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Standard Guide for Selecting Volatile Organic Compounds (VOCs) and Semi- Volatile Organic Compounds (SVOCs) Emission Testing Methods to Determine Emission Parameters for Modeling of Indoor Environments¹

This standard is issued under the fixed designation D8141; 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 guide is intended to serve as a foundation for understanding when to use emission testing methods designed for volatile organic compounds (VOCs) to determine area-specific emission rates that are typically used in modeling indoor VOC concentrations and when to use emission testing methods designed for semi-volatile organic compounds (SVOCs) to determine mass transfer emission parameters that are typically used to model indoor SVOC concentrations.

1.2 This guide discusses how organic chemicals are conventionally categorized with respect to volatility.

1.3 This guide presents a simplified mass transfer model describing organic chemical emissions from a material to bulk air. The values of the model parameters are shown to be specific to material/chemical/chamber combinations.

1.4 This guide shows how to use a mass transfer model to estimate whether diffusion of the chemical within the material or convective mass transfer of the chemical from the surface of the material to the overlying air limits chemical emissions from the material surface.

1.5 This guide describes the range of different chambers that are available for emission testing. The chambers are classified as either dynamic or static and either conventional or sandwich. The chambers are categorized as being optimal to determine either the area-specific emission rate or mass transfer emission parameters.

1.6 This guide discusses the roles sorption and convective mass transfer coefficients play in selecting the proper emission chamber and analysis method to accurately and efficiently characterize emissions from indoor materials for use in modeling indoor chemical concentrations.

1.7 This guide gives recommendations on when to choose an emission test method that is optimized to determine either

the area-specific emission rate or mass transfer emission parameters. For chemicals where the controlling mass transfer process is unknown, the guide outlines a procedure to determine if the chemical emission is controlled by convective mass transfer of the chemical from the material.

1.8 This guide does not provide specific guidance for measuring emission parameters.

1.9 Mechanisms controlling emissions from wet and dry materials and products are different. This guide considers the emission of chemicals from dry materials and products. Examples of SVOCs that this guide applies to include flame retardants, plasticizers, antioxidants, preservatives, and coalescing agents (**1**).² Emission estimations for other SVOC classes including those generated by incomplete combustion, sprayed, or applied as a powder (pesticides, termiticides, herbicides, stain repellents, sealants, water repellants) (**1**) may require different approaches than outlined in this guide.

1.10 The effects of the emissions (for example, exposure, and health effects on occupants) are not addressed and are beyond the scope of this guide.

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

1.12 *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.*

1.13 *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.*

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

2. Referenced Documents

2.1 ASTM Standards:³

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D5116 Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products

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

D6330 Practice for Determination of Volatile Organic Compounds (Excluding Formaldehyde) Emissions from Wood-Based Panels Using Small Environmental Chambers Under Defined Test Conditions

D6345 Guide for Selection of Methods for Active, Integrative Sampling of Volatile Organic Compounds in Air

D6670 Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products

D7706 Practice for Rapid Screening of VOC Emissions from Products Using Micro-Scale Chambers

E1333 Test Method for Determining Formaldehyde Concentrations in Air and Emission Rates from Wood Products Using a Large Chamber

2.2 Other Documents:

Directive 2004/42/CE of the European Parliament and of the Council on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC

Emission Testing Method for CDPH Standard Method V1.2., 2017 Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers, Indoor Air Quality Section, Environmental Health Laboratory Branch, Division of Environmental and Occupational Disease Control, California Department of Public Health

I.S. EN 16402:2013 Paints and Varnishes—Assessment of Emissions of Substances from Coatings into Indoor Air—Sampling, Conditioning, and Testing

ISO 16000-6:2011 Indoor Air—Part 6: Determination of Volatile Organic Compounds in Indoor and Test Chamber Air by Active Sampling on Tenax TA Sorbent, Thermal Desorption and Gas Chromatography using MS or MS-FID

ISO 12219-1 Interior Air of Road Vehicles—Part 1: Whole Vehicle Test Chamber—Specification and Method for the Determination of volatile Organic Compounds in Cabin Interiors

3. Terminology

3.1 Definitions:

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.

3.1.1 For definitions of terms commonly used for sampling and analysis of atmospheres, refer to Terminology **D1356**. For definitions and terms commonly used when testing materials and products for emissions, refer to Guide **D5116**.

4. Significance and Use

4.1 Emissions of VOCs are typically controlled by internal mass transfer limitations (for example, diffusion through the material), while emissions of SVOCs are typically controlled by external mass transfer limitations (migration through the air immediately above the material). The emission of some chemicals may be controlled by both internal and external mass transfer limitations. In addition, due to their lower vapor pressure, SVOCs generally adsorb to different media (chamber walls, building materials, particles, and other surfaces) at greater rates than VOCs. This sorption can increase the amount of time required to reach steady-state SVOC concentrations using conventional VOC emission test methods to months for a single test (2).

4.2 Thus, existing methods for characterizing emissions of VOCs may not be practical to properly characterize emission rates of SVOCs for use in modeling SVOC concentrations in indoor environments. A mass transfer framework is needed to accurately assess emission rates of SVOCs when predicting the SVOC indoor air concentrations in indoor environments. The SVOC mass transfer framework includes SVOC emission characteristics and its partition to multimedia including sorption to indoor surfaces, airborne particles, and settled dust. Once the SVOC emission parameters and partitioning coefficients have been determined, these values can be used to modeling SVOC indoor concentrations.

5. Overview of Concepts Related to Organic Chemical Emissions in Indoor Environments

5.1 *Semi-Volatile Organic Compound (SVOC)*—There are many physical property based definitions used to describe the difference between a Very Volatile Organic Compound (VVOC), a VOC, an SVOC, and a Non-Volatile Organic Compound (NVOC). The definitions typically are based on the chemicals' vapor pressure at 25 °C, the chemical boiling point, or the relative position (time) a chemical is observed on a chromatograph. These definitions are useful to differentiate between chemicals in laboratory settings and experiments. **Table 1** lists the different physical property-based definitions from ten different references. The data in **Table 1** are not provided as authoritative definitions for VOC and SVOCs, but rather to inform the reader to the extent of variation in accepted definitions for these terms. As an example, the chemical properties used to differentiate between a VOC and an SVOC are listed in the row between the VOC and SVOC rows. There are five different boiling points spanning a 107 °C range that have been used to define the cut off between a VOC and an SVOC. The delineation between VOC and SVOC is further complicated by the fact that some chemicals do not have an accurately measured boiling point or decompose prior to boiling. Likewise, there are no universally accepted vapor pressure or chromatographic retention time delineations between VOCs and SVOCs. The use of chromatographic retention time as a delineator is further complicated by the

TABLE 1 Chemical Classification Definition Ranges for VVOC, VOC, SVOC, and NVOC

NOTE 1—The chemical properties used to differentiate between different classifications are listed in the row between the classification rows. Some values listed are illustrative examples given in the references listed below the table. The maximum chromatogram retention time describes how the chemical elutes from a non-polar or slightly polar gas chromatographic separation column compared to n-alkane.

	Maximum Vapor Pressure at 25 °C	Maximum Boiling Point at 101.3 kPa	Maximum Chromatogram Retention Time
VVOC			
VVOC / VOC Delineation	15 kPa ^A 500 kPa ^C	30 °C ^A 68 °C ^D 50–100 °C ^F	C ₅ ^B C ₆ ^{E,D}
VOC			
VOC / SVOC Delineation	10 ⁻² kPa ^{G,H,I,J,C}	180 °C ^A 250 °C ^K 240–260 °C ^{F,H} 287 °C ^{E,D}	C ₁₆ ^{E,D} C ₁₇ ^B
SVOC			
SVOC / NVOC Delineation	10 ⁻⁸ kPa ^{G,H,J} 10 ⁻¹² kPa ^I	>300–350 °C ^A 380–400 °C ^{F,H}	C ₂₂ ^D
NVOC			

^A Guide D6345 – 10

^B Emission Testing Method for CDPH Standard Method V1.2., 2017 (also known as California Specification 01350)

^C Practice D6330

^D I.S. EN 16402:2013

^E ISO 16000-6:2011

^F WHO (3)

^G Terminology D1356 – 15b

^H ISO 12219-1

^I Little, Weschler (1)

^J Practice D6177 – 14

^K Directive 2004/42/CE

retention times are strongly influenced by chromatographic conditions such as the choice of the column stationary phase polarity.

5.1.1 Labeling chemicals as VVOCs, VOCs, SVOCs, or NVOCs using chemical properties such as vapor pressure and boiling point may have limited value when trying to describe how chemicals emit from materials in indoor environments. This is especially true for chemicals close to the edge of these physical property definitions.

5.1.2 When modeling material emissions into an indoor environment, the classification (VOC, SVOC) is not as important as defining the rate limiting step for the emission of the chemical. The rate limiting step is the slowest step in the migration of a chemical from the interior of the material to the bulk air and is a function of the chemical, material, and environment combination. Chemicals emitting from materials can be broadly classified into three groups: (1) chemicals where the rate limiting step is the migration of the chemical to the material's surface (internal mass transfer, typical of chemicals classified as VOCs), (2) chemical where the rate limiting step is the migration of the chemical from the materials surface

to the bulk air (external mass transfer, typical of chemicals classified as SVOCs), or (3) chemicals where the rate of migration of the chemical to the material surface and migration of the chemical from the material surface into the bulk air are similar for a given environment.

5.1.3 In addition, the emission of a chemical might be limited by internal diffusion in one material, but limited by external mass transfer in another material depending upon the material composition and physical structure. These cases illustrate that there is no definitive delineation between a VOC or an SVOC from either a chemical characteristic definition or from a mass transfer framework.

5.2 Mass Transfer Parameters—To understand how VOC and SVOC emissions differ, it is important to understand a mathematical model of mass transfer for a chemical moving from the solid material phase to the air phase. Fig. 1 illustrates a simplified, one dimensional mass transfer model for a chemical emitting from a material. This model is applicable to the emission of both VOCs and SVOCs from a material. In this model, the following parameters are defined as:

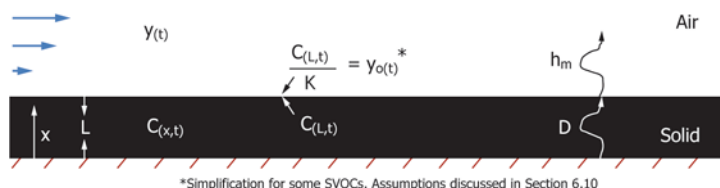


FIG. 1 Mass Transfer from a One Dimensional Material to Bulk Air (adapted from Xu and Zhang (4))