Designation: ~~D6669 – 12~~ D6669 – 19

Standard Practice for Selecting and Constructing Exposure Scenarios for Assessment of Exposures to Alkyd and Latex Interior Paints[1]

This standard is issued under the fixed designation D6669; 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 provides procedures for constructing scenarios for assessment of inhalation exposure to airborne emissions of chemicals released from alkyd or latex paints that are used indoors.

1.2 The indoor environments covered in this practice, in terms of considerations for developing exposure scenarios, are residences and office buildings.

1.3 Elements of the exposure scenarios include the product and chemical(s) to be assessed, the indoor environment where the product is applied, application of the product, chemical emissions during and after product application, and location/activity patterns of individuals who may be exposed to the airborne chemical emissions.

1.4 Steps to be performed after developing exposure scenarios, such as monitoring, modeling and exposure/risk assessment, also are described.

1.5 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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]

D1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers
D1212 Test Methods for Measurement of Wet Film Thickness of Organic Coatings
D1356 Terminology Relating to Sampling and Analysis of Atmospheres
D5116 Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products
D6178 Practice for Estimation of Short-term Inhalation Exposure to Volatile Organic Chemicals Emitted from Bedding Sets
D6485 Guide for Risk Characterization of Acute and Irritant Effects of Short-Term Exposure to Volatile Organic Chemicals Emitted from Bedding Sets
E741 Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

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

[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.

Current edition approved ~~April 1, 2012~~March 15, 2019. Published ~~May 2012~~April 2019. Originally approved in 2001. Last previous edition approved in ~~2007~~2012 as ~~D6669 – 01a (2007)~~D6669 – 12.~~ε1~~. DOI: ~~10.1520/D6669-12.~~10.1520/D6669-19.

[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~~standard's Document Summary page on the ASTM website.

3.2.2 *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.

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

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

4. Summary of Practice

4.1 This practice documents the items that need to be described when developing an exposure scenario for assessment of exposures to chemicals released indoors from alkyd or latex paints. Important considerations are discussed for each item, along with examples or alternatives where appropriate.

4.2 An exposure ~~scenario—a~~ scenario — a description of how and where an estimated exposure ~~occurs—includes~~ occurs — includes the following elements for paints used indoors (that is, interior paints):

4.2.1 The product and chemical(s) to be assessed.

4.2.2 The indoor environment where the product is applied, including properties such as volume and airflow rate.

4.2.3 The amount and rate of product use.

4.2.4 Chemical emissions during and after paint application.

4.2.5 Locations and breathing rates of an individual, or individuals, who may be exposed to the airborne chemical emissions.

4.3 Further considerations discussed in this practice include typical versus conservative assumptions, short-term versus long-term exposure perspectives, alkyd versus latex paints, and residential versus office settings.

4.4 More than one exposure scenario can be constructed. The practice also provides a list of elements to be included when comparing multiple scenarios.

5. Significance and Use

5.1 Increasing attention is being paid to human exposure to airborne chemicals from products or materials used indoors, for two reasons:

5.1.1 Individuals spend substantial fractions of their time indoors.

5.1.2 Such exposures can occur repeatedly throughout ~~one's~~one's lifetime.

5.2 The primary objectives of this practice are as follows:

5.2.1 To list the elements that need to be considered in developing a scenario to describe how exposure occurs to chemicals emitted from alkyd or latex interior paints.

5.2.2 To discuss procedures and alternatives for choosing and describing these elements.

5.3 Elements of an exposure scenario, in turn, are used to ~~practice~~inform a subsequent step of estimating exposures through monitoring studies or computer modeling exercises.

5.4 Once exposures have been estimated, the results can be used to assess the potential impacts of a specific paint formulation on the health of exposed individuals, or to compare the relative impacts of alternative formulations.

5.5 Estimation of exposures, or comparisons of estimated exposures across alternative paint formulations, can lead to development of environmentally preferable products by minimizing adverse health effects for exposed individuals.

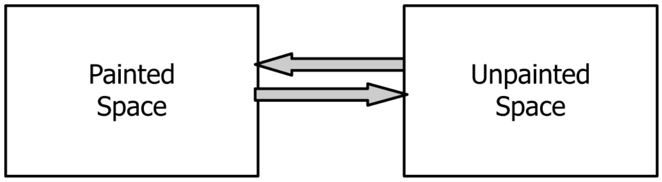

FIG. 1 Conceptualization of a Painted Building

6. Procedures for Developing Exposure Scenarios

6.1 *Describing the Product and Chemical(s):*

6.1.1 Chemical emissions can vary according to the type of paint and painted substrate. Describe the following:

6.1.1.1 Alkyd or latex paint.

6.1.1.2 Flat, gloss, or semi-gloss paint.

6.1.1.3 Physical properties such as paint density, ~~c~~mg/cm^3.

6.1.1.4 Typical applications of the paint, in terms of (*1*) type of substrate to which it is applied (for example, gypsum wallboard ~~vs.~~versus wood/trim ~~vs.~~versus metal) and (*2*) type of room (for example, bedroom ~~vs.~~versus bathroom or kitchen).

6.1.1.5 Typical warnings or advice on the paint container (for example, "Use in a well-ventilated area").

6.1.2 The pattern and potential impact of chemical emissions over time can vary by chemical. Describe the following:

6.1.2.1 Physical/chemical properties of the chemical(s) under investigation, such as molecular weight and vapor pressure.

6.1.2.2 Role of the chemical(s) in the paint (for example, solvent).

6.1.2.3 Weight fraction of the chemical(s) in the paint.

6.1.2.4 Toxicity information, such as that commonly reported in ~~Material~~ Safety Data Sheets.

6.1.3 Chemical emissions can be affected by environmental factors such as temperature and humidity. These factors are discussed in 6.2. The pattern of chemical emissions also can depend on factors such as the paint application method, the amount of paint applied, and the rate of application. These factors are discussed in 6.3.

6.2 *Describing the Indoor Environment Where the Product Is ~~Applied~~Applied:~~:~~*

6.2.1 Describe the size/volume and general configuration of the environment (for example, a two-story residence consisting of eight rooms with a volume of 425 m^3). Specific considerations for residential versus office buildings are discussed under 6.6~~6.6.~~. Distributions for volumes of U.S. residences are presented in the *Exposure Factors Handbook* (**1**).[3]

6.2.2 Describe the indoor-outdoor air change rate (for example, in ~~h~~1/h~~$^{-1}$~~ or air changes per hour, ACH) and associated conditions such as opening of doors/windows and use of exhaust/circulation fans. Distributions for air change rates of U.S. residences are presented in the *Exposure Factors Handbook* (**1**). Persily (**2**) has measured air change rates in a limited set of office buildings.

6.2.3 *Discussion*—When conducting an actual exposure assessment, as opposed to constructing an exposure scenario to guide the assessment, it may be preferable to replace assumptions regarding air change rates with actual measurements, using methods such as those described in Test Method E741.

6.2.4 Describe the fraction of the building (or building volume) that is being painted. It usually is convenient to conceptualize the building as consisting of two indoor air ~~spaces—a~~ spaces — a painted space and an unpainted space, with communicating air flows between the two ~~spaces—as~~ spaces — as illustrated in Fig. 1.

6.2.5 Describe the airflow rates between the painted and unpainted spaces. The flows in the two directions are not necessarily equal, but it is often convenient to assume so. More than two indoor spaces can be specified, but the number of airflow rates will increase rapidly (for example, 2 rates for 2 spaces, 6 rates for 3 spaces, 12 rates for 4 spaces).

6.2.6 *Discussion*—In specifying air flows it is important to maintain a flow balance; that is, for any air space or zone, the sum of air flows entering the zone should equal the sum of exiting air flows. One relatively simple means of accomplishing this is to assume that the airflow rates to/from outdoors are proportional to the air change rate (for example, if the zone volume is 100 m^3 and the air change rate is 0.5 ~~h~~1/h,~~$^{-1}$,~~ then the airflow rate to/from outdoors is 50 m^3/h) and that the airflow rates between the two zones are the same in both directions. As with other elements describing an exposure scenario, assumptions here ultimately should be replaced by measurements where possible. However, airflow measurements (typically involving the use of multiple tracer gases) are not simple to perform. A possible alternative is to use an indoor-air model that can model air flows, such as CONTAM (**3**) or COMIS (**4**). The MCCEM model (**5, 6**) has a built-in library of airflow rates for a variety of residences. The models IAQX (**7**) and IECCU (**8**) have built-in routines to check airflow inputs for flow balance.

6.2.7 Describe the outdoor concentration for the chemicals(s) of concern assumed to prevail during and following the painting event. Often the outdoor concentration of the chemical(s) being assessed is low relative to that indoors, such that an assumption of zero concentration outdoors is not unreasonable. Even if a non-zero-concentration is assumed, the estimation process can be simplified by assuming that the outdoor concentration is constant over time.

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

6.2.8 Describe the environmental conditions of the indoor space where paint is to be applied. Conditions such as temperature and relative humidity are particularly important, as these can affect the rate of chemical emissions.

6.2.9 Indoor-air concentrations of chemicals released from paint can be affected by certain types of materials that absorb (and sometimes desorb) emitted chemicals. Describe wall, ceiling and floor materials as well as furnishings such as upholstered furniture or draperies. The preferred method for documenting the presence of such materials is to note their loading rates (that is, ratio of surface area to indoor volume, in units of m^2/m^3).

6.3 *Describing the Product Application:*

6.3.1 Describe the substrate that is being ~~painted—gypsum~~ painted — gypsum wallboard, wood, metal, ~~etc.—and~~ etc. — and indicate whether it ever has been painted before.

6.3.2 Indicate whether the substrate is being painted with primer only, paint only, or primer plus paint.

6.3.3 Indicate the number of coats of primer/paint being applied.

6.3.4 Indicate the drying time(s) between successive coats of primer/paint.

6.3.5 Indicate the total amount of primer/paint being used. This quantity, commonly expressed in litres, can be indicated or calculated in any of the following ways:

6.3.5.1 If the actual quantity used is known, then indicate that quantity.

6.3.5.2 If the painted surface area is known, then the amount applied (A) can be estimated as follows:

~~$A \cong painted\ surface\ area/(coverage\ per\ coat) \times number\ of\ coats\ (for\ example, 100\ m^2/(10\ m^2/L) \times 2\ coats = 20\ L)$~~

$$A \cong \text{painted surface area} / (\text{coverage per coat}) \times \text{number of coats} \quad (1)$$

$$(\text{for example, } 100\ \text{m}^2 / (10\ \text{m}^2/\text{L}) \times 2\ \text{coats} = 20\ \text{L})$$

6.3.5.3 If the wet film thickness in µm is known (see Test Methods D1005 and D1212), it can be converted to coverage per coat using the following formula:

~~$Coverage\ per\ coat\ (m^2/L) = 1000/wet\ film\ thickness\ (\mu m)$ (2)~~

$$\text{Coverage per coat } (\text{m}^2/\text{L}) = 1000 / \text{wet film thickness } (\mu\ \text{m}) \quad (2)$$

The amount applied can then be calculated as in 6.3.5.2.

6.3.5.4 If the volume of the painted space is known and if walls or ceilings are being painted, then the painted surface area can be estimated from the following relationships given in the *Exposure Factors Handbook* (**1**~~)~~**)**, Chapter 19, Loading Ratios, for residences:

~~$Wall\ area\ (m^2) \cong volume\ (m^3) \times 0.95$ (3)~~

~~$Ceiling\ area\ (m^2) \cong volume\ (m^3) \times 0.43$~~

$$\text{Wall area } (\text{m}^2) \cong \text{volume } (\text{m}^3) \times 0.95 \quad (3)$$

$$\text{Ceiling area } (\text{m}^2) \cong \text{volume } (\text{m}^3) \times 0.43 \quad (4)$$

The amount applied can then be calculated as in 6.3.5.2.

6.3.6 Indicate the product application rate (for example, L/h). This rate can depend on factors such as application method (roller, brush, spray) and the number of painters. Indicate the application method and number of painters along with the rate.

6.3.7 Indicate the total duration of the painting event. The duration can be calculated by dividing the total amount of primer or paint, or both used (in L) by the application rate (in L/h), assuming a constant application rate. The drying time(s) between successive coats needs to be added to the painting time to obtain the total duration. In cases where the duration is relatively long (for example, ~~> 8~~ >8 h), indicate the number of painting hours per day and the resultant number of painting days.

6.4 *Describing the Chemical Emissions from the Paint:*

6.4.1 *General Nature of Emissions Profile.* When primer or paint is applied quickly to a small specimen (as when conducting a small-chamber test to characterize emissions), the chemical emissions tend to be higher at first and then to decline over time. Studies of airborne chemical concentrations in chambers (**~~6~~9, ~~7~~10**), following instantaneous application of paint to a substrate such as gypsum wallboard, indicate that the declining emission rate tends to follow a single-exponential model for chemicals released from alkyd paint and a double-exponential model for chemicals released from latex paint.

6.4.2 *Direct Estimation of Emissions Profile.* An emission profile for the chemical(s) of concern released from primer or paint can be estimated using a small-chamber facility (see Guide D5116) by (*1*) applying the primer/paint to the substrate of interest and determining the mass applied through before/after weight differentials, (*2*) inserting the painted substrate in the chamber immediately after applying the paint and then measuring the airborne chemical concentrations over time, and (*3*) using non-linear regression to fit a single- or double-exponential emission model to the concentration data.

6.4.3 *Indirect Estimation of Emission Profile.* Studies have been conducted to investigate the dependence of an emissions profile on physical/chemical properties. These include empirical models relating the rate of exponential decline to molecular weight and