



Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products¹

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1. Scope

1.1 This practice is intended for determining volatile organic compound (VOC) emissions from materials and products (building materials, material systems, furniture, consumer products, etc.) and equipment (printers, photocopiers, air cleaners, etc.) under environmental and product usage conditions that are typical of those found in office and residential buildings.

1.2 This practice is for identifying VOCs emitted and determining their emission rates over a period of time.

1.3 This practice describes the design, construction, performance evaluation, and use of full-scale chambers for VOC emission testing.

1.4 While this practice is limited to the measurement of VOC emissions, many of the general principles and procedures (such as methods for evaluating the general performance of the chamber system) may also be useful for the determination of other chemical emissions (for example, ozone, nitrogen dioxide). Determination of aerosol and particle emissions is beyond the scope of this document.

1.5 Values stated in the International System of Units (SI) are to be regarded as the standard.

1.6 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

[D1356 Terminology Relating to Sampling and Analysis of Atmospheres](#)

¹ This practice 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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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.

[D1914 Practice for Conversion Units and Factors Relating to Sampling and Analysis of Atmospheres](#)

[D3686 Practice for Sampling Atmospheres to Collect Organic Compound Vapors \(Activated Charcoal Tube Adsorption Method\)](#)

[D5116 Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products](#)

[D5197 Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air \(Active Sampler Methodology\)](#)

[D5466 Test Method for Determination of Volatile Organic Chemicals in Atmospheres \(Canister Sampling Methodology\)](#)

[D6196 Practice for Selection of Sorbents, Sampling, and Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air](#)

[D6345 Guide for Selection of Methods for Active, Integrative Sampling of Volatile Organic Compounds in Air](#)

[D7706 Practice for Rapid Screening of VOC Emissions from Products Using Micro-Scale Chambers](#)

[E741 Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution](#)

[E779 Test Method for Determining Air Leakage Rate by Fan Pressurization](#)

[E1333 Test Method for Determining Formaldehyde Concentrations in Air and Emission Rates from Wood Products Using a Large Chamber](#)

[IEEE/ASTM SI-10 Standard for Use of the International System of Units \(SI\): The Modern Metric System](#)

2.2 Other Documents:

[ACGIH 2012](#) (American Conference of Governmental Industrial Hygienists), Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH

[ASHRAE 2010a, ASHRAE 62.1-2010](#) "Ventilation for Acceptable Indoor Air Quality," American Society of Heating, Refrigerating, and Air-Conditioning Engineers. Atlanta, GA.

[ASHRAE 2010b, ASHRAE 62.2-2010](#) "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential

Buildings,” American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA.

CMEIAQ 1999a “A Method for Sampling and Analysis of Volatile Organic Compounds in Emission Testing of Building Materials.” Final Report 1.1 Consortium for Material Emissions and Indoor Air Quality, Institute for Research in Construction, National Research Council Canada, Ottawa, Canada

CMEIAQ 1999b “Models for Predicting Volatile Organic Compound (VOC) Emissions from Building Materials.” Final Report 3.1 Consortium for Material Emissions and Indoor Air Quality, Institute for Research in Construction, National Research Council Canada, Ottawa, Canada

ECA-IAQ (European Collaborative Action) “Indoor Air Quality and Its Impact on Man,” 1997. Total volatile organic compounds (TVOCs) in indoor air quality investigations. Report No. 19. EUR 17675 EN. Luxembourg: Office for Official Publications of the European Community

U.S. EPA Compendium of Methods for Determination of Toxic Organic Compounds in Ambient Air, Report EPA-600/4-89/017 available through the National Technical Information Service, Springfield, VA 22161; PB90-116989. This report contains TO-17

World Health Organization, 1989 “Indoor Air Quality: Organic Pollutants,” EURO Reports and Studies No. 111, World Health Organization, Copenhagen, pp. 1-64

ISO 14644-1:1999 Cleanrooms and Associated Controlled Environments—Part 1: Classification of Air Cleanliness Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Compendium Methods TO-15 and TO-17, EPA/625/R-96-010b, January 1999, (NTIS No. PB99-172355)

3. Terminology

3.1 *Definitions*—or definitions and terms commonly used in ASTM standards, including this standard, 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 *chamber loading ratio*—the total amount of test specimen divided by the net air volume of the environmental test chamber in $1/m^3$, m/m^3 , m^2/m^3 , and m^3/m^3 for unit, line, area, and volume emission sources, respectively (see 3.2.5).

3.2.2 *clean air*—defined in this practice as air that satisfies all of the following criteria:

- (1) concentrations of total VOCs $\leq 10 \mu\text{g}/m^3$;
- (2) concentration of any individual compound to be measured $\leq 2.0 \mu\text{g}/m^3$;
- (3) particle concentrations $\leq 35,200$ particles/ m^3 of $0.5 \mu\text{m}$ diameter or larger (that is, the ISO Class 6 according to ISO 14644;
- (4) concentrations of ozone and other potentially reactive species such as nitrogen oxides (NO_x) and sulfur oxides (SO_x) should be at or below detectable levels (for example, $<10 \mu\text{g}/m^3$).

3.2.3 *clean air change rate (1/h)*—the flow rate of clean air (defined in 3.2.2) in m^3/h supplied into the chamber divided by

the net air volume (in m^3) of the environmental test chamber (that is, volume of an empty chamber minus the volume taken by all contents in the chamber during testing such as the test specimen, sampling ports). The clean air flow rate may be measured directly at the clean air supply duct. The clean air change rate can also be determined by conducting a tracer gas test (for example, a tracer gas decay test) in the chamber. Note that the air exchange rate (in units of 1/h) is abbreviated as ACH.

3.2.4 *dry materials*—materials such as carpets, wood-based products, and polyvinyl chloride (PVC) floorings, whose emission is generally controlled by diffusion processes within the bulk of the material.

3.2.5 *emission factor*—the mass of a VOC or total VOC emitted per unit time and per unit amount of source tested. Depending on the type of source, the amount of source may be expressed by its exposed surface area (that is, an area source such as a painted gypsum wallboard surface), its dominant dimension (that is, a line source such as a caulk or sealant), its mass, or its standard setup (that is, a “unit” source such as a predefined work station system). As a result, the unit for the emission factor will be mg/h , $\text{mg}/(m \text{ h})$, $\text{mg}/(m^2 \text{ h})$, $\text{mg}/(\text{kg h})$, and $\text{mg}/(m^3 \text{ h})$ for the “unit,” line, area, mass, and volume emission sources, respectively.

3.2.6 *emission rate*—the mass of a VOC or total VOC emitted from all the test specimen(s) present in the space per unit time, mg/h . It is equal to the emission factor times the amount of emission source.

3.2.7 *full-scale chamber*—a room-size chamber that can house the material/product to be tested in its real dimensions, and provide the required environmental conditions (temperature, relative humidity, air exchange, and air velocity) that are similar to the material/product use in full-scale room conditions.

3.2.8 *time zero*—the start time when the emission factor is measured. It will depend on the purpose of the testing. For example, time zero may be defined as the time when the test specimen is loaded into the chamber if the test specimen is prepared outside the chamber. Alternatively, when the emission during an application process (for example, painting) is to be tested, time zero may be defined as the time when the application begins.

3.2.9 *total volatile organic compound (TVOC)*—the sum of the concentrations of all the individual VOCs captured from air by a given sorbent, or a given combination of several sorbents, thermally desorbed into and eluted from a given gas chromatographic system, and measured by a given detector. For VOC definition, see Terminology **D1356** (formaldehyde and other very volatile organic compounds are included in this definition).

NOTE 1—The measured value of TVOC will depend on the collection and desorption efficiency of the sorbent trap; the efficiency of transfer to the GC column; the type and size of the GC column; the GC temperature program and other chromatographic parameters; the type of GC detector, as well as the calibration method and peak integration process. Compounds such as formaldehyde, which are typically monitored using analytical systems other than GC, are not included in the TVOC value.

3.2.10 *tracer gas*—a gaseous compound that can be used to determine the mixing characteristics of the test chamber and be a cross-check of the air change rate. The tracer gas must not be emitted by the test specimen and must not be contained in the supply air.

3.2.11 *wet materials*—materials such as paints, stains, and varnishes, whose initial emission period is primarily controlled by evaporative mass transfer and therefore dependent on surface air velocity.

4. Summary of Practice

4.1 Materials or products are placed in a full-scale test chamber within which temperature, relative humidity, and air change rate are controlled according to set parameters. Air is sampled at the exhaust of or inside the chamber, and analyzed by appropriate methods to identify the major emitted compounds and their concentrations as a function of time. The measured concentrations are then used to determine the emission rates, and/or the emission characteristics of the material or product. This information can be used to assess the contribution of the materials and products to the concentrations in the space of interest (for example, the occupied zone).

5. Significance and Use

5.1 VOCs emitted from materials/products affect indoor air quality (IAQ) in buildings. To determine the impact of these emissions on IAQ, it is necessary to know their emission rates over time. This practice provides guidelines for using a full-scale environmental chamber for testing large materials and full-scale material systems/assemblies.

5.2 While this practice is developed for measuring VOC emissions, the chamber facilities and methods of evaluation presented in this practice are also useful for a variety of purposes including: (1) testing the emissions during the application process (for example, painting), or other related sources; (2) developing scaleup methods (for example, from small chamber results to a full-scale scenario); (3) studying the interaction between sources and sinks, and validating source/sink models which are the basis for IAQ prediction; (4) testing interactions between source emissions and other compounds in the air (for example, NO_x, ozone, SO_x); and (5) evaluating the performance of air cleaning devices intended to remove contaminants from indoor air.

6. Principles

6.1 *Tests Under Uniform Chamber Concentration Conditions*—Assuming that the concentration of each emitted VOC tested in the chamber air is uniform as a result of good mixing, the concentration is then governed by the mass balance equation:

$$V \frac{dC(t)}{dt} = R(t) - QC(t) - S(t) \quad (1)$$

where:

V = air volume of the chamber excluding air volume taken by test specimens, m³;

t = time, h;

$C(t)$ = concentration of the emitted VOC in the air exhausted from the chamber at time t (can be measured at the chamber return or exhaust air ducts), mg/m³;

$R(t)$ = emission rate at time t , of the source(s) in the chamber, mg/h;

Q = clean air flow rate supplied to the chamber (measured at clean air supply duct or determined by a tracer gas test), m³/h; and,

$S(t)$ = sink term representing loss (or re-emission if negative) of the VOC at time t due to adsorption/desorption effect on the interior surfaces of the chamber and ducts, mg/h (see section 8.6 for its determination).

Based on Eq 1, the VOC emission rates of a test specimen as a function of time can be determined by measuring the concentrations of the air exhausted from the chamber and the clean airflow rate (refer to Section 11 for the actual calculation procedure). The concentrations and clean airflow rate must be determined for the same temperature condition since the air volume changes with air temperature. For example, when testing products that generate significant heat (for example, copiers), the exhaust air temperature will be higher than the supply air temperature. If the concentration is measured at the chamber exhaust while airflow rate is measured at the chamber supply, the supply airflow rate must be first adjusted to the equivalent airflow rate under the exhaust air temperature (that is, multiplied by the ratio of exhaust to supply air temperature in degrees Kelvin) before it is used for determining the emission rate.

Note that, in addition to the uniform VOC concentration assumption, Eq 1 also assumes no chemical reaction in the chamber, no air entry into the chamber other than the supply air, and a negligible VOC concentration at the supply air, compared to that measured at the chamber exhaust. The validity of using Eq 1 depends on how well the chamber's actual operation meets these assumptions. Therefore, the performance of the chamber must be evaluated against certain criteria in order to obtain reliable and reproducible test results (see Section 8).

6.2 *Tests Under Non-Uniform Concentration Conditions*—The full-scale chamber system can also be used to simulate the room airflow conditions in real buildings, which are not necessarily well mixed (for example, in the case of a displacement ventilation system). In this case, the VOC concentrations measured within a defined occupied zone in the chamber (for example, concentrations measured at the center of or various locations within the chamber) can be used directly to simulate the impact of the test materials/products on the VOC concentration levels in the room under a specified material/product loading ratio and ventilation rate conditions that are similar to those expected in real buildings. Such tests may be useful in evaluating complex field situations. However, a detailed understanding of air movement and emission dynamics for each simulation is necessary in order to extrapolate the test results to other field situations.

Typical airflow patterns and air distributions in ventilated spaces may be simulated by appropriate designs of supply air diffusers and return air grilles with appropriate recirculated