](#))

6.1 *General*—Short-term detector tubes are used for grab-sampling, capturing a concentration in a defined moment in time. They allow for the determination of contaminant concentrations, typically in the period of 1 min to 10 min with most measurements under 5 min.

6.2 *Apparatus:*

6.2.1 The detector tube method is a two-component system comprised of the detector tubes and pump(s) calibrated as a unit by the manufacturers. Detector tubes made by one manufacturer must not be used with pumps made by a different manufacturer due to the flow characteristics and physical relationship of the detector tubes and pumps.

6.2.2 In some sampling situations, particularly when testing for hazardous contaminant concentrations in confined spaces, a remote sampling line and adapter can be used. This allows placement of the detector tube in the potentially hazardous area

to be tested while the operator is in a safer area (for example, sampling from a confined space prior to entry).

6.3 *Detector Tube*—A detector tube consists of a glass tube containing an inert granular material that has been impregnated with a chemical system which reacts with the gas or vapor of interest. As a result of this reaction, the impregnated chemical changes color. The granular material is held in place within the glass tube by porous plugs of a suitable inert material. The ends of the glass tube are flame-sealed to protect the contents during storage.

6.4 *Pumped Systems (30):*

6.4.1 *Short-Term Sampling*—A mechanical, hand-operated, aspirating pump is used to draw the sample through the detector tube during the short-term sampling. Two types of pumps are commercially available: piston-operated and bellows-operated. The pumps have a capacity of 100 mL for a full pump stroke, and offer an option for collection of 50 mL. By varying the number of pump strokes, the sample volume is controlled. The pumps contain a flow-finish indicator that alerts the user to sampling completion. Sampling pumps shall be maintained and the sampling volume checked periodically according to the manufacturer's instructions. The pumps shall be accurate to $\pm 5\%$ of the volume stated.

6.4.2 *Long-Term Sampling*—Small electrical pumps having stable low flow rates (2 mL/min to 50 mL/min), are required for long-term sampling. Flow rates to be used with each detector tube are given by the manufacturers. As with the mechanical pumps, the electrical pumps shall be maintained and the flow checked regularly. Maintenance and flow determination are performed using the instructions supplied by the manufacturer of the pump. The pump flow rate, and, therefore, the sampled volume, shall be accurate to $\pm 5\%$ of the stated flow rate. With this system either area or personal monitoring can be accomplished.

6.5 *Diffusive Systems*—Unlike pumped systems, neither a mechanical nor electric pump is required. Measurement is initiated as soon as the sampling end is broken, and is completed when re-sealed. Tubes are typically calibrated in terms of ppm.hours, where the reading is divided by the number of hours to provide the time-weighted average concentration in ppm. Because the diffusion coefficient (a component of Fick's Law) is affected by both pressure and temperature, corrections for these are required for accurate results.

6.6 *Accessories*—Several accessories are provided with detector tubes for special applications:

6.6.1 *Reactor Tubes*—These are tubes that are used in conjunction with detector tubes. Some gases and vapors, because of their low reactivity, are not easily detected by detector tubes alone. The reactor tubes consist of very powerful chemical reactants, which break down the unreactive compound into other more readily detectable substances, which standard detector tubes can detect. Thus, the reactor tube is placed upstream of the detector tube and the combination must be used for certain compounds as a detector tube system.