Designation: D6178 − 19

Standard Practice for Estimation of Short-Term Inhalation Exposure to Volatile Organic Chemicals Emitted from Bedding Sets[1]

This standard is issued under the fixed designation D6178; 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 describes the procedures for estimation of short-term human inhalation exposure to volatile organic compounds (VOCs) emitted from bedding sets when a new bedding set is first brought into a bedroom.

1.2 The estimated exposure is based on an estimated emission profile of VOCs from bedding sets.

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

1.4 Exposure to airborne VOC emissions in a residence is estimated for a household member, based on location and activity patterns.

1.5 The estimated exposure may be used for characterization of health risks that could result from short-term exposures to VOC emissions.

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

1.7 *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.*

1.8 *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]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

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

D6177 Practice for Determining Emission Profiles of Volatile Organic Chemicals Emitted from Bedding Sets

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

3. Terminology

3.1 *Definitions*—For definitions and terms used in this practice, refer to Terminology D1356.

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *emission profile, n*—a time-series of emission rates of one or more compounds.

3.2.3 *exposure scenario, n*—a description of how and where an estimated exposure occurs, including (*1*) the location and emission profile of the product or material that causes exposure, (*2*) the indoor environment where the individual is exposed to airborne emissions from the product or material, and (*3*) the location and activity patterns of the exposed individual.

3.2.4 *potential inhaled dose, n*—the product of air concentration to which an individual is exposed multiplied by the breathing rate times duration of exposure.

[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.

3.2.4.1 *Discussion*—The potential inhaled dose is different from the dose actually absorbed by a target organ.

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

4. Summary of Practice

4.1 This practice describes procedures for estimation of inhalation exposure to VOCs emitted from new and used bedding sets in homes. A recent literature review of human exposure to indoor air pollutants in sleep microenvironments describes the range of issues surrounding exposure during sleep (**1**).[3] This estimation of bedding exposure is based on the emission profiles for a bedding set, the environmental conditions in a residence where the bedding set is being used, and the location and activity patterns of an exposed individual. Emission profiles are derived from environmental chamber emission tests (see Practice D6670, Guide D5116, and Practice D6177).

4.2 Estimation of exposure involves development of exposure scenarios, modeling of indoor-air concentrations, and selection and calculation of exposure measures.

5. Significance and Use

5.1 The objective of this practice is to provide procedures for estimation of human inhalation exposure to VOCs emitted from bedding sets in homes. The estimated inhalation exposure can be used as an input for characterization of health risks from short-term VOC exposures.

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

6. Procedures for Exposure Estimation

6.1 The procedures for exposure estimation include development of an exposure scenario and modeling of breathing zone concentrations accounting for emission rates, room size, air change rate, concentration distribution, occupant age, and activity patterns.

6.2 *Development of Exposure Scenarios:*

6.2.1 An exposure scenario describes how and where exposure occurs. In specifying the exposure scenario(s), include a description of (*1*) the emitting product or material, in terms of its age, emission profile, and location; (*2*) the indoor environment where exposure occurs; and (*3*) the location and activity patterns of an exposed individual.

6.2.2 A key decision in determining the exposure scenario is determining the appropriate occupant for the bedding set (adult or infant). Infants inhale roughly six times more air per unit of body mass than adults and sleep longer (**2**). Hence, emissions from crib bedding should be analyzed differently than adult bedding.

6.3 *Modeling Approach:*

6.3.1 There are a several methods to model indoor air concentrations. Multizone models, such as CONTAM (**3**) or the Multi- Chamber Concentration and Exposure Model (MCCEM) (**4**), can be used to determine indoor air concentrations or interzonal airflow rates, or both. However, interzonal airflows has not been well characterized in the literature, and airflow patterns between the immediate vicinity of the bed and the rest of the room are also not well-known or easily characterized. Computational fluid dynamic models can also be used to model indoor environments. But these models require significant effort to define the environment (air inlets and outlets, windows, furniture, wall thermal properties). Other issues, such as the impacts of increased localized surface temperature and moisture near the human body, along with sleeping position, are usually not accounted for in these models (**1**). Because models will result in unknown errors dependent upon numerous assumptions the user may not be familiar with, this practice uses a simplified box model to estimate inhalation concentrations for the bedding occupant.

6.4 *Bedroom Volume:*

6.4.1 The indoor location for the bedding set is assumed to be a bedroom. The interquartile (or middle 50 %) volume of 500 bedrooms in Denmark measured by Beko et al. (**5**) was 20 m^3 to 30 m^3. Select a room volume or range of room volumes that is appropriate for the exposure scenario. The National Association of Home Builders determined that the average American master bedroom occupies 10.7 % of the floor area of new homes (total average area 270 m^2) built in 2018 (**6**).

6.5 *Emitting Product or Material:*

6.5.1 For this practice, the emitting product is a bedding set. Specify the assumed age, emission profile, and size of the bedding set of interest.

6.5.2 For a conservative estimate of exposure, assume that the bedding set has just been purchased and the wrapper is not removed until it is placed in the residence.

6.5.3 Select a size of bedding set that is appropriate for the size of the bedroom (king, queen, full, twin, crib) and the occupant (adult or infant).

6.5.4 Estimate the bedding emission profile using Practice D6177. The time varying emission rate determined for new bedding in Practice D6177 includes a first order emission rate decay constant.

6.6 *Air Change Rate:*

6.6.1 In general, building air change rates vary with time; ranging by at least a factor of five or more for a given building due to weather and occupant actions (opening windows) (**7**). Room air change rates are harder to define and measure due the complexities of interzonal airflows.

6.6.2 Air change rates in 500 bedrooms in apartments, single family homes, and rowhouses in Denmark were measured by Beko et al. (**5**). The lognormally distributed air change rates varied from 0.05 1/h to 4.5 1/h with a geometric mean value of 0.46 1/h.

6.6.3 Select a value or range of values for the air change rate for the bedroom to be modeled. Smaller rooms and those with more windows and door openings tend to have higher air change rates (**5**).

[3] The boldface numbers in parentheses refer to the list of references at the end of the standard.