



Designation: D5116 – 17

Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products¹

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1. Scope

1.1 This guide provides direction on the measurement of the emissions of volatile organic compounds (VOCs) from indoor materials and products using small-scale environmental test chambers.

1.2 This guide pertains to chambers that fully enclose a material specimen to be tested and does not address other emission chamber designs such as emission cells (see instead Practice [D7143](#)).

1.3 As an ASTM standard, this guide describes options, but does not recommend specific courses of action. This guide is not a standard test method and must not be construed as such.

1.4 The use of small environmental test chambers to characterize the emissions of VOCs from indoor materials and products is still evolving. Modifications and variations in equipment, testing procedures, and data analysis are made as the work in the area progresses. For several indoor materials, more detailed ASTM standards for emissions testing have now been developed. Where more detailed ASTM standard practices or methods exist, they supersede this guide and should be used in its place. Until the interested parties agree upon standard testing protocols, differences in approach will occur. This guide will continue to provide assistance by describing equipment and techniques suitable for determining organic emissions from indoor materials. Specific examples are provided to illustrate existing approaches; these examples are not intended to inhibit alternative approaches or techniques that will produce equivalent or superior results.

1.5 Small chambers have obvious limitations. Normally, only samples of larger materials (for example, carpet) are tested. Small chambers are not applicable for testing complete assemblages (for example, furniture). Small chambers are also inappropriate for testing combustion devices (for example, kerosene heaters) or activities (for example, use of aerosol spray products). For some products, small chamber testing may

provide only a portion of the emission profile of interest. For example, the rate of emissions from the application of high solvent materials (for example, paints and waxes) by means of brushing, spraying, rolling, etc. are generally higher than the rate during the drying process. Small chamber testing cannot be used to evaluate the application phase of the coating process. Large (or full-scale) chambers may be more appropriate for many of these applications. For guidance on full-scale chamber testing of emissions from indoor materials refer to Practice [D6670](#).

1.6 This guide does not provide specific directions for the selection of sampling media or for the analysis of VOCs. This information is provided in Practice [D6196](#).

1.7 This guide does not provide specific directions for determining emissions of formaldehyde from composite wood products, since chamber testing methods for such emissions are well developed and widely used. For more information refer to Test Methods [E1333](#) and [D6007](#). It is possible, however, that the guide can be used to support alternative testing methods.

1.8 This guide is not applicable to the determination of emissions of semi-volatile organic compounds (SVOCs) from materials/products largely due to adsorption of these compounds on materials commonly used for construction of chambers suitable for VOC emissions testing. Alternate procedures are required for SVOCs. For example, it may be possible to screen materials for emissions of SVOCs using micro-scale chambers operated at temperatures above normal indoor conditions (see Practice [D7706](#)).

1.9 This guide is applicable to the determination of emissions from products and materials that may be used indoors. The effects of the emissions (for example, toxicity) are not addressed and are beyond the scope of the guide. Guide [D6485](#) provides an example of the assessment of acute and irritant effects of VOC emissions for a given material. Specification of “target” organic species of concern is similarly beyond the scope of this guide. As guideline levels for specific indoor contaminants develop, so too will emission test protocols to provide relevant information. Emissions databases and material labeling schemes will also be expected to adjust to reflect the current state of knowledge.

¹ This guide is under the jurisdiction of ASTM Committee [D22](#) on Air Quality and is the direct responsibility of Subcommittee [D22.05](#) on Indoor Air.

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1.10 Specifics related to the acquisition, handling, conditioning, preparation, and testing of individual test specimens may vary depending on particular study objectives. Guidelines for these aspects of emissions testing are provided here, specific direction is not mandated. The purpose of this guide is to increase the awareness of the user to available techniques for evaluating organic emissions from indoor materials/products by means of small chamber testing, to identify the essential aspects of emissions testing that must be controlled and documented, and therefore to provide information, which may lead to further evaluation and standardization.

1.11 Within the context of the limitations discussed in this section, the purpose of this guide is to describe the methods and procedures for determining organic emission rates from indoor materials/products using small environmental test chambers. The techniques described are useful for both routine product testing by manufacturers and testing laboratories and for more rigorous evaluation by indoor air quality (IAQ) researchers. **Appendix X1** provides references to standards that are widely employed to measure emissions of VOCs from materials and products used in the interiors of buildings. Some of these standards directly reference this guide.

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

1.13 *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.*

1.14 *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:²

- D1193** Specification for Reagent Water
- D1356** Terminology Relating to Sampling and Analysis of Atmospheres
- D1914** Practice for Conversion Units and Factors Relating to Sampling and Analysis of Atmospheres
- D3195** Practice for Rotameter Calibration
- D3609** Practice for Calibration Techniques Using Permeation Tubes
- D3686** Practice for Sampling Atmospheres to Collect Organic Compound Vapors (Activated Charcoal Tube Adsorption Method)
- D3687** Practice for Analysis of Organic Compound Vapors

² 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.

Collected by the Activated Charcoal Tube Adsorption Method

- D6007** Test Method for Determining Formaldehyde Concentrations in Air from Wood Products Using a Small-Scale Chamber
- D6177** Practice for Determining Emission Profiles of Volatile Organic Chemicals Emitted from Bedding Sets
- D6196** Practice for Choosing Sorbents, Sampling Parameters and Thermal Desorption Analytical Conditions for Monitoring Volatile Organic Chemicals in Air
- D6330** Practice for Determination of Volatile Organic Compounds (Excluding Formaldehyde) Emissions from Wood-Based Panels Using Small Environmental Chambers Under Defined Test Conditions
- D6485** Guide for Risk Characterization of Acute and Irritant Effects of Short-Term Exposure to Volatile Organic Chemicals Emitted from Bedding Sets
- D6670** Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products
- D6803** Practice for Testing and Sampling of Volatile Organic Compounds (Including Carbonyl Compounds) Emitted from Paint Using Small Environmental Chambers
- D7143** Practice for Emission Cells for the Determination of Volatile Organic Emissions from Indoor Materials/Products
- D7339** Test Method for Determination of Volatile Organic Compounds Emitted from Carpet using a Specific Sorbent Tube and Thermal Desorption / Gas Chromatography
- D7706** Practice for Rapid Screening of VOC Emissions from Products Using Micro-Scale Chambers
- D7911** Guide for Using Reference Material to Characterize Measurement Bias Associated with Volatile Organic Compound Emission Chamber Test
- E355** Practice for Gas Chromatography Terms and Relationships
- E1333** Test Method for Determining Formaldehyde Concentrations in Air and Emission Rates from Wood Products Using a Large Chamber

3. Terminology

3.1 *Definitions*—For definitions and terms used in this guide, refer to Terminology **D1356**. For an explanation of units, symbols, and conversion factors, refer to Practice **D1914**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air change rate, n*—the flow rate of clean, conditioned air into the chamber divided by the net chamber volume; usually expressed in units of 1/h.

3.2.2 *chamber loading ratio, n*—the total amount of test specimen exposed in the chamber divided by the net or corrected internal air volume of the chamber.

3.2.2.1 *Discussion*—Net internal air volume of the chamber is calculated as the internal volume of the chamber enclosure minus the volume internally displaced by test specimen, holder, inlet/exhaust manifolds, etc. The chamber loading ratio is typically expressed as the ratio of the exposed specimen surface area, *A*, to net chamber volume (1/m) but depending on the nature of the test specimen, can also be expressed as 1/m³,

m/m^3 , and unitless for unit, line, and volume emission sources, respectively. Chamber loading also can be expressed in terms of area-specific airflow rate calculated as the ratio of the chamber's volumetric inlet airflow rate, Q , divided by the specimen surface area, A , that is Q/A (m/h).

3.2.3 test chamber, n —an enclosed test volume constructed of chemically inert materials with a clean air supply and exhaust.

3.2.3.1 Discussion—These chambers are designed to permit testing of emissions from samples of building materials and consumer products. The internal volume of small-scale chambers usually ranges from a few litres to a few cubic metres. Micro-scale chambers are typically less than one litre in volume and further differ from small-scale chambers in that the entire airflow rate at the chamber exhaust is sampled (see Practice D7706).

4. Significance and Use

4.1 Objectives—The use of small chambers to evaluate VOC emissions from indoor materials has several objectives:

4.1.1 Develop techniques for screening of products for VOC emissions;

4.1.2 Determine the effect of environmental variables (that is, temperature, humidity, air speed, and air change rate) on emission rates;

4.1.3 Rank various products and product types with respect to their emissions profiles (for example, emission factors, specific organic compounds emitted);

4.1.4 Provide compound-specific data on various organic sources to guide field studies and assist in evaluating indoor air quality in buildings;

4.1.5 Provide emissions data for the development and verification of models used to predict indoor concentrations of organic compounds; and

4.1.6 Develop data useful to stakeholders and other interested parties for assessing product emissions and developing control options or improved products.

4.2 Mass Transfer Considerations—Small chamber evaluation of emissions from indoor materials requires consideration of the relevant mass transfer processes. Three fundamental processes control the rate of emissions of organic vapors from indoor materials; evaporative mass transfer from the surface of the material to the overlying air, desorption of adsorbed compounds, and diffusion within the material.

4.2.1 The evaporative mass transfer of a given VOC from the surface of the material to the overlying air can be expressed as:

$$ER = A k_m (VP_s - VP_a) MW / RT \quad (1)$$

where:

ER = emission rate, mg/h ,

A = source area, m^2 ,

k_m = mass transfer coefficient, m/h ,

VP_s = vapor pressure at the surface of the material, Pa ,

VP_a = vapor pressure in the air above the surface, Pa ,

MW = molecular weight, mg/mol ,

R = gas constant, $8,314 \text{ J}/\text{mol}\cdot\text{K}$ or $\text{Pa m}^3/\text{mol}\cdot\text{K}$, and

T = temperature, K .

Thus, the emission rate is proportional to the difference in vapor pressure between the surface and the overlying air. Since the vapor pressure is directly related to the concentration, the emission rate is proportional to the difference in concentration between the surface and the overlying air. The mass transfer coefficient is a function of the diffusion coefficient (in air) for the specific compound of interest and the level of turbulence in the bulk flow.

4.2.2 The desorption rate of compounds adsorbed on materials can be determined by the retention time (or average residence time) of an adsorbed molecule:

$$\tau = \tau_o e^{-Q/RT} \quad (2)$$

where:

τ = retention time, s ,

τ_o = constant with a typical value from 10^{-12} to 10^{-15} s , and

Q = molar enthalpy change for adsorption (or adsorption energy), J/mol .

The larger the retention time, the slower the rate of desorption.

4.2.3 The diffusion mass transfer within the material is a function of the diffusion coefficient (or diffusivity) of the specific compound. The diffusion coefficient of a given compound within a given material is a function of the compound's physical and chemical properties (for example, molecular weight, size, and polarity), temperature, and the structure of the material within which the diffusion is occurring. The diffusivity of an individual compound in a mixture is also affected by the composition of the mixture.

4.2.4 Variables Affecting Mass Transfer—While a detailed discussion of mass transfer theory is beyond the scope of this guide, it is necessary to examine the critical variables affecting mass transfer within the context of small chamber testing:

4.2.4.1 Temperature affects the vapor pressure, desorption rate, and the diffusion coefficients of the organic compounds. Thus, temperature impacts both the mass transfer from the surface (whether by evaporation or desorption) and the diffusion mass transfer within the material. Increases in temperature cause increases in the emissions due to all three mass transfer processes.

4.2.4.2 The air change rate indicates the amount of dilution and flushing that occurs in indoor environments. The higher the air change rate the greater the dilution, and assuming the outdoor air is cleaner, the lower the indoor concentration. If the concentration at the surface is unchanged, a lower concentration in the air increases the evaporative mass transfer by increasing the difference in concentration between the surface and the overlying air.

4.2.4.3 Air Speed—Surface air speed is a critical parameter for evaporative-controlled sources as the mass transfer coefficient (k_m) is affected by the air speed and turbulence at the air-side of the boundary layer. Generally, the higher the air speed and turbulence, the greater the mass transfer coefficient. In a practical sense for most VOCs, above a certain air speed and turbulence, the resistance to mass transfer through the boundary layer is minimized (that is, the mass transfer coefficient reaches its maximum value). In chamber testing, some investigators prefer to use air speeds high enough to minimize