Designation: D6177 – 14

Standard Practice for Determining Emission Profiles of Volatile Organic Chemicals Emitted from Bedding Sets[1]

This standard is issued under the fixed designation D6177; 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 procedures for estimating emission profiles of volatile organic chemicals (VOCs) from bedding sets when a new bedding set is first brought into a house, based on emissions testing in environmental chambers.

1.2 Emission profiles from bedding sets are determined from air concentrations measured in environmental chambers.

1.3 VOC emissions from bedding sets, as in the case of other household furnishings, usually are highest when the products are new. Procedures described in this practice also are applicable to used bedding sets.

1.4 The practice is applicable to VOCs and not to semivolatile organic chemicals or nonvolatile organic chemicals.

1.5 This practice summarizes procedures for sample selection and handling. This practice also refers to pertinent sampling procedures and analytical methods for emission testing, but does not include technical details on selection of appropriate collection media and analytical methods or on sampling and analytical equipment and associated procedures.

1.6 Emission profiles based on this practice may be used for estimating human exposures to VOCs.

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

1.8 *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 regulating limitations prior to its use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D3687 Practice for Analysis of Organic Compound Vapors Collected by the Activated Charcoal Tube Adsorption Method

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

D5157 Guide for Statistical Evaluation of Indoor Air Quality Models

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

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

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:*

3.1.1 For definitions and terms used in this practice, refer to Terminology D1356.

[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.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air change rate, n*—the volume of outdoor air that enters the indoor environment in one hour, divided by the volume of the indoor space.

3.2.2 *bedding set, n*—an ensemble that includes a mattress for sleeping and a supporting box spring.

3.2.3 *emission profile, n*—a time–series of emission rates of one or more chemicals.

3.2.4 *nonvolatile organic chemical, n*—an organic compound with saturation vapor pressure less than 10^{-8} kPa at 25°C.

3.2.5 *semi-volatile chemical, n*—an organic compound with saturation vapor pressure between 10^{-2} and 10^{-8} kPa at 25°C.

3.2.6 *short-term exposure, n*—an exposure of one week or less in duration.

3.2.7 *volatile organic chemical, n*—an organic compound with saturation vapor pressure greater than 10^{-2} kPa at 25°C.

4. Summary of Practice

4.1 This practice describes procedures for determining VOC emission profiles of a bedding set using an environmental chamber.

4.2 This practice includes procedures for selection and handling of samples, and conducting chamber emission tests. Details related to storage and transportation of samples are included in selection and handling. Procedures for conducting chamber tests include selection of test conditions and methods for collection and analysis of air samples.

4.3 The practice also describes procedures for estimating emission profiles from the chamber concentration data.

5. Significance and Use

5.1 The objective of this practice is to provide procedures for estimating emission profiles of VOCs from bedding sets. These profiles can then be used to estimate human inhalation exposures to VOCs emitted from bedding sets. The estimated inhalation exposures ultimately can be used as an input to characterization of health risks from short–term VOC exposures.

5.2 The results of emissions testing for specific raw materials and components, or processes used in manufacturing different bedding sets, can be used to compare their relative impacts on airborne concentrations.

6. Facilities and Equipment

6.1 A facility to determine product or material emissions from bedding sets requires use of a room–size environmental test chamber, typically larger than 22.6 m^3. Emissions from components of bedding sets can be characterized in small chambers ranging in size from a few liters to 5 m^3. Chamber testing also requires associated equipment such as a clean–air generation system, monitoring and control systems, and sample collection and analysis equipment (see Practice D6670, Guide D5116, and Test Method E1333).

7. Procedures for Sample Selection and Handling

7.1 The procedures for sample selection and handling include sample selection, packaging for shipping, and shipment and storage.

7.2 Select bedding sets to be tested directly from the production line. Volume of production can be considered as a criterion in selecting the type(s) of bedding set to be tested. Use a random number table to avoid biases in selection.

7.3 The selected bedding set(s) should be wrapped using the manufacturer's normal packaging materials and procedures. Further, to protect from damage during shipping, place the bedding sets in corrugated shipping containers.

7.4 Upon receipt at the testing laboratory, remove the bedding from corrugated shipping containers, but do not remove the manufacturer's normal packaging materials. Inspect for shipping damage and record the arrival condition. To isolate the bedding sets from the surrounding laboratory environment, place each bedding set wrapped in its normal packaging (manufacturer's shipping bag) in a larger outer bag, which has an inert surface.

7.5 Maintain a chain of custody record to note dates, times, and operations performed (such as storage and transportation) for each bedding set.

8. Procedures for Emissions Testing

8.1 Volatile organic emissions from indoor sources such as bedding sets vary widely in the number of chemicals and the strength of their emissions. To characterize emissions fully, the sample collection and analysis system must be capable of quantitative collection and analysis of volatile, polar, and nonpolar compounds. The design and operation of sample collection and analysis systems must be appropriate for the organic chemicals and their concentrations. Such systems include collection of samples using canister sampling methodology (Test Method D5466) or, more often, collection on solid adsorbent tubes (for example, Practice D6196), and instruments to analyze organic emissions (for example, gas chromatographs, see Practice E355). Determination of formaldehyde and other aldehydes are performed using different methods (EPA Compendium, 1990).[3,4] One of these methods (Test Method D5197), which collects air samples on 2,4-dinitrophenylhydrazine (DNPH)–treated silica gel cartridges followed by high performance liquid chromatography (HPLC), is preferred because of better sensitivity.

8.2 The remainder of this section describes certain air sampling procedures related to emissions testing of bedding sets and briefly summarizes analytical methods. Technical

[3] "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air," 2nd Ed., 1999, US. Environmental Protection Agency/625/R-96/010b. Available from United States Environmental Protection Association (EPA), Ariel Rios Bldg., 1200 Pennsylvania Ave, NW, Washington, DC 20460, http://www.epa.gov.

[4] Research Triangle Institute, "Final Report—Performance of Testing in Support of Research by the SPSC Indoor Air Quality Task Force," RTI/5736/00-02RFR, Research Triangle Park, NC, September 1995.

details on selection of appropriate collection media and analytical methods, and on sampling and analytical equipment and associated procedures, are provided in the references cited in 8.1.

8.3 *Screening Samples:*

8.3.1 The purpose of the screening samples is to identify volatile organic chemicals and their relative concentrations, to aid in selecting sampling durations, collection media, and laboratory analysis methods for conducting emissions testing.

8.3.2 Collect air samples from the manufacturer's shipping bags using sampling lines connected directly to sampling devices.

8.4 *Background Samples:*

8.4.1 The following types of background samples are necessary:

(1) Background concentrations in the outer storage bag and the laboratory atmosphere, and

(2) Background concentrations in the chamber prior to insertion of a bedding set for chamber testing.

8.4.2 The background concentrations in the outer storage bag and the laboratory atmosphere are used to assess whether there is contamination from the laboratory environment.

8.4.3 A chamber background sample is taken to quantify any contributions of organic compounds from the clean air system or the empty chamber. Ideally, measured concentrations for such a sample should be at or below minimum detection limits. If not, the chamber background concentration can be used for correcting the chamber concentrations measured when a bedding set is placed in the chamber, as specified in 8.6.

8.5 *Chamber Conditions and Sampling Locations:*

8.5.1 The chamber air should be well mixed: a mixing fan should be used as necessary. The chamber temperature, humidity, and air change rate should be carefully controlled. At least one test should be done at the base conditions recommended as follows:

8.5.1.1 the base condition for temperature is 23 ± 0.5°C,

8.5.1.2 the base condition for humidity is 50 ± 5 %, and

8.5.1.3 the base condition for the air change rate is 1.0 ± 0.1 h^{-1}. The air change rate can be reduced to 0.5 ± 0.05 h^{-1}, but in that case the use of a mixing fan is especially recommended.

8.5.2 In addition to the base chamber conditions, it may be useful to conduct the chamber testing at an elevated temperature (for example, near the human body temperature) to determine the effect of elevated temperature on emissions.

8.5.3 A preferred location for collection of air samples is the outlet air stream from the chamber. Alternatively, multiple sampling locations within the chamber may be used. All sampling lines shall be made of inert materials, and the length of sampling lines should be minimized to limit deposition of VOCs.

8.6 *Bedding Set Samples:*

8.6.1 Immediately prior to testing, remove the bedding set from the outer bag and the manufacturer's packing bags and place the bedding set in the center of the chamber. Place the box spring on a stainless steel mattress frame, and the mattress over the box spring.

8.6.2 Collect a minimum of four samples for VOC and aldehyde analysis at 4, 8, 16, and 24 h after placing the bedding set in the chamber. Although previous testing indicates that the peak concentration occurs around 4 h after the bedding set is placed in the chamber (Research Triangle Institute, 1995),[4] there may be some uncertainties in this early sample.

8.7 *Analysis of Samples:*

8.7.1 *Analysis of volatile organic chemicals*—Volatile organic chemicals collected on solid adsorbent tubes are thermally desorbed (EPA Compendium, 1990)[3,5] and separated by gas chromatography (GC) and measured by a mass spectrometric (MS) detector. For the samples collected in canisters, VOCs are concentrated by collection in a suitable cryogenically cooled or adsorbent trap, revolatilized by heating the trap and then determined by GC–MS (see Test Method D5466). Identification of unknown sample constituents is conducted using electronic searches of mass spectral databases.

8.7.2 *Analysis of aldehydes*—DNPH/aldehyde derivatives on silica gel cartridges are extracted by eluting with acetonitrile and analyzed by HPLC, using an ultraviolet absorption detector (see Test Method D5197).

8.8 *Quality Assurance/Quality Control:*

8.8.1 Chamber testing of volatile organic chemicals from bedding sets should be conducted within the framework of a quality assurance project plan (QAPP). The QAPP should include data quality objectives and acceptance criteria, custody procedures, quality control checks, and quality assurance audits.

8.8.2 The data quality objectives should be defined in terms of precision, bias, completeness, and representativeness of data. Custody procedures should include procedures for safeguarding samples from tampering or contamination and procedures for prevention of data loss. Sample duplicates, spikes, and blanks should be included as quality control checks. In the case of continuous analyzers, quality control checks should include multipoint calibrations.

8.8.3 Quality assurance audits should include performance and system audits. Periodic performance audits should be conducted to verify that the total measurement system meets the data quality objectives. Periodic system audits should evaluate the conformance of the facilities and equipment, personnel training, procedures, record keeping, and data quality with the QAPP.

8.9 *Calculations:*

8.9.1 The calculations associated with emissions testing involve the following:

(1) Determination of the air concentration for each collected sample,

(2) Adjustment of bedding set sampling results for chamber background concentrations, and

(3) Estimation of the bedding set emission profile based on adjusted sampling results.

8.9.2 *Determination of Air Concentration*—The air concentration for each sample is determined as follows:

[5] Guo, Z., "On Validation of Source and Sink Models: Problems and Possible Solutions," *Modeling of Indoor Air Quality and Exposure*, ASTM STP 1205, ASTM, West Conshohocken, 1993, pp. 131–144.

$$C = M/V \quad (1)$$

where:

C = air concentration μg/m^3,
M = mass collected in sample μg, and
V = air volume for sample m^3.

8.9.3 *Adjustment of Chamber Air Concentration*—Air concentrations measured when bedding sets are placed in the chamber shall be adjusted for chamber background (for any chemical for which the background concentration is above the minimum detection limit) by subtracting the chamber background concentration from each measured concentration.

8.9.4 *Estimation of Emission Profile*—The following equation, which describes an exponentially decaying time series (first-order decay), has been found useful in estimating an emission profile for a chemical emitted from a bedding set (Guo 1995):[5]

$$E(t) = E_o exp(-kt) \quad (2)$$

where:

$E(t)$ = bedding set emission rate at time t μg h^{-1},
E_o = initial emission rate μg h^{-1},
k = first-order emission rate decay constant h^{-1}, and
t = time h.

The emission rate per unit area (in $\mu g\ m^{-2}\ h^{-1}$) is obtained by dividing the bedding set emission rate by its total exposed surface area. Estimate the parameters of the above equation using nonlinear regression. The appropriate equation for estimation, which considers the adjusted air concentration in the chamber at different points in time (C_t), the chamber volume (V, m^3), the air change rate for the chamber (N, h^{-1}) and the elapsed time since the bedding set was placed in the chamber (t, h), is as follows:

$$C_t = E_o \{exp(-kt) - exp(-Nt)\}/\{V(N-k)\} \quad (3)$$

For an adequate fit, the time series of air concentrations in the chamber should include at least four points in the first 24 h (for example, 4, 8, 16, and 24 h) in addition to an assumed concentration of zero at time zero. Other types of emission models besides the single exponential model given above may be useful, depending on the chemical and the factors that are controlling the emission rate. Tools described in Test Method D5157 should be used to assess the adequacy of the model's fit to the chamber data.

9. Report

9.1 Report the following information on emissions testing and results as follows:

9.1.1 *Facilities and Equipment*—Describe the test chamber and associated control system, sample collection, analytical instrumentation, and standards generation and calibration.

9.1.2 *Bedding Set Samples*—Describe the bedding sets (for example, size, style), the sample selection process (for example, random), and brand name (if appropriate) and storage and handling conditions.

9.1.3 *Test Conditions and Procedures*—Describe the conditions for chamber testing, including temperature, humidity, and air change rate. Describe the experimental procedures used during the testing, including details of sampling and analysis techniques.

9.1.4 *Results of Emissions Testing*—List the air concentrations measured in the chamber and associated times of sample collection. Describe the technique(s) used to estimate emissions based on chamber concentrations and the resultant emission profile over time.

9.1.5 *Quality Assurance/Quality Control*—Summarize the QAPP and discuss adherence to the data quality objectives and the acceptance criteria. This should be done for both the environmental variables and the chemicals that are measured. Provide the results of duplicate sampling as well as any sample blanks and spikes, and discuss the outcome of quality assurance audits.

10. Keywords

10.1 air change rate; bedding set; emissions; emission profile; environmental chamber; indoor air quality; volatile organic chemicals