STANDARD METHOD FOR THE TESTING AND EVALUATION OF VOLATILE ORGANIC CHEMICAL EMISSIONS FROM INDOOR SOURCES USING ENVIRONMENTAL CHAMBERS

VERSION 1.1

*(Emission testing method for **California Specification 01350.***
Supercedes the previous version of
STANDARD PRACTICE FOR THE TESTING OF VOLATILE ORGANIC EMISSIONS FROM VARIOUS SOURCES USING SMALL-SCALE ENVIRONMENTAL CHAMBERS)

PREPARED BY:

Indoor Air Quality Section

Environmental Health Laboratory Branch

Division of Environmental and Occupational Disease Control

California Department of Public Health

FEBRUARY 2010

California Department of Public Health
DR. MARK HORTON, Director

California Health and Human Services Agency
KIM BELSHÉ, Secretary

State of California
ARNOLD SCHWARZENEGGER, Governor

FOREWORD

It has been five years since the Indoor Air Quality Program issued the ***Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers (Standard Practice)*** on behalf of the California Sustainable Building Task Force. We recognized from the start that maintenance of this document would be required to keep up with changes in the field and to track current health standards. Limitations in staff resources have delayed this effort till now. It is our intention that the update of the ***Standard Practice*** will be a continuous process, and this document presents an initial effort.

The major changes to the prior document in this draft include:

- The title has been changed to ***Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers*** as the document addresses both practice and method as well as testing using chambers of various sizes.
- Adoption of OEHHA's new CRELs to set allowable emission limits. For formaldehyde, it is recommended to continue using one-half of the prior CREL (33 $\mu g\ m^{-3}$) until December 31th, 2011, and the new full CREL (9 $\mu g\ m^{-3}$) starting January 1st, 2012.
- Incorporation of the ANSI/BIFMA M7.1-2007 test and power-law model prediction method as the recognized test method for pupil desks and chairs, open-plan office furniture and office seating, provided that test results meet all the requirements described in this method at 336 hr (14 days).
- Revision of exposure model parameters for the standardized school classroom and the typical office environments, including reference to ASHRAE Standard 62.1-2007 for the outdoor ventilation flow rates.
- Addition of general guidelines to manufacturers and certification/verification organizations for the use of this standard method as the basis for a product-wide claim.
- Revision of specimen collection, preparation and environmental chamber testing in accordance with current best practices.
- Addition of a section on quality management and measurement uncertainty.
- General document clean up.
- Addition of an informative appendix to document a preliminary new single-family residence scenario for IAQ concentration modeling.

Background

In 1990, the California legislation directed the Indoor Air Quality (IAQ) Program to develop guidelines for the reduction of exposure to volatile organic compounds (VOCs) from building construction materials in newly constructed or remodeled office buildings. The IAQ Program issued the report, ***Reducing Occupant Exposure to Volatile Organic Compounds (VOCS) From Office Building Construction Materials: Non-Binding Guidelines.*** This 1996 report provided a simple technical approach for evaluating, selecting, and installing building construction materials in order to minimize occupant exposures to VOCs emitted from these materials.

In 1999, the California Integrated Waste Management Board (CIWMB) initiated a multi-stakeholder process to develop "sustainability" criteria for office furniture which could be used in the pending State contract. CIWMB staff convened State agencies to address energy efficiency (lighting), material recycled content and recyclability, and enhanced IAQ, and they hired several consultants to help draft the *Special Environmental Specifications for Office Furniture*. In it, we adopted the IAQ Program's approach to low-VOC emitting materials, drawing from testing protocols and the limited set of allowable VOC limits used for the San Francisco Public Library. The Office Furniture contract was successfully bid in 2000.

At the same time, another multi-agency group, the California Sustainable Building Task Force, was formed to direct State "green building" requirements, which were notably applied in the design and construction of the State's Capitol Area East End Complex, completed in 2002-03. The *Special Environmental Specifications* for the CAEEC required material testing for VOC emissions and expanded the health-based exposure limits to all volatile organic chemicals with Chronic Reference Exposure Levels (CREL) issued by Office of Environmental Health Hazard Assessment (OEHHA). The CAEEC specifications were rewritten in Construction Specification Institute (CSI) format, and they became known under the moniker of their CSI section: 01 35 00 General Requirements - Special Project Procedures) or simply "Section 01350". The Collaborative for High Performance Schools (CHPS) subsequently adopted the specifications for their Low-emitting Material IEQ credit in 2002.

Section 01350 received wide acceptance from numerous manufacturers of building materials due to its flexibility, relative low cost, and the fact that it is the only health-based building material specification. As laboratories started to implement the VOC testing requirements within *Section 01350* on a wider scale, it became apparent that certain sub-sections of this specification needed to be expanded. In 2004, the Program issued its *Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers (Standard Practice)*. Its highlights were the more detailed requirements given for testing and the allowable emission limits tied explicitly to health-based exposure levels. Notably, the ***Standard Practice*** addressed testing, exposure modeling and allowable limits for modeled indoor air concentrations at 14 days, based on the chemicals of concern listed by Cal-EPA (notably, chemicals with established Chronic Reference Exposure Levels or CRELs).

Subsequently, the health-based criteria of the ***Standard Practice*** were incorporated into the State of California *Open Office Panel Systems* 2007-2008 purchasing criteria issued by the Department of General Services. The State of Minnesota government similarly adopted these environmental purchasing criteria. A variety of other product certification programs have adopted or adapted the ***Standard Practice***; these include the *Leadership in Energy and Environmental Design (LEED) Indoor Environmental Quality criteria*; the *National Green Building Standard*; *Business and Institutional Furniture Sustainability Standard (for the health-based criteria)*; *Carpet and Rug Institute (CRI) Green Label Plus (GLP); Scientific Certification Systems (SCS) Indoor Advantage Gold; Resilient Floor Covering Institute (RFCI) FloorScore; and GREENGUARD Children & Schools.*

Author/Acknowledgements

The California Department of Public Health (CDPH), Indoor Air Quality (IAQ) Section, prepared this document, and CDPH approved its release on March 4, 2010. Dr. Wenhao Chen was the primary author, and Mr. Robert Miller crafted updates for Sections 2 and 3. Dr. Jed Waldman and Mr. Leon Alevantis (CDPH Senior Mechanical Engineer) provided Departmental technical review. In addition, numerous individuals outside CDPH contributed invaluable suggestions and recommendations during the public review process, which were essential for final document development. Appendix A lists stakeholders who submitted written comments (or oral comments in public meetings).

Disclaimer

The ***Standard Practice*** and ***Standard Method*** are in the public domain, and the State has no financial interest in their use or application. The mention of commercial products or services, their source, or their use in connection with material presented in this report is not to be construed as actual or implied endorsement of such products or services by the State of California.

TABLE OF CONTENTS

FOREWORD 2

1 BACKGROUND INFORMATION 7

1.1 Scope 7
1.2 References 8
1.3 Terminology 10

2 COLLECTION, PACKAGING, SHIPMENT, & DOCUMENTATION OF PRODUCT SAMPLES 14

2.1 Product Sample Collection 14
2.2 Packaging and Shipment of Samples 18
2.3 Chain-of-Custody Documentation 18
2.4 Rejection of Samples by Laboratory 19
2.5 Receipt of Samples by Laboratory 19
2.6 Storage of Samples by Laboratory Prior to Testing 19

3 LABORATORY SAMPLE PREPARATION, TESTING, CHEMICAL ANALYSES AND CALCULATIONS 20

3.1 Test Specimen Preparation 20
3.2 Preparation of Paint Test Specimens 21
3.3 Preparation of Adhesive Product Test Specimens 22
3.4 Preparation of Caulking Product Test Specimens 22
3.5 Selection and Preparation of Dry Product Test Specimens 23
3.6 Preparation of Dry Product Test Specimen Assemblies 24
3.7 Conditioning of Test Specimens 24
3.8 Environmental Chamber Testing 26
3.9 Chemical Analyses 30
3.10 Calculations 32

4 TARGET CHEMICALS, MAXIMUM ALLOWABLE CONCENTRATIONS, AND IAQ CONCENTRATION MODELING 35

4.1 Target VOCs 35
4.2 Maximum Allowable Concentrations for Target VOCs. 35
4.3 IAQ Concentration Modeling 36

5 QUALITY ASSURANCE AND QUALITY CONTROL 41

5.1 Mandatory Practices on Quality Management 41
5.2 Mandatory Laboratory Practices 41
5.3 Measurement Uncertainty 42

6 REQUIRED ELEMENTS OF THE LABORATORY TEST REPORT 43

6.1 Required elements of the Laboratory Test Report 43

7 TESTING OF FREESTANDING FURNITURE 45

7.1 Test Method for Freestanding Furniture 45
7.2 Concentration Modeling for Furniture and Office Seating 45
7.3 Compliance with Maximum Allowable Concentrations 46

8 GUIDELINES FOR USE OF STANDARD METHOD AS BASIS FOR A BUILDING PRODUCT CLAIM 47

8.1 Manufacturer and Third-Party Claims 47
8.2 Laboratory Selection 47
8.3 Breadth of Claim 47
8.4 Modifications of Method 47
8.5 Acceptable Alternative to Method 48
8.6 Quality Control 48
8.7 Product Sample Selection 48
8.8 Retesting 49

APPENDIX A LIST OF STAKEHOLDER REVIEWERS 50

APPENDIX B NEW SINGLE-FAMILY RESIDENCE SCENARIO 51

TABLES

Table 2-1 Sample collection and testing chronology for products 15
Table 3-1 Chamber conditions for 96-h test period 27
Table 4-1 Target CREL VOCs and their maximum allowable concentrations 37
Table 4-2 Definition of standard school classroom 38
Table 4-3 Product quantities and specific air flow rates to be used for estimation of VOC concentrations in standard school classroom 38
Table 4-4 Definition of standard private office 39
Table 4-5 Product quantities and specific air flow rates to be used for estimation of VOC concentrations in a standard private office 39
Table 5-1 Guidelines for measurement uncertainty and precision of chamber conditions and VOC measurements 42
Table 7-1 Standard open-plan office defined in ANSI/BIFMA M7.1-2007 46
Table 7-2 Product quantities and specific air flow rates to be used for estimation of VOC concentrations in a standard open-plan office 46
Table B-1 Definition of new single-family residence. 51
Table B-2 Product quantities and specific air flow rates to be used for estimation of VOC concentrations in standard new single-family residence. 52

1 BACKGROUND INFORMATION

1.1 Scope

1.1.1 This method applies to any product category generally used within the envelope of an enclosed indoor environment. The method is applicable to products that can be tested whole or by representative sample in environmental chambers. This includes, as examples, paints, other architectural coatings and finishes, sealants, adhesives, wallcoverings, floor coverings, acoustical ceilings, wood paneling, wall and ceiling insulation used in public and commercial office buildings, schools, residences and other building types.

1.1.2 This method applies to freestanding furniture used in schools and offices by incorporation of an American National Standard Method for furniture VOC emissions. For open-plan office furniture, this method adopts the open-plan office defined in an American National Standard Method for furniture VOC emissions. Private office workstations are not addressed within the current scope of this Standard Method.

1.1.3 This method applies to newly manufactured products before they are used in construction, finishing and furnishing of buildings.

1.1.4 The standard does not apply to structural building products, janitorial products, air fresheners, electronic air cleaners, and other electronic equipment.

1.1.5 This method establishes the procedures for product sample collection, emission testing, indoor concentration modeling, and documentation requirements associated with quantifying the emissions of volatile organic chemicals from various sources using environmental chambers.

1.1.6 This method defines scenarios for a standardized school classroom (including pupil desks and chairs) and a typical private office environment (for building products other than office furniture). These scenarios include the dimensions, occupancy and ventilation characteristics of the space and the amounts of major products contained within the space.

1.1.7 This method establishes performance criteria for specific chemicals of interest. These criteria are specifically for evaluating potential chronic health risks from inhalation exposures of vapor phase organic chemicals emitted by the products covered within the scope.

1.1.8 This method includes requirements on laboratory quality management system and measure uncertainty estimation.

1.1.9 The indoor concentration modeling scenarios and the performance criteria may be applied to emission test results obtained from other recognized test methods.

1.1.10 This method may be utilized as the basis for product claims and for certification/verification programs. General guidelines are provided for incorporation of the method into such programs.

1.1.11 This method specifies target chemicals and their maximum allowable concentrations. However, this method does not purport to address all of the safety, health, comfort (e.g.,

odor) and performance concerns, if any associated with its use. Users of this method may establish additional safety, health, comfort and other performance conditions and determine the applicability of regulatory requirements prior to use.

1.2 References

1.2.1 ASTM Standards

D 1356-05 Standard Terminology Relating to Sampling and Analysis of Atmospheres

D 5116-06 Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products

D 5197-03 Standard Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology)

D 6196-03 Standard Practice for Selection of Sorbents, Sampling and Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air

D 6345-98 (2004) Standard Guide for Selection of Methods for Active, Integrative Sampling of Organic Compounds in Air

D 6670-01 (2007) Standard Practice for Full-Scale Determination of Volatile Organic Emissins from Indoor Materials/Products

D 7339-07 Standard Test Method for Determination of Volatile Organic Compounds Emitted from Carpet using a Specific Sorbent Tube and Thermal Desorption / Gas Chromatography

1.2.2 Other Documents

ANSI/ASHRAE Standard 62.1-2007. *Ventilation for Acceptable Indoor Air Quality*, American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA

ANSI/ASHRAE Standard 62.2-2007. *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA

ANSI/BIFMA M7.1-2007. *Standard Test Method for Determining VOC Emissions from Office Furniture Systems, Components and Seating*, BIFMA International, Grand Rapids, MI

BIFMA e3-2008. *Furniture Sustainability Standard*, BIFMA International, Grand Rapids, MI. Standard is accessible at: http://levelcertified.org/wp-content/uploads/2009/06/2009-02-20%20SASe3.pdf

Cal/EPA, ARB list of Toxic Air Contaminants (TACs). The current version of this list is accessible at http://www.arb.ca.gov/toxics/id/taclist.htm

Cal/EPA OEHHA Safe Drinking Water and Toxic Enforcement Act or 1986 (Proposition 65). The current versions of these lists are accessible at http://www.oehha.ca.gov/prop65/prop65_list/newlist.html

Cal/EPA OEHHA list of chemicals with noncancer chronic Reference Exposure Levels (RELs). The current version of this list is accessible at http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html

Carter, R.D and J.S. Zhang. 2007. Definition of Standard Office Environments for Evaluating the Impact of Office Furniture Emissions on Indoor VOC Concentrations. *ASHRAE Transactions,* Volume 113, Part 2, pp 466-477.

CHPS 2009 Criteria. *CHPS Best Practice Manual Volume III California Criteria for High Performance Schools (2009 Edition)*, Collaborative for High Performance Schools, San Francisco, CA

ISO 14021:2001. *Environmental labels and declarations. Self-declared environmental claims (Type II environmental labeling)*, International Organization for Standardization, Geneva, Switzerland.

ISO 16000-9:2006. *Indoor Air - Part 9: Determination of the Emission of Volatile Organic Compounds from Building Products and Furnishing - Emission Test Chamber Method*, International Organization for Standardization, Geneva, Switzerland.

ISO 16000-11:2006. *Indoor Air - Part 11: Determination of the Emission of Volatile Organic Compounds from Building Products and Furnishing - Sampling, Storage of Samples and Preparation of Test Specimens*, International Organization for Standardization, Geneva, Switzerland.

ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*, International Organization for Standardization, Geneva, Switzerland.

ISO/IEC Guide 65:1996 *General Requirements for Bodies Operating Product Certification Systems*, International Organization for Standardization, Geneva, Switzerland.

Jenkins, P.L., T.J. Phillips and J. Waldman, 2004. Environmental Health Conditions in California's Portable Classrooms. Report is accessible at http://www.arb.ca.gov/research/indoor/pcs/pcs.htm

Offermann, F.J., 2009. Ventilation and Indoor Air Quality in New Homes. Report is accessible at http://www.arb.ca.gov/research/apr/past/indoor.htm.

U.S. Census Bureau. 2008. Housing and Household Economic Statistics Division, Hagerstown, MD. Accessible at http://www.census.gov/const/C25Ann/sftotalmedavgsqft.pdf

U.S. DOE. 2008. Buildings Energy Data Book. Chapter 2.2 Residential Sector Characteristics. U.S. Department of Energy, Energy Efficiency and Renewable Energy, Washington DC. Accessible at http://buildingsdatabook.eren.doe.gov/

U.S. EPA. Method TO-1. 1984. Method for the Determination of Volatile Organic Compounds in Ambient Air Using Tenax Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS). *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition* (EPA/625/R-96/010b). This method is accessible at http://www.epa.gov/ttn/amtic/airtox.html

U.S. EPA. Method TO-17. 1997. Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition* (EPA/625/R-96/010b). This method is accessible at http://www.epa.gov/ttn/amtic/airtox.html

1.3 Terminology

1.3.1 Acronyms and Abbreviations

ARB – Air Resources Board, Cal/EPA

ANSI – American National Standards Institute

ASHRAE – American Society of Heating Refrigerating and Air Conditioning Engineers

ASTM – American Society for Testing and Materials

BIFMA – Business and Institutional Furniture Manufacturer's Association International

CDPH – California Department of Public Health

Cal/EPA – California Environmental Protection Agency

CHPS – Collaborative for High Performance Schools

CIWMB – California Integrated Waste Management Board, Cal/EPA

DNPH – 2,4-Dintrophenylhydrazine

DOE – U.S. Department of Energy

EF – Emission factor

EPA – U.S. Environmental Protection Agency

GC/MS – Gas chromatography/mass spectrometry

HAP – Hazardous Air Pollutant

HPLC – High performance liquid chromatography

IAQ – Indoor air Quality

ISO – International Standards Organization

LEED – Leadership in Energy and Environmental Design Green Building Rating System™

LOQ – Limit of quantitation, lower

MDF – Medium density fiberboard

MFC – Mass flow controller

MSDS – Material safety data sheet

NAHB – National Association of Home Builders

OEHHA – Office of Environmental Health Hazard Assessment, Cal/EPA

OSB – Oriented strand board

QMS – Quality management system

REL – Reference exposure level

RH – Relative humidity in percent

TAC – Toxic Air Contaminant

TD-GC/MS – Thermal desorption GC/MS

TIC – Total ion-current chromatogram

TVOC – Total volatile organic compounds

UV – Ultraviolet wavelength

VCT – Vinyl composition tile

VOC – Volatile organic compound

1.3.2 **Definitions**

Air change rate – Ratio of volume of conditioned air brought into the emission test chamber or building space per unit time to the chamber or building space volume

Air flow rate – Air volume entering the emission test chamber per unit time

Air velocity – Air speed over the surface of the test specimen

Aldehydes – Formaldehyde, acetaldehyde and other carbonyl compounds detectable by derivatization with DNPH and analysis by HPLC

Area specific flow rate – Ratio of the inlet air flow rate to the nominal surface area of the product or the product test specimen

Background concentration – VOC concentrations in emission test chamber in the absence of a product test specimen

Chain-of-custody – Document providing written evidence of transfer of a product sample, air sample, or another document from one organization to another organization or from one individual to another individual within the same organization. Document is signed and dated by each party involved in the transfer

CREL – Noncancer chronic reference exposure level developed by Cal/EPA OEHHA. These are inhalation concentrations to which the general population, including sensitive individuals, may be exposed for long periods (10 years or more) without the likelihood of serious adverse systemic effects other than cancer.

Concentration – Mass of VOC per unit air volume expressed at standardized conditions for temperature and pressure (i.e., 298^{o} K, 101.3 kPa)

Data acquisition system – System used to monitor, acquire and store data defining the environmental conditions for an emission test

Emission factor – Mass of VOC emitted from a specific unit area of product surface per unit time. Other unit measures such as product mass or length may be used as appropriate

Emission rate – Mass of VOC emitted by an entire product or test specimen per unit time

Emission test chamber – Non-contaminating enclosure of defined volume with controlled environmental conditions for inlet air flow rate, temperature and humidity used for determination of VOC emissions from product test specimens

Loading factor – Ratio of the nominal exposed surface area of the product or the test specimen to the volume of the building space or the emission test chamber

Manufacturer's identification number – Unique product identifier from which a manufacturer is able to determine the product name, product category or subcategory, manufacturing location, date of manufacture, production line, and/or other pertinent identifying information for the product

Mass flow controller – Electronic device based on principle of thermal conductivity used to control the flow rate of air entering the emission test chamber and the flow rate of air passing through a sampling device

Product category – General group of similar products intended for a particular application and performance, such as VCT, laminated wood flooring, broadloom carpet, sheet vinyl flooring, plywood, OSB, interior paint, etc.

Product subcategory – Group of products within a product category having similar chemistry, construction, weight, formulation and manufacturing process and which may have a similar VOC emissions profile

Representative product sample – A product sample that is representative of the product manufactured and produced under typical operating conditions

Sampling interval – Time over which a single air sample is collected

Sampling period – Established time for collection of air sample from emission test chamber

Scan mode – Operation of an electron impact GC/MS to continually and repeatedly scan masses between m/z 35 – 350, or some other range

Sorbent tube – Solid phase sampling device through which a sample of chamber exhaust air at controlled flow rate is passed to capture VOCs. Device typically contains Tenax-TA, or equivalent, as primary sorbent material backed up by higher surface area sorbent material to quantitatively capture the most volatile VOCs

Specific emission rate – Emission rate normalized to the area, mass or length of a product (i.e., equivalent to emission factor)

Test specimen – Portion of representative sample prepared for emission testing in an emission test chamber following a defined procedure

Total-ion-current (TIC) chromatogram – Chromatographic representation of a GC/MS analysis produced as the sum of all of the scanned masses between m/z 35 – 350, or some other range

TVOC – Sum of the concentrations of all identified and unidentified VOCs between and including n-pentane through n-heptadecane (i.e., C_5 – C_{17}) as measured by the GC/MS TIC method and expressed as a toluene equivalent value

Ventilation rate – Same as air change rate

VOCs - Carbon-containing compounds (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates and ammonium carbonate) with vapor pressures at standard conditions approximately ranging between those for n-pentane through n-heptadecane. For the purposes of this method, formaldehyde and acetaldehyde are considered to be VOCs

Zero time – Time establishing the beginning of an emission test

1.3.3 **Symbols and Units**

Symbol	Description	Units
A	Projected surface area	m^2
N_{ACH}	Air change rate	h^{-1}
C_i	Concentration of VOC_i	$\mu g\ m^{-3}$
EF_A	Emission factor, area specific	$\mu g\ m^{-2}\ h^{-1}$
EF_P	Emission factor, unit specific	$\mu g\ h^{-1}$ per unit
L	Product loading factor	$m^2\ m^{-3}$
Q	Air flow rate	$m^3\ h^{-1}$
q_A	Area specific flow rate	$m^3\ h^{-1}\ m^{-2}$ ($m\ h^{-1}$)
q_P	Unit specific flow rate	$m^3\ h^{-1}$ per unit
t	Time after start of test	h or day
V	Volume	m^3

2 COLLECTION, PACKAGING, SHIPMENT, & DOCUMENTATION OF PRODUCT SAMPLES

2.1 Product Sample Collection

2.1.1 Purpose

Guidelines are established for the collection, handling and documentation of product samples to ensure the samples being tested are reliable, uncontaminated, and well preserved. The guidelines are generally consistent with ISO 16000-11:2006.

2.1.2 Personnel

2.1.2.1 Personnel in charge of sample collection must perform the task carefully and conscientiously. If the sampling is done improperly, the sample is in error and any subsequent analysis is invalid.

2.1.2.2 Because of the importance of proper sampling, individuals engaged in sample collection and handling must be qualified by training and experience and possess a thorough understanding of the relevant practices and techniques or, at a minimum, be under the direct supervision of such an individual.

2.1.3 Representative Sample

Samples selected for testing shall be representative of the product manufactured and produced under typical operating conditions. See Section 8.7 for additional guidelines.

2.1.4 Sample Preservation

Due to the adsorptive and absorptive nature of most products being tested, special care shall be taken to prevent contamination of the product sample from any external source, such as solvent-containing products, prior, during and subsequent to the sample collection procedure. Samples must be stored immediately after collection in airtight, moisture-proof containers/packaging to prevent contamination and to preserve their chemical integrity by preventing subsequent VOC emission losses.

2.1.5 Location of Sampling

The product type and manufacturing process determine the optimal sampling location as described in the sampling procedures. The sampling location/site shall be selected to allow for reproducible, easy access to a representative cross section of the product category. The location shall be documented.

2.1.6 **Sample Age**

2.1.6.1 With the exception of containerized products, samples shall be collected at the point of production as soon as possible after the normal manufacturing process. Samples shall be collected within 24 hours of production with the exceptions specified in Sections 2.1.9.2, 2.1.10.3 and 2.1.11.2 for individual product categories. Containerized products (i.e., paints, sealants, adhesives, and other wet products) shall be collected and shipped within three months of production.

2.1.6.2 Samples shall be shipped to the laboratory within 24 hours of actual collection.

2.1.6.3 Timing of sample collection shall be coordinated between the manufacturing facility and the testing laboratory to ensure that testing of samples can commence within 5 weeks of the actual production date, except for containerized products for which testing of samples shall commence within 4 weeks of receipt at the laboratory (maximum 4 months from actual production date).

2.1.6.4 The schedule for sample collection, shipping, specimen preparation, and testing is summarized in **Table 2-1**.

Table 2-1 Sample collection and testing chronology for products

Event	Schedule
Dry Products (e.g., resilient flooring, carpet, wallcovering, etc.)	
Manufacturing date	Production date establishes initial time
Sample collection	Within 24 hours of production (see specific exceptions in Sections 2.1.9.2, 2.1.10.3 and 2.1.11.2)
Shipment to laboratory	Within 24 hours of sample collection
Commence laboratory testing	Within 5 weeks of production
Containerized products (e.g., adhesive, sealant, paint, etc.)	
Manufacturing date	Production date establishes initial time
Shipment to laboratory	No more than 3 months after production
Commence laboratory testing	No more than 4 months after production

2.1.7 If cutting or other preparation of a test specimen at a testing laboratory is exceptionally difficult or requires highly specialized equipment, a fully prepared test specimen may be fabricated by the manufacturer and shipped to the laboratory following all other applicable procedures. Such fabrication procedures shall be fully documented and reported. All cutting and other tools used to prepare the test specimen shall be cleaned properly to avoid sample contamination.

2.1.8 **Sample Collection Procedures – General Considerations**

2.1.8.1 Samples shall be collected directly from the manufacturing or packing line within 24-hours of production unless otherwise specified below in Sections 2.1.9.2, 2.1.10.3 and 2.1.11.2. Products meeting the specific requirements described in Sections 2.1.9.2, 2.1.10.3 and 2.1.11.2 for individual product categories may be collected within 7 days of actual production. Sample size shall be determined based on the surface area needed for testing. Seal the samples with two layers of heavy-duty aluminum foil so the air space within the package is minimized and the seams are crimped to create an airtight seal. Use clear packaging tape to assure that the package is airtight. Label the foil package and place in a clear polyethylene or Mylar bag. No more than one hour shall elapse between collection and packaging.

2.1.8.2 A sample label, listing the manufacturer, sample ID, product name, and date and time of sample collection, shall be affixed to both the outside of the foil-wrapped product package and the outside of the bag.

2.1.9 **Sample Collection Procedures - Tile, strip, panel and plank products less than or equal to 2-feet wide including VCT, resilient floor tile, linoleum tile, wood floor strips, parquet flooring, laminated flooring, modular carpet tile, etc.**

2.1.9.1 A minimum of four representative tiles, strips or planks, each with a surface area that is greater than the surface area needed for testing, shall be collected. The tiles, strips or planks shall be stacked tightly together for packaging (normally face to back). Package the stack of samples as described in Sections 2.1.8.

2.1.9.2 Samples may be collected from consumer packages up to 7 days from the actual product completion date only if these packages contain tightly stacked pieces. A package containing stacked pieces shall be opened and a sufficient number of pieces shall be selected and withdrawn from the center of the stack to prepare the sample as described in Section 2.1.9.1.

2.1.10 **Sample Collection Procedures – Sheet and roll goods greater than 2-feet wide including broadloom carpet, sheet vinyl, sheet linoleum, carpet cushion, wallcovering, fabric, etc**.

2.1.10.1 A strip approximately one-foot wide (or wider depending on surface area needed for testing) shall be cut across the width of the roll. At least one foot shall be discarded from each end of the strip. The remaining material shall be cut into squares. A minimum of four squares is required. The squares shall be stacked tightly together face to back, and packaged as described in Section 2.1.8.

2.1.10.2 Wallcovering and other fabric may be collected as a full or partial production roll. In this case, the roll shall have at least 10 layers of material. Package samples as described in Sections 2.1.8.

2.1.10.3 Samples may be collected from tightly wound rolls up to 7 days from the actual production completion date by unrolling a minimum of 2 m or at least two full roll circumferences (i.e., roll diameter x 3.14 x 2) from the end of the roll.

2.1.11 **Sample Collection Procedures – Rigid panel products greater than 2-feet wide including gypsum board, other wall paneling, insulation board, OSB, MDF, plywood, particleboard, etc**.

2.1.11.1 For large panel products, the sample shall be taken at least 6 inches away from all edges of a panel. Within this boundary, the panel shall be cut into squares. A minimum of four squares is required. The squares shall be stacked tightly together face to back, and packaged as described in Sections 2.1.8.

2.1.11.2 Samples may be collected from stacks of panels without spacers up to 7 days from the actual production completion date by selecting a panel that is positioned at least three panels down from the top of the stack.

2.1.12 **Sample Collection Procedures – Insulation products**

2.1.12.1 Batt and roll insulation products – Remove one or two pieces of insulation from the center of a newly produced consumer package. Cut four 2-foot long sections across the width of the batt or roll. These may be cut into smaller sizes, 12-in by 12-in or larger, depending upon chamber size. Stack four pieces together, compress them to reduce the air volume and wrap them in two layers of heavy-duty aluminum foil. Package as described in Sections 2.1.8. It may be necessary to package thick insulation as two separate stacks. Alternately, an unopened consumer package may be shipped to the laboratory.

2.1.12.2 Blowing wools and loose fill insulation products – Collect insulation directly from the production line or from a newly produced consumer package. Remove enough material from the center of the package to produce at least one-cubic foot or more of installed insulation depending upon chamber size. Compress the material and package in one or two batches as described for batt and roll products. Alternatively, an unopened consumer package may be shipped to the laboratory.

2.1.12.3 Boards and rigid foam insulation products – Collect a board directly from the production line or from a newly produced consumer package. If removed from a consumer package, select a board from the center of the stack. Cut individual pieces at random, 12-in by 12-in or larger depending upon chamber size, from the board. Stack four pieces together and package as described for batt and roll products.

2.1.12.4 Spray foam insulation – Closed cell and open cell spray foam insulation test samples are prepared at the manufacturer's location following the product specifications. For a substrate, use a 12-in by 12-in piece of clean cardboard, or larger depending upon chamber size, and wrap with one layer of aluminum foil. Spray foam onto the substrate covering the large majority of the surface. Closed cell foam is sprayed to a thickness of 2 inch. Open cell foam is sprayed to a thickness of 4 inch or 6 inch depending upon application. Record the product names and lot numbers of the A- and B-side materials and the relevant equipment parameters (temperatures, pressures, etc.) for the application. For open cell foam, scarf the sample (i.e., remove the skin) one hour after application to a minimum thickness of 3.5 inch or 5.5 inch with a clean knife or saw (do not use a hot knife). Create two identical samples. Wrap each sample in two layers of aluminum foil and package as described for batt and roll products.

2.1.13 **Sample Collection Procedures – Containerized products including adhesives, sealants, paints, other coatings, primers and other "wet" products**.

2.1.13.1 Paints, other coatings and primers can be supplied in original, standard 1-quart or 1-gallon consumer containers.

2.1.13.2 Adhesives can be supplied in their consumer packaging such as an applicator tube or can if these are small (i.e., less than 1 gallon). Alternately, the samples of adhesives can

be collected in clean, unused paint cans (1-pint or 1-quart size). Special care is required to assure these samples are representative of the larger batches from which they are collected. Containers shall be filled so there is minimal unfilled headspace above or below the adhesive. The collection procedure shall be documented.

2.1.13.3 Samples of containerized products sent to a laboratory shall be accompanied by a Material Safety Data Sheet (MSDS) and a specification sheet that describes the products, lists the major chemical ingredients, identifies the intended uses, describes the application methods and coverage rates.

2.1.13.4 If specialized tools are required to apply a containerized product to a substrate (e.g., a specific notched trowel not readily obtainable in a hardware store) these tools also shall be supplied to the laboratory.

2.1.13.5 A sample label, listing the manufacturer, sample ID, and date and time of sample collection, shall be affixed to the outside of the product container.

2.1.13.6 Testing laboratories shall have the right to return the unused portion of any containerized product to the organization supplying the product for testing.

2.2 Packaging and Shipment of Samples

2.2.1 Product samples shall be carefully packaged in a cardboard box or other shipping container suitable for air shipment so that the sealed polyethylene or Mylar bag and the foil layers will not be damaged or punctured during shipment.

2.2.2 Only one product shall be placed in a shipping container.

2.2.3 The product sample shall be shipped in a manner to meet the timetable set in Table 2.1.

2.2.4 A chain of custody form described below (Section 2.3) shall be prepared for each sample. The form shall be completed, signed and attached to the outer bag containing the packaged sample using a clear plastic window envelope or equivalent method.

2.3 Chain-of-Custody Documentation

2.3.1 A completed and signed chain of custody form shall accompany each product sample

2.3.2 The chain-of-custody shall be executed every time the product sample moves between organizations or between physical facilities within an organization prior to be tested.

2.3.3 The chain of custody form shall be printed as a multi-layered carbonless copy form or if a single-layered form is used, each signatory shall sign, date and transmit the original and retain a photocopy for their record.

2.3.4 The chain of custody form shall include, at a minimum, the following information:

2.3.4.1 *Manufacturer/Company Details* – Name, Street Address, City, State/Province, Country, Zip/Postal Code

2.3.4.2 *Contact Details* – Contact Name, Title, Phone Number, E-mail Address

2.3.4.3 *Sample Details* – Sample ID, Product Category, Product Subcategory (if applicable), Product Name, Manufacturers Identification Number, Date Manufactured, Sample Collection Location, Sample Collection Date and Time, Sample Collected By, Number of Sample Pieces

2.3.4.4 *Shipping Details* – Packed By, Shipping Date, Carrier, Airbill Number (Carrier and Airbill Number may be filled in by Laboratory upon receipt)

2.3.4.5 *Ship to Laboratory* – Name, Street Address, City, State/Province, Country, Zip/Postal Code, Phone Number, Fax Number

2.3.4.6 *Laboratory Receiving Details* – Received By, Received Date, Condition of Shipping Package, Condition of Sample, Assigned Laboratory Material tracking Number

2.3.4.7 *Packaging Details* – Types of Air-tight Containers or Seals

2.3.4.8 *Signature Tracking Details* – Relinquished By, Received By, Signature, Company, Date and Time

2.4 Rejection of Samples by Laboratory

2.4.1 A testing laboratory shall have the right to reject a product sample for testing due to, but not limited to, any of the following reasons: damaged shipping or product packaging; incomplete or missing Chain of Custody; or sample receipt occurs too late to accommodate the last possible testing initiation date as stated in Section 2.1.6.3.

2.4.2 When a product sample is rejected, the testing laboratory shall inform the manufacturer within two days of the decision and provide the reason for rejection.

2.4.3 The manufacturer has the right to collect a new sample and resubmit it for testing, subject to the conditions described within this method. All costs for recollection and shipment shall be the responsibility of the manufacturer.

2.5 Receipt of Samples by Laboratory

2.5.1 As soon as practical after a package is received from the shipping company, the laboratory's sample custodian or other authorized personnel shall inspect the package and product container for visible signs of damage that could potentially affect the integrity of the product sample.

2.5.2 The product container (i.e., external bag, foil package, can, tube, etc) shall not be opened at this time.

2.5.3 The sample custodian shall note the condition of the package and container on the chain-of-custody form and sign and date the form.

2.5.4 If a package or container is significantly damaged or the other criteria are not met, the laboratory shall reject the sample as described in Section 2.4.

2.5.5 Valid samples shall be assigned a unique laboratory ID number. The sample information and the ID number shall be entered into the laboratory's sample-tracking database.

2.6 Storage of Samples by Laboratory Prior to Testing

Prior to testing, samples shall be stored in their original unopened containers in a conditioned space at typical indoor conditions. The samples shall be protected from chemical contamination and exposure to temperatures in excess of 25^{o}C and relative humidity in excess of 65%. Samples shall not be refrigerated or stored at reduced temperature.

3 LABORATORY SAMPLE PREPARATION, TESTING, CHEMICAL ANALYSES AND CALCULATIONS

3.1 Test Specimen Preparation

3.1.1 For product assemblies (e.g., wall paint primer and finish coat, wallcoverings, and floor systems where the finish material is applied to a substrate, with or without the use of adhesives), the individual products comprising the assembly shall be tested separately. If all individual products meet the emissions criteria established herein, no further testing is required. For assemblies where one component, such as an adhesive, does not meet the criteria, the products may be tested together with assembly preparation following the manufacturer's recommended procedures. If the products are tested as an assembly, test results are only applicable to this particular assembly configuration.

3.1.2 Products manufactured to arrive on site preassembled (e.g., adhesive impregnated wallpaper, adhesive applied floor tiles, or raised floor panels of sandwich construction with adhesive between layers) shall be tested as an a single unit, that is, the manufacturer is not required to submit separate samples of the primary material and adhesive for testing.

3.1.3 The dimensions shall be optimized for small-scale test chambers with volumes of 50 L to 1 m^3 operating at 1 ± 0.05 air change per hour to achieve the loading factor of 0.3 – 1.0 $m^2\ m^{-3}$ as specified in Table 3.1. See also Section 3.8.2 for more information.

3.1.4 For products not covered in this specification, it may be necessary to develop alternate procedures for preparation of test specimens. If procedures other than described in this section are used, they shall be fully described and reported.

3.1.5 A fraction of the specimens shall be prepared in duplicate from the same product sample. See Section 3.8.5.5 for the required fraction of duplicates.

3.1.6 Completion of specimen preparation and placement of the test specimen in the conditioning environment shall be regarded as the starting time for the VOC emission test (i.e., zero time).

3.1.7 If special substrates and/or edge sealing materials (i.e., gypsum board and aluminized tape) are required for specimen preparation, appropriate tests shall be conducted to determine background concentrations of VOCs for these materials. They shall not emit VOCs above the limits specified for the chamber background. Additionally, an attempt shall be made to use materials that do not emit measurable amounts of any target VOC of concern. In some cases, it may be acceptable to perform background tests for batches or lots of substrate materials and subtract background values from test values.

3.1.8 Use clean, stainless steel plates or trays for single-sided sample tests. Samples requiring multiple side exposure should be suspended within the chamber. Special substrates, such as gypsum board, shall be conditioned at 23 ± 2°C, 50 ± 10 % RH while ventilated with clean air for twenty-four hours before use.

3.2 Preparation of Paint Test Specimens

3.2.1 Apply "flat" and "eggshell" wall paints to conditioned standard 5/8" thick gypsum board (e.g., USG Sheetrock brand or equivalent). The substrate size shall be appropriate to achieve the specified loading factor (Table 3.1). Just prior to painting, accurately weigh (±0.1 g) substrate, mask borders ¼" on all sides with tape (e.g., 3M Scotch-Blue™ Painter's masking tape, or equivalent) to avoid paint dripping on edges. Accurately measure (±2 mm) the dimensions of the area to be painted. Alternative approaches for protecting the edges may be acceptable and shall be reported if used.

3.2.1.1 Apply paint using a standardized roller procedure that simulates application of paint in a building by this technique. For most wall paint applications, use a 4" wide 3/8" nap roller intended for smooth surfaces. Alternate methods shall be reported if used.

3.2.1.2 Thoroughly stir paint in the container and transfer 100 mL of paint to a heavy-duty aluminum foil disposable tray, or equivalent.

3.2.1.3 Completely saturate roller cover with paint by running roller back and forth in tray.

3.2.1.4 Apply paint to substrate using four strokes, two in vertical direction and two in horizontal direction, so the entire area is uniformly covered. For most wall paints, use a single loaded roller application.

3.2.1.5 Remove tape mask from substrate and re-weigh substrate. Difference in weight before and after painting determines mass of applied paint and coverage in grams of wet paint per square meter of substrate surface. The measured mass amount shall be compared with the desired mass of paint to be applied to substrate. This comparison is used to check whether the paint has been properly applied to the substrate. The desired mass is calculated as the paint product density (g/L) divided by the manufacturer's recommended paint coverage (m^2/L) and then multiplied by the painted area of test specimens. Unless otherwise specified, use a coverage of 350 ft^2/gal (or 8.6 m^2/L).

3.2.1.6 Place substrate on a piece of sheet stainless steel to cover entirely the back surface. Attach substrate to stainless steel with strips of aluminized tape emitting no VOCs so only the painted surface is exposed. *(Note: a variety of aluminized tapes are available including tapes manufactured specifically for cleanroom use. As specified in Section 3.1.7, appropriate background tests shall be performed to demonstrate selected tape is not a source of VOC contamination. Also note that it may be more convenient to seal the back and edges of the substrate prior to applying paint.)* For a blank specimen, similarly prepare an unpainted piece of gypsum board. Alternate procedures to cover unpainted surfaces of gypsum board may be acceptable and shall be reported if used.

3.2.1.7 Immediately transfer specimen to conditioning environment and record the time.

3.2.1.8 Where multiple coats of paint, which may include primer, are being tested, apply paints as described above and follow manufacturers' instructions for minimum or optimal drying time between coats. Report weight of test specimen prior to and after each coat of paint is applied. Hold specimen in conditioning environment between coats. The test period begins immediately after application of final coat.

3.2.2 Apply "semi-gloss" and "gloss" paint to a clean stainless steel sheet metal following the procedure described above. Mask edges of substrate as described to create the appropriate exposed area. Substrate shall be weighed immediately before and after painting.

3.2.3 Some types of finishes are designed for specific substrates. One category of specialized finishes consists of dyes, sealers, hardeners and toppings for concrete floors. Such products require a porous surface for proper application and curing. If gypsum board or stainless steel sheet metal is an inappropriate substrate for a specialized finish, an alternate substrate may be used. The laboratory shall provide full description of the substrate in the test report if any alternate substrate is used. Condition the substrate prior to use as discussed in Section 3.1.8.

3.3 Preparation of Adhesive Product Test Specimens

3.3.1 Apply adhesive to clean stainless steel sheet metal plate unless product is specifically designed to be applied to gypsum board. If the choice of substrate is optional, a sheet metal plate shall be used. If substrate is gypsum board, condition as described in Section 3.1.8.

3.3.1.1 Accurately weigh (±0.1 g) substrate before applying adhesive. If substrate is gypsum board, mask boarders with tape as described for paint application (Section 3.2.1). Accurately measure (±2 mm) the dimensions of the area to which the adhesive will be applied.

3.3.1.2 Thoroughly mix adhesive in container and apply to entire surface of substrate or masked area with a notched trowel, nap roller or spray applicator based on manufacturer's recommendations, closely matching the dimensions of manufacturer's specified tool. Record the details of the applicator used (i.e., dimensions of the trowel).

3.3.1.3 Re-weigh substrate after removing tape mask from substrate, if applicable. Difference in weight before and after application is used to determine mass of applied adhesive and coverage in grams of wet adhesive per square meter of substrate surface. The measured mass amount shall be compared with the desired mass of adhesive to be applied. This is used to check whether the adhesive has been properly applied to the substrate. The desired mass is calculated as the adhesive product density (g/L) divided by manufacturer's recommended coverage (m^2/L) and then multiplied by the area of the test specimen.

3.3.1.4 If substrate is porous material, complete preparation of test specimen by covering back and cut edges as described in Section 3.2.1.6.

3.3.1.5 Immediately transfer specimen to conditioning environment and record the time.

3.4 Preparation of Caulking Product Test Specimens

3.4.1 Apply caulks, sealants, adhesives and other products supplied in tube applicators or containers into a metal channel (aluminum, brass or stainless steel). The width and height of the metal channel shall match the intended diameter of the caulk bead, i.e., either ¼" or 3/8" and shall be 6" to 10" in length (or as appropriate for chamber size).

3.4.1.1 Accurately weigh (±0.1 g) and measure (±2 mm) metal channel before applying caulk.

3.4.1.2 Insert the container into a caulk gun. Cut the applicator tip to produce the desired bead width. Dispense approximately 100 g from the container and discard. Then, fill the metal channel with caulk using a single, smooth stroke of the gun. Wipe any excess caulk from the exterior of the channel.

3.4.1.3 Re-weigh the channel after applying the caulk. Difference in weight before and after application determines mass of applied caulk and coverage in grams of wet caulk per linear meter of a defined-size bead.

3.4.1.4 Immediately transfer specimen to conditioning environment and record the time.

3.5 Selection and Preparation of Dry Product Test Specimens

3.5.1 The period of time between unpacking a product sample and preparation of the test specimen shall be as short as practical, one-hour or less, with exceptions reported. The time of placement of the specimen in the conditioning environment shall be recorded.

3.5.2 All surface dimensions of specimens shall be accurately measured (±2 mm) after they are cut. It also may be necessary to measure the thickness of the specimen. The actual exposed surface dimensions of the specimen shall be measured. Exclude any portion of the surface that is masked with aluminized tape or otherwise covered.

3.5.3 **Selection of test specimen from package containing stacked pieces of the product samples**: Open the packaging containing the product sample. Select a piece from the center of the stack in a random manner, i.e., do not purposefully select the piece based on any appearance characteristic. Cut the specimen from the center of the selected piece at least 1" away from the previously cut edges. Exceptions are products for which it may be important to incorporate a factory-finished edge into the VOC emission test (e.g., laminate counter top, acoustical ceiling panel, etc.) For these products, cut the specimen from the selected piece leaving one factory-finished edge.

3.5.4 **Selection of test specimens from sample rolls (e.g., wallcoverings and other fabrics)**: Open the package containing the product sample. Discard at least the outer two layers of the roll. Cut the test specimen from the remaining material at least 4" away from the factory-finished edges.

3.5.5 **Dry specimen preparation techniques:** Depending on the product being tested, there are a few variations in preparation technique. Some products, such as resilient flooring, are cut to size and placed on a stainless steel plate with either edge taping or in a stainless steel tray that conceals the edges. Carpet is cut to size and placed in a stainless steel tray that provides tight fit at edges. Insulation specimens are normally prepared and tested as tray-fitted specimens since insulation products are typically used where only one side is exposed or facing toward the occupied space. Any alternate specimen preparation procedures, such as for insulation products with more than one surface exposed, shall be fully described.

3.5.5.1 **Stainless steel plate with edge-taping:** Cut a square to the appropriate size and place on a clean stainless steel plate. Attach the specimen to the plate using strips of low VOC aluminized tape so that the edges are masked by at least ¼ - inch. Composite wood products, gypsum boards and similar rigid wall panels, sheet and tile resilient flooring and wallcovering products are tested with this preparation.

3.5.5.2 **Tray-fitted specimens:** Cut the specimen to fit snugly within a clean, stainless steel tray. Broadloom carpet, carpet cushion and carpet tile are tested with this preparation. Sheet and tile resilient flooring may be tested with this preparation. For batt and roll insulation products, cut the specimen to fit an appropriately-sized stainless steel tray, e.g., 3.5-in deep for many wall applications and 6-in deep for many ceiling and floor

applications. A product facing material, if present, is exposed to chamber air. For blowing wools and loose fill insulation products, the mass of blowing wools and loose fill insulation to be added to an appropriately-sized tray is calculated based on the manufacturer's recommended installed density. Weight this amount and pour/pack it into the tray. For spray foams and other rigid insulation products, samples are trimmed to size and placed into an appropriately-sized tray. Weigh spray foam specimens and calculate product density.

3.5.5.3 **Specimens not requiring substrate:** Cut the specimen to the appropriate size and place in the conditioning environment. The exposed area for calculation of emission factors and room concentrations is considered to be the area of the primary face. Acoustical ceiling panels, woven and nonwoven fabrics not used as wallcovering (e.g., upholstery fabric) are tested using this preparation.

3.5.5.4 **Special considerations:** (a) Acoustical Ceiling Panels – include one factory finished edge when preparing the specimen and test with both sides exposed. Use the primary face area for the concentration modeling calculation.

3.6 Preparation of Dry Product Test Specimen Assemblies

3.6.1 Products tested as assemblies are generally either adhered to a substrate or glued directly to a stainless steel plate or tray.

3.6.2 Assemblies shall utilize the manufacturer's recommended adhesive and procedures.

3.6.3 **Specific Requirements**

3.6.3.1 **Tile and broadloom carpeting applied with adhesives:** Fit into a stainless steel tray that provides tight fit at edges.

3.6.3.2 **Laminates or wood veneers applied with adhesives:** Use no-added formaldehyde medium density fiberboard (MDF) as a substrate; Seal the edges as described in Section 3.5.5.1. Alternately, if a specimen of appropriate size is produced by a manufacturer specifically for VOC emission testing, it is recommended that the core be fully encapsulated so all six sides are covered with the finish material.

3.6.3.3 **Sheet and tile resilient flooring applied with adhesives:** Adhere directly to a stainless steel plate. Seal the edges as described in Section 3.5.5.1.

3.6.3.4 **Wallcoverings applied with adhesives:** Wallcoverings are adhered to a conditioned, gypsum board substrate. Seal the edges as described in Section 3.5.5.1.

3.7 Conditioning of Test Specimens

3.7.1 **Principle:** The principle of conditioning is to maintain test specimens in clean air at controlled conditions of temperature and RH for a defined period of 10 days before initiating a 96-hour test in a small-scale test chamber at more precisely controlled conditions. In this manner, the final VOC measurements determining the suitability of a product are made after the specimen has been exposed for a total of 14 days. Fourteen days represents an early, but realistic, time for first occupancy after new building construction or major renovation. At the 14-day time point, the emissions of VOCs from most products primarily will be dependent upon the characteristic diffusion rate of the VOCs within the material and the concentration of the VOCs in the bulk material and should change slowly from day to day and from week to week. Thus, minor differences in product sample age at the time of collection should be partially or wholly compensated

for by use of a 10-day conditioning period and any minor surface contamination not directly related to the content of VOCs in the bulk material should be eliminated. Also, the potential effect of external mass transfer resistance on the emission rates of most VOCs should be diminished substantially after 10 days of conditioning. Incorporation of conditioning into a product testing method is described in ISO 16000-9:2006, Section 12.3.

3.7.2 **Apparatus:** Conditioning can be accomplished by different approaches using different apparatus. Product specimens can be maintained for the entire 14-day period in the emission test chambers. A potentially less expensive approach utilizes a specially constructed facility. This facility is based on an isolated room constructed entirely with low emitting and low sorbing interior surfaces such as stainless steel sheet metal. The room is supplied with acceptably clean air and maintained at controlled temperature and RH conditions. The test specimens are maintained in separate metal containers with ventilation air drawn into each container from the room.

3.7.2.1 **Emission test chambers:** If the emission test chambers are used for conditioning, the apparatus and procedures described in Section 3.8 shall apply.

3.7.2.2 **Separate containers for conditioning specimens:** Specimens shall be placed in individual clean metal containers with a volume of at least 10-L. Containers shall be kept in a conditioned environment (room). The conditioned room shall be operated with a clean air supply at a minimum of 2 air changes per hour. Containers shall be of sufficient size so air freely circulates through the container and all emitting surfaces of prepared specimens are exposed to circulating air. Air shall be drawn through the containers with a vacuum system at a flow rate that provides an area specific flow rate nearly equivalent (i.e., within ± 20%) to the area specific flow rate achieved in the emission test chamber. Alternatively, the containers may be operated at the same flow rate with clean air supplied at the inlet by a pressurized source.

3.7.3 **Clean air supply:** The air used to supply the conditioning environment shall contain low levels of VOCs and shall be filtered for particulate matter. The supply air, if not from gas cylinders, shall pass through an active filtration system consisting of a bed of granulated activated carbon (or other methods specifically designed for removing organic compounds) and a particle filter. The VOC content of the supply air shall not exceed 5 $\mu g/m^3$ for any individual compound including formaldehyde and 25 $\mu g/m^3$ for TVOC.

3.7.4 **Temperature and relative humidity control:** The temperature and humidity of the air to which specimens are exposed during the conditioning period shall be maintained within ranges of 23 ± 2^o C and 50 ± 10% RH.

3.7.5 **Verification of conditions:** The airflow rates to a conditioning room and to individual containers used for conditioning shall be measured and recorded on a periodic basis according to the laboratory's quality management system. The temperature and relative humidity of a conditioning room or of emission test chambers used for conditioning shall be continuously monitored and recorded using temperature/RH probes and a data acquisition system. The air used for conditioning periodically shall be sampled and analyzed for VOCs, aldehydes and TVOC on at least a monthly basis according to the laboratory's quality management system.

3.7.6 **Time:** Placement of a test specimen in the conditioning environment establishes the beginning of the test period. This critical time shall be recorded and all subsequent times for transfer of the specimen to the test chamber and collection of air samples from the chamber shall be scheduled relative to this initial zero time. A ± 2% deviation in transfer time and sampling times is allowed. Thus, transfer from the conditioning environment to the test chamber shall occur at an elapsed time of 10 days ± 5 hours.

3.8 Environmental Chamber Testing

3.8.1 **Principle**: The principle of the test is to determine the specific emission rates of VOCs emitted from prepared specimens of building products. The test is conducted in a small-scale environmental chamber at specified constant conditions of temperature, relative humidity, ventilation rate and product loading factor. The chamber is considered to be a constantly stirred tank reactor. As the air in the chamber is fully mixed, VOC concentrations measured at the chamber exhaust are representative of air concentrations in the chamber. From the airflow rate into the chamber, the VOC concentration, and the exposed surface area of the specimen, an area-specific emission rate or emission factor is calculated using the steady-state form of the mass-balance model. The chamber test is conducted following the guidance of ASTM Standard D 5116-06. ISO 16000-9:2006 provides additional guidance.

3.8.2 **Test Conditions**: The test shall be conducted at the conditions and within the limits specified in **Table 3-1**. Standard conditions for the purpose of calibrating flow measurement devices and calculating all flow rates shall be 25^{o} C (298^{o} K) and one atmosphere pressure (101.3 kPa). The chamber volume shall be between 50 L and 1 m^3. The chamber shall be ventilated at 1 ± 0.05 air changes per hour. The loading factor shall be optimized to produce an area specific flow rate approximately equal to the area specific flow rate for the product in the modeled scenarios (Section 4.2). For example, a value of 0.5 m^2 of exposed specimen surface area per m^{-3} chamber volume results in an area specific flow rate of 2 m^3 h^{-1} m^{-2} (m h^{-1}), which is close to the value for many materials in both the classroom and private office scenarios. A loading factor of 0.3 to 1.0 m^2 m^{-3} is allowed for all materials. Specimen sizes are to be adjusted according to the chamber volume to achieve the specified loading factors.

Table 3-1 Chamber conditions for 96-h test period

Parameter	Symbol	Units	Value
Chamber volume	V	m^3	0.05 – 1.0
Loading factor [1]	L	$m^2\ m^{-3}$	0.3 – 1.0
Air change rate	a	h^{-1}	1.0 ± 0.05
Area specific flow rate	q_A	$m\ h^{-1}$	1.0 – 3.3
Temperature	T	^oC	23 ± 1 [2]
Relative humidity	RH	%	50 ± 5 [2]

1. Specimen sizes are to be adjusted according to the chamber volume to achieve the specified loading factor range. See Sections 3.1.3 and 3.8.2
2. Values must be within range for at least 90% time throughout the 96-h test, and within range during sampling and for three air changes prior to sampling. See section 3.8.4.

3.8.3 **Duration**: The chamber test shall last 96 hours. Sealing of the chamber lid/door following insertion of the product specimen into the chamber establishes the starting time for the chamber test, following 10 days of conditioning.

3.8.4 **Apparatus and Facilities**: The apparatus and facilities shall be constructed to maintain the test specimen at the specified conditions within a non-contaminating and low sorption environment.

3.8.4.1 **Clean air supply and flow control:** A clean air generator or high purity air cylinders shall be used to supply pressurized clean, dry air. The flow rate of the supply air to a chamber shall be regulated and monitored with electronic mass flow controllers (MFCs), or equivalent, with an accuracy of ± 2 % of full scale, or better, and capable of continuously maintaining the flow within ± 5 % of the specified value. The supply air flow rate shall be maintained within ± 5 % of the specified value throughout the 96-hr test. MFCs shall be calibrated periodically according to the Laboratory's quality management system. At a minimum, flow measurement devices shall be calibrated on an annual basis against NIST traceable standards. As the humidity of the supply air is maintained by mixing dry and saturated gas streams, two mass flow controllers may be required per chamber (i.e., one for the dry stream and one for the wet stream). The dry and wet streams shall be mixed before the supply air enters the chamber.

3.8.4.2 **Chamber and materials:** The chamber volume shall be between 50 L and 1 m^3. The chamber shall be constructed of stainless steel. Stainless steel chambers shall have electro-polished, or equivalent, interior surfaces. Either rectangular or cylindrical shapes are acceptable. The chamber shall be designed as a single-pass system without recirculation of chamber air. The chamber shall be operated at a slight positive pressure relative to the room to prevent the entrainment of room air. The chamber inlet and exhaust shall be positioned and designed to ensure complete mixing of chamber air. The chamber lid/door shall have a non-contaminating, non-sorbing gasket and a closure mechanism to create an airtight seal. Other materials introduced into to the chamber (e.g., racks and probes) shall be constructed of non-contaminating materials such as stainless steel.

3.8.4.3 **Background concentrations** in the empty chamber ventilated at 1.0 air changes per hour shall not exceed 2 µg m^{-3} for any individual VOC, and 25µg m^{-3} for TVOC.

3.8.4.4 **Temperature and humidity control:** The temperature of the chamber shall be maintained within the range of 23 ± 1°C for at least 90% time throughout the 96-hr test, and within range during sampling and for three air changes prior to sampling. In no case shall the temperature range exceed 23 ± 2°C. All surfaces of the chamber shall be held at the same temperature so that the temperature inside the chamber is uniform. Typically, this is accomplished by placing the chamber inside a temperature-controlled environment such as an incubator or a dedicated room. The humidity of the chamber air shall be maintained within the range of 50 ± 5% RH for at least 90% time throughout the 96-h test, and within range during sampling and for three air changes prior to sampling. In no case shall the relative humidity range exceed 50 ± 10% RH. As wet products (e.g., water-based paints) will have 10 days of prior conditioning, the RH of the chamber air should be nearly equivalent to the RH of the inlet air. Thus, the humidity can be established by controlling the humidity of the inlet air. Generally, this is accomplished by mixing equivalent flows of dry and water saturated air streams. Water used in bubblers to saturate gas streams shall be free of organic solvents and contaminants (i.e., HPLC grade or equivalent).

3.8.4.5 **Monitoring and data acquisition:** The temperature and relative humidity for a chamber shall be measured continuously and independently of the systems for controlling temperature and humidity. The measurements shall be made inside the chamber or immediately at the chamber exhaust using electronic probes. The probes shall be calibrated periodically according to the laboratory's quality management system. At a minimum, these probes shall be calibrated on an annual basis against NIST traceable standards. Chamber inlet flow rates, temperature and relative humidity shall be recorded using a computer-based data acquisition system. At a minimum, these data shall be recorded at 5-minute intervals.

3.8.5 **Procedures**

3.8.5.1 **Chamber cleaning and preparation:** Prior to reuse, the chamber shall be fully disassembled and washed. At a minimum, the chamber and components shall be washed with a dilute solution of laboratory detergent in warm water, thoroughly rinsed with clean water and dried. Alternative cleaning methods may be used provided that the background chamber concentrations can meet the requirements specified in section 3.8.4.3. The clean chamber shall be operated at the test conditions for a minimum of three full air changes prior to making a background measurement or introducing a test specimen.

3.8.5.2 **Background measurement:** Chamber background measurements shall be made on a regular basis according to the laboratory's quality management system. At a minimum, the background of VOCs and aldehydes shall be determined prior to each third use of a chamber. VOC and aldehyde samples are to be collected as described in Section 3.8.6 to provide lower quantitation limits of at least 2 µg m^{-3} for individual VOCs and 25 µg m^{-3} for TVOC.

3.8.5.3 **Specimen loading:** Test specimens shall be taken directly from the conditioning facility and placed in a cleaned test chamber minimizing the time the specimen is exposed to laboratory air. Generally, this time shall not exceed 15 minutes. In a rectangular chamber with flat surfaces, the specimen may be placed directly on the floor of the

chamber without additional support. In a horizontally oriented cylindrical chamber, a wire rack shall be used to hold the specimen near the midpoint of the chamber. A wire rack may also be used in a rectangular chamber. There shall be sufficient space for chamber air to circulate freely around the exposed face of the specimen. The specimen loading factor shall be 0.3 - 1.0 m^2 m^{-3}.

3.8.5.4 **Chamber air leakage:** The air leakage of the chamber shall be determined immediately after loading a test specimen. This is accomplished by measuring the flow rate at the chamber exhaust and comparing this to the supply airflow rate. The flow measurement device shall have low pressure drop. Bubble flow meters and low-pressure drop rotameters are suitable for use. The exhaust flow rate shall be within 10% of the inlet flow rate by this method.

3.8.5.5 **Replicate chamber tests:** A fraction of the tests shall be conducted in replicate using specimens prepared from the same product sample. The fraction of replicates is determined by the laboratory's quality management system, but at least one replicate is required for every twenty tests.

3.8.6 **Air Sampling**

3.8.6.1 **Sampling schedule:** Chamber air samples shall be collected at average elapsed times of 24, 48 and 96 hours after initiating the chamber test.

3.8.6.1.1 **At 24 and 48 hours**, only samples for formaldehyde and TVOC analyses are required to be collected. These first measurements, when compared to the corresponding 96-h measurements, are used to determine whether the chamber concentrations remained relatively constant or declined slowly throughout the test. Temporal variations or fluctuations outside of the normally expected range (e.g., ± 25%) likely indicate that a test parameter was uncontrolled or an analysis was incorrect. In this case, the cause of the variations shall be determined and the test repeated if necessary.

3.8.6.1.2 **At an average time of 96 ± 2 hours** after initiating the test, samples for the full characterization of VOC emissions shall be collected.

3.8.6.2 **Sampling media**

3.8.6.2.1 **VOC sampling media** for individual VOCs and TVOC shall consist of thermally desorbed, solid-phase sorption tubes. Refer to ASTM Standards D6196-03 and D 6345-98 (2004), and U.S. EPA Methods TO-1 and TO-17 for guidance. The samplers shall be capable of quantitatively collecting VOCs with a broad range of functional groups and volatilities approximately within the volatility range of n-pentane through n-heptadecane (C_5 - C_{17}). Minimal losses of analytes (i.e., <5%) due to breakthrough shall occur. This can be accomplished by the use of sampling tubes containing two or more sorbent materials in series, with the highest surface area material used as the backup to prevent the breakthrough of the most volatile compounds. Typical sorption tubes contain Tenax-TA as the primary sorbent backed up by carbonaceous sorbent(s). Before use, samplers shall be conditioned by thermal desorption. Samplers taken from refrigerated storage shall be warmed to room temperature prior to use.

3.8.6.2.2 **Sampling media** for formaldehyde, acetaldehyde and other low molecular weight aldehydes through butanal (C_4 aldehydes) shall consist of cartridges containing a solid support material (e.g., silica gel) treated with an acid solution of 2,4-dinitrophenylhydrazine (DNPH) as a derivatizing reagent. Refer to ASTM Standard D 5197-03 for guidance. Samplers shall be warmed to room temperature prior to use.

3.8.6.3 **Flow control:** Sampling flow rates shall be regulated with electronic mass flow controllers, or equivalent, with an accuracy of ±2% of full scale, or better, and capable of continuously maintaining the flow during sampling within ±5% of the specified value.

3.8.6.4 **Sampling procedures:** Air samples shall be collected directly from the chamber exhaust at the specified elapsed times. A short manifold with multiple ports and a maximum length of 6 in (15 cm) may be used at the exhaust to allow simultaneous collection of multiple samples. No other tubing is allowed between the chamber exhaust and the sampler inlet. The DNPH cartridge is placed downstream of the VOC sorption tubes to reduce the chance of VOC sample contamination with residual acetontrile that may be present in the DNPH cartridge. The total sampling flow rate at any time shall not exceed 75% of the inlet flow rate. The start and stop times and the sampling flow rates shall be recorded. A unique identification number shall be assigned to each air sample.

3.8.6.5 **Duplicate air samples:** A fraction of the samples shall be collected in duplicate. The fraction of duplicates is determined by the laboratory's quality management system, but at least one duplicate is required for every ten samples.

3.8.6.6 **Sampler storage:** Following collection, air samples shall be sealed in clean airtight containers and stored at reduced temperature in a dedicated refrigerator or freezer. Samples shall be analyzed as soon as practical after collection. Use unexposed samplers as storage blanks.

3.9 Chemical Analyses

3.9.1 **Principle**: Chamber air samples are analyzed using instrumental methods that are capable of positively identifying individual VOCs and quantifying them using multi-point calibrations prepared using pure standards. The methods provide sufficient sensitivity and accuracy to reliably quantify individual VOCs at concentrations of 2 µg m^{-3}, or less.

3.9.2 Analytical Instruments

3.9.2.1 VOCs and TVOC: Sorbent tube samples for individual VOCs and TVOC shall be analyzed by thermal desorption GC/MS (TD-GC/MS). The thermal desorber desorption and inlet parameters shall be optimized to obtain quantitative recovery of VOCs in the range defined in Section 3.8. The GC column and oven temperature parameters shall be optimized for the analysis of volatiles. The MS shall be an electron impact instrument operated in the scanning mode over a mass range of at least *m/z* 35-350.

3.9.2.2 Formaldehyde, acetaldehyde and other low molecular weight aldehydes: Aldehyde samples shall be analyzed by HPLC equipped with a UV detector and an analytical column providing full resolution of the formaldehyde hydrazone derivative from unreacted DNPH in a sample.

3.9.3 Methods for Individual VOCs

3.9.3.1 The analytical methods for individual VOCs shall be based on ASTM Standard D 6196-03, ASTM Standard D 7339-07, and U.S. EPA Methods TO17 and TO-1, or equivalent methods. Standards and chamber samples shall be analyzed using identical conditions.

3.9.3.2 The analytical methods for formaldehyde, acetaldehyde and other low molecular weight aldehydes shall be based on ASTM Standard D 5197-03, or an equivalent method. It is

recognized that unsaturated low molecular weight aldehydes such as acrolein are not accurately determined by this method. Aldehydes with molecular weights equal or greater than that of butanal can be analyzed by TD-GC/MS.

3.9.4 **TVOC Method**

3.9.4.1 Because the TVOC results are dependent upon the details of the analytical method and because there are substantial variations in the TIC response of VOCs with different chemical functionality, the analysis of TVOC is a semi-quantitative measure that is inherently less accurate than the calibrated measurement of individual VOCs. Formaldehyde and acetaldehyde are not included in TVOC calculations.

3.9.4.2 The TVOC method shall span a retention time interval consistent with the analysis of individual VOCs. Per definition of TVOC used in this Method, the mass range is n-pentane through n-heptadecane (i.e., $C_5 – C_{17}$). Use toluene as the reference compound for calculating TVOC mass.

3.9.4.2.1 The integrated TIC areas in a sample less the TIC area of the internal standard are summed over the retention time interval. The ratio of summed area to the area of the internal standard is calculated. This value is multiplied by the internal standard mass to obtain the internal standard equivalent sample mass.

3.9.4.2.2 When using toluene-d_8 as the internal standard, the toluene-equivalent sample mass is calculated as the internal standard equivalent sample mass times the ratio of the density of toluene to toluene-d8 (i.e., 0.860/0.943).

3.9.4.2.3 When using another internal standard (e.g., 1-bromo-4-fluorobenzene), determine the Toluene /internal standard TIC response factor by analyzing at least two toluene calibration standards within the linear response range for toluene. For each level, the TIC response of the internal standard and the TIC response of toluene are divided by their corresponding masses in nanograms to produce normalized area-per-unit mass responses. Then area/mass relative responses are determined by dividing the normalized values for toluene by the normalized value for the internal standard. The relative responses from each calibration level are averaged to produce an average toluene response factor. The internal standard equivalent sample mass is then divided by this average toluene response factor to produce a toluene-equivalent sample mass.

3.9.4.3 Alternate TVOC test methods (e.g., use of $C_6 – C_{16}$ as the mass range) may be used. The laboratory shall provide full method description in the test report if any alternate TVOC method is used.

3.9.5 **Identification of Individual VOCs**

3.9.5.1 The identification of an individual VOC by GC/MS shall be determined by comparing the chromatographic retention time and mass spectrum of the unknown to the corresponding parameters for the pure compound analyzed on the same instrument using identical methods. Matching retention times and mass spectra provide positive, confirmed identifications. All VOCs of concern occurring on the referenced list (Section 4.1) that can be analyzed by this method shall be positively identified.

3.9.5.2 If no high quality match is obtained, the unknown spectrum is compared to spectra contained in the latest version of the NIST electronic database. A trained analyst shall decide if the identification is likely based on the match quality and the reasonableness of the retention time. Compounds identified by this procedure shall be clearly

indicated. If no highly probable match is obtained, the compound shall be labeled as an unknown.

3.9.5.3 Aldehyde hydrazone derivatives analyzed by HPLC shall be identified by matching the chromatographic retention times of the unknowns with the retention times of derivatives of the pure compounds analyzed on the same instrument using identical methods.

3.9.6 Analytical Calibrations

3.9.6.1 All target VOCs of concern shall be quantified by GC/MS based on multi-point calibrations prepared using pure compounds. If possible, other positively identified VOCs shall be quantified by the same method. An internal standard calibration method is recommended. A minimum of four points shall be used. Target analytes shall be introduced onto sorbent tubes as gas or liquid standards and then analyzed using methods identical to those used for the analysis of chamber samples. Analyze at least one calibration standard with each batch of samples. Perform full calibrations at least once every three months or more frequently to ensure accuracy for the analyses.

3.9.6.2 Individual VOCs not positively identified by GC/MS shall be quantified using toluene as the reference compound for calculating compound mass. Fully describe the method. VOCs quantified by this surrogate method shall be clearly indicated.

3.9.6.3 Aldehydes analyzed by HPLC shall be quantified based on multi-point calibrations prepared from hydrazone derivatives of the pure compounds. Standards and samples shall be analyzed using identical methods. At least one standard shall be analyzed with each batch of samples.

3.9.7 Lower Limits of Quantitation (LOQ)

3.9.7.1 A lower LOQ often is quantitatively defined as the analyte mass that produces a response that is 10 times higher than the instrumental noise level or is 10 times the standard deviation for repeated analyses of a low level standard. A lower LOQ that is higher than this absolute value may be defined based on practical considerations.

3.9.7.2 The lower LOQ for TVOC shall be 25 $\mu g\ m^{-3}$, or better.

3.9.7.3 The lower LOQ for VOCs appearing on list of chemicals of concern (see Section 4.1) shall be 2 $\mu g\ m^{-3}$, or better.

3.9.7.4 The lower LOQ for non-listed VOCs (see Section 4.1) shall be 2 $\mu g\ m^{-3}$, or better.

3.9.8 A LOQ verification sample shall be analyzed after each calibration. Target analytes shall be introduced onto sorbent tubes as gas or liquid standards at or below the level of quantitation and then analyzed using methods identical to those used for the analyses of chamber samples.

3.10 Calculations

3.10.1 Calculation of Emission Factors

3.10.1.1 Since the chamber measurements are made starting on the 11^{th} day and ending on the 14^{th} day after preparation of the test specimen when chamber concentrations are expected to change slowly with time, the steady state form of the mass-balance equation shall be used for analysis of the chamber data (ASTM Standard D 5116-06).

3.10.1.2 The area specific emission rate or emission factor, EF_{Ai} ($\mu g\ m^{-2}\ h^{-1}$), at a given time, t (h), after placing a test specimen in the chamber shall be calculated using Equation 3.1:

$$EF_{Ai} = Q \times (C_{it} - C_{i0}) / A_C \qquad \textit{(Eq. 3.1)}$$

The inlet flow rate, Q ($m^3\ h^{-1}$), is the measured flow rate of air into the chamber. The chamber concentration, C_{it} ($\mu g\ m^{-3}$), is the concentration of a target VOC_i, formaldehyde and other carbonyl compounds measured at time *t*. The chamber background concentration, C_{i0} ($\mu g\ m^{-3}$), is the corresponding concentration measured with the chamber operating without a test specimen or with an appropriate substrate. The exposed projected surface area of the test specimen in the chamber, A_C (m^2), is determined from the measurements made at the time of specimen preparation.

3.10.1.3 Volume, length, mass or unit specific emission rates or emission factors, EF_V, EF_L or EF_M EF_P ($\mu g\ m^{-3}\ h^{-1}$, $\mu g\ m^{-1}\ h^{-1}$, $\mu g\ kg^{-1}\ h^{-1}$ or $\mu g\ h^{-1}$per unit), can be calculated using Equation 3.1 by substituting the appropriate parameter used to quantify the material specimen (i.e., volume in cubic meters, length in meters, mass in kilograms or number of products tested).

3.10.2 **Calculation of Estimated Building Concentrations**

3.10.2.1 Building concentrations can be calculated on a case-by-case basis using input parameters for the amount of installed product, the size of the space and the air change rate (or air flow rate) that are specific to the architectural project under consideration. In order to evaluate and compare products for use in a wide range of building products, concentrations also can be calculated for selected building scenarios as described below.

3.10.2.2 Building concentrations are estimated based on the measured VOC emission factors, the amount of material to be installed in the building and flow rate of outside air used for ventilation. Steady state conditions with respect to emission rates and building ventilation shall be assumed in making the prediction. Additional assumptions are zero outdoor concentrations, perfect mixing within the building and no net losses of VOC from air due to other effects such as irreversible or net sorption on surfaces (i.e., net sink effects) and chemical reactions.

3.10.2.3 The projected surface area of an installed material by product category and the building parameters to be used in the calculation of estimated VOC concentrations are established by this method for three standard model building scenarios, a school classroom, an office and a single family residence (Section 4.2).

3.10.2.4 The estimated building concentration, C_{iB} ($\mu g\ m^{-3}$), of a target VOC_i shall be calculated using Equation 3.2a or 3.2b.

For products that have the area specific emission factor, EF_A ($\mu g\ m^{-2}\ h^{-1}$), Equation 3.2a shall be used:

$$C_{Bi} = (EF_{Ai} \times A_B) / Q_B = EF_{Ai} / (Q_B / A_B) = EF_{Ai} / q_A \qquad \textit{(Eq. 3.2a)}$$

The area specific emission rate EF_A at 336 hours (14 days) total exposure time is divided by the area specific flow rate, q_A ($m\ h^{-1}$). The area specific flow rate, q_A, is calculated as the ratio of the flow rate of outside ventilation air, Q_B ($m^3\ h^{-1}$), to the exposed surface area of the installed material in the building, A_B (m^2).

For products that only have the unit specific emission factor, EF_P (µg h^{-1} per unit), Equation 3.2b shall be used:

$$C_{Bi} = (EF_{Pi} \times N_B) / Q_B = EF_{Pi} / (Q_B / N_B) = EF_{Pi} / q_P \qquad \textit{(Eq. 3.2b)}$$

The unit specific emission rate EF_P at 336 hours (14 days) total exposure time is divided by the unit specific flow rate, q_P (m^3 h^{-1} per unit). The unit specific flow rate, q_P, is calculated as the ratio of the flow rate of outside ventilation air, Q_B (m^3 h^{-1}), to the number of the installed products in the building, N_B.

3.10.2.5 In some cases, it may be necessary to calculate the results using the volume, length or mass of a product to be installed in a building and the corresponding volume, length or mass specific emission rate.

4 TARGET CHEMICALS, MAXIMUM ALLOWABLE CONCENTRATIONS, AND IAQ CONCENTRATION MODELING

4.1 Target VOCs

4.1.1 VOCs emitted by products appearing on State of California lists of toxic substances (see below) are considered to be *chemicals of concern* and shall be included as "Target VOCs" for the testing of emissions under this method.

4.1.2 *Chemicals of concern* include known or probable human carcinogens, reproductive/ developmental toxins, and systemic toxins with noncancer chronic effects contained in the latest published editions of the following lists:

Cal/EPA OEHHA list of chemicals for which non-cancer Chronic Reference Exposure Levels (CRELs). CRELs are inhalation concentrations to which the general population, including sensitive individuals, may be exposed for long periods (10 years or more) without the likelihood of serious adverse systemic effects (excluding cancer). CREL values are continuously updated by OEHHA (see http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html).

Cal/EPA OEHHA Safe Drinking Water and Toxic Enforcement Act of 1986 (*Proposition 65*) lists of known or probable human carcinogens and reproductive/developmental toxins. These lists are accessible at http://www.oehha.ca.gov/prop65/prop65_list/newlist.html.

Cal/EPA ARB list of Toxic Air Contaminants (TACs). The TAC list includes all substances on the EPA list of Hazardous Air Pollutants plus additional compounds. This list is accessible at http://www.arb.ca.gov/toxics/id/taclist.htm.

4.1.3 The VOCs emitted from tested products shall be quantified using pure standards as described in Section 3. Many VOCs approximately within the volatility range of n-pentane through n-heptadecane (C_5 - C_{17}) can be analyzed by TD-GC/MS and low molecular weight aldehydes through butanal can be analyzed using HPLC.

4.1.4 Non-listed VOCs that are abundant in the emissions from a product specimen shall also be quantified. At a minimum, the ten VOCs having the highest emission factors (most abundant VOCs), which may include listed compounds, shall be quantified. If pure standards are not readily available, abundant, non-listed VOCs are quantified using a surrogate (see Section 3.9).

4.1.5 Chemical substances (on the CREL or other lists) that are *not* VOCs (e.g., metals, acids and pesticides) are not required to be analyzed under this Standard Method

4.2 Maximum Allowable Concentrations for Target VOCs.

4.2.1 Target VOCs *except formaldehyde*. Multiple sources of individual VOCs are often present in a building. To ensure indoor air concentrations are within allowable limits, each individual product category is capped at no more than *one-half* of the CREL for each chemical in a building type. To determine acceptability of the emission results, the estimated building VOC concentrations are compared to one-half their corresponding CRELs (except formaldehyde, which is discussed below). The CRELs are currently

published at **http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html**. The specific VOCs on the CREL list that are required to be included in this assessment (i.e., those VOCs that can be analyzed by the sampling and analytical methods specified herein) are identified in **Table 4-1**.

4.2.2 Formaldehyde. The allowable limit for emissions of formaldehyde corresponds to an indoor air concentration not to exceed the full CREL of 9 µg m^{-3} commencing January 1, 2012. Until that date, one-half of 33 µg m^{-3} (i.e., 16.5 µg m^{-3}, the value given for formaldehyde in the Standard Practice 2004 document) will continue to be used as the allowable concentration limit.

4.2.3 Changes in the CREL list or values issued by OEHHA or in other references following the publication of this document do not automatically update these maximum allowable concentrations. The target CREL VOCs to be tested by this Standard Method and their maximum allowable concentrations (**Table 4-1**) shall continue to apply until these changes are published in a revised version of this document.

4.3 IAQ Concentration Modeling

4.3.1 **Principle**: The purpose of IAQ concentration modeling is to convert the *measured VOC emission rates* into *estimated airborne concentrations* that are relevant to potential indoor inhalation exposures of building occupants. The calculation is accomplished using a steady-state mass-balance model with several simplifying assumptions described in Section 3.10. The calculation requires inputs for the emission factor of a VOC emitted by a product and the flow rate of outdoor air per unit amount of product.

4.3.2 **Area-specific air flow rate:** For a product with a given VOC emission factor, the relationship that determines, to a first-order approximation, the gas-phase VOC concentration in a test chamber and in a built environment is the flow rate of outdoor ventilation air per unit area of product. This parameter is termed the area-specific air flow rate and has units of m^3 h^{-1} m^{-2} (m h^{-1}). It is also obtained from the ratio of the air change rate to the loading factor (sometimes described as N/L) with the same units.

4.3.3 **Standardized scenarios:** Typical product categories (e.g., floor coverings, wall coverings, paint, acoustical ceilings, etc.) are specified with respect to their loading in each building environment (i.e., school classrooms and private offices in public/commercial buildings) and the flow rate of outdoor air.

4.3.4 **School classroom scenario**: The school classroom model is based on the dimensions of a typical re-locatable classroom; the classroom size also is generally representative of site-built classrooms for K-12 schools (Jenkins, Phillips and Waldman, 2004). The parameters that define the standard school classroom to be used with this method are listed in **Table 4-2**. The surface areas of major product categories and unit quantities of pupil desks and seating in the school classroom are presented in **Table 4-3** along with the calculated correspondent area-specific air flow rates or unit-specific air flow rates.

Table 4-1 Target CREL VOCs and their maximum allowable concentrations

No.	Compound Name	CAS No.	Allowable Conc.[a] (µg/m^3)
1	Acetaldehyde	75-07-0	70
2	Benzene	71-43-2	30
3	Carbon disulfide	75-15-0	400
4	Carbon tetrachloride	56-23-5	20
5	Chlorobenzene	108-90-7	500
6	Chloroform	67-66-3	150
7	Dichlorobenzene (1,4-)	106-46-7	400
8	Dichloroethylene (1,1)	75-35-4	35
9	Dimethylformamide (N,N-)	68-12-2	40
10	Dioxane (1,4-)	123-91-1	1,500
11	Epichlorohydrin	106-89-8	1.5
12	Ethylbenzene	100-41-4	1,000
13	Ethylene glycol	107-21-1	200
14	Ethylene glycol monoethyl ether	110-80-5	35
15	Ethylene glycol monoethyl ether acetate	111-15-9	150
16	Ethylene glycol monomethyl ether	109-86-4	30
17	Ethylene glycol monomethyl ether acetate	110-49-6	45
18	Formaldehyde	50-00-0	16.5 [b]
19	Hexane (n-)	110-54-3	3,500
20	Isophorone	78-59-1	1,000
21	Isopropanol	67-63-0	3,500
22	Methyl chloroform	71-55-6	500
23	Methylene chloride	75-09-2	200
24	Methyl *t*-butyl ether	1634-04-4	4,000
25	Naphthalene	91-20-3	4.5
26	Phenol	108-95-2	100
27	Propylene glycol monomethyl ether	107-98-2	3,500
28	Styrene	100-42-5	450
29	Tetrachloroethylene	127-18-4	17.5
30	Toluene	108-88-3	150
31	Trichloroethylene	79-01-6	300
32	Vinyl acetate	108-05-4	100
33-35	Xylenes, technical mixture (m-, o-, p-xylene combined)	108-38-3, 95-47-6, 106-42-3	350

a) Refer to http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html. All maximum allowable concentrations are one-half the corresponding CREL adopted by Cal/EPA OEHHA with the exception of formaldehyde. For any future changes in the CREL list by OEHHA, values in Table 4.1 shall continue to apply until these changes are published in the Standard Method.

b) Formaldehyde has a CREL of 9 µg/m^3 (December 2008); guidance value established by this Standard Method at 16.5 µg/m^3 before Dec 31th, 2011 and at 9 µg/m^3 starting from Jan 1st, 2012. See Section 4.3.2.

Table 4-2 Definition of standard school classroom

Parameter	Unit of Measure	Parameter Value
Length (40 ft)	m	12.2
Width (24 ft)	m	7.32
Floor (ceiling) area	m^2	89.2
Ceiling height (8.5 ft)	m	2.59
Volume	m^3	231
Windows (4 ft x 4 ft and 4ft x 8 ft)	m^2	4.46
Door (3 ft x 7 ft)	m^2	1.89
Net wall area	m^2	94.6
Occupancy	Unit	27
Outdoor air flow rate[1]	m^3/h	654
Adjusted outdoor air flow rate[2]	m^3/h	191
Effective outdoor air change rate[2]	1/h	0.82

1. Based on ASHRAE 62.1-2007, Table 6-1, for classrooms occupied by pupils, ages five and up. The minimum ventilation requirement is 5 L/s-person (10 cfm/person) and 0.6 L/s-m^2 floor area (0.12 cfm/ft^2). The code minimum total flow rate of outdoor air is then 654 m^3 h^{-1} (182 L/s or 385 cfm). This produces a ventilation rate of 2.8 h^{-1} for occupied hours.
2. As documented in various reports, classroom HVAC systems sometimes do not deliver the required amount of outdoor air for a variety of reasons including poorly designed or overridden controls and lack of maintenance. In addition, HVAC systems may not be started sufficiently early in the school day to achieve a fully ventilated condition prior to the start of class. Therefore for use in this method, average the ventilation over a 168-h week assuming 40 hours of operation at 654 m^3 h^{-1} (2.8 h^{-1}) and 128 hours of operation with ventilation of only 0.2 h^{-1} due to infiltration. This yields an average ventilation rate of 0.82 h^{-1} and an average flow rate of 191 m^3 h^{-1} (53.1 L/s or 112 cfm).

Table 4-3 Product quantities and specific air flow rates to be used for estimation of VOC concentrations in standard school classroom

Product Type	Area or Quantity		Area- or Unit-Specific Air Flow Rate	
Flooring (all types)	m^2	89.2	m/h	2.14
Ceiling (all types)	m^2	89.2	m/h	2.14
Wall paint & wallcoverings[1]	m^2	94.6	m/h	2.02
Thermal insulation				
Ceiling	m^2	89.2	m/h	2.14
Wall	m^2	94.6	m/h	2.02
Ceiling & Wall	m^2	183.8	m/h	1.04
Wall base (10-inch)	m^2	9.68	m/h	19.7
Visual aid boards[2]	m^2	11.9	m/h	16.1
Desk (pupil)	Unit	27 ea	m^3/h	7.07
Seating (pupil)	Unit	27 ea	m^3/h	7.07

1. The net wall area is 94.6 m^2 based on the total wall area minus the area of one door and two windows.
2. Area of visual aid boards is assumed to be 1.22 m by 9.75 m (4 ft by 32 ft) based on typical classroom layouts and traditional markerboard/chalkboard materials. Unique, specialty visual aid board products (e.g. with multimedia projection capabilities, etc.) that are restricted in size by the manufacturer may justify different area values. Any deviations from the area specified in Table 4.3 shall be stated in reports and public claims of compliance.

4.3.5 **Private office scenario**: The private office model is based on assumed dimensions of an enclosed office in a public/commercial building that is occupied by a single individual. The parameters that define the standard private office to be used with this method are listed in **Table 4-4**. The surface areas of major product categories are presented in **Table 4-5** along with the calculated correspondent area-specific air flow rates. This private office scenario applies to building materials and products other than office furniture or seating units. Private office workstations are not addressed within the current scope of this Standard Method. For office seating, refer to Section 7.

Table 4-4 Definition of standard private office

Parameter	Unit of Measure	Parameter Value
Length (12 ft)	m	3.66
Width (10 ft)	m	3.05
Floor (ceiling) area	m^2	11.15
Ceiling height (9 ft)	m	2.74
Volume	m^3	30.6
Window (4 ft x 4 ft)	m^2	1.49
Door (3 ft x 7 ft)	m^2	1.89
Net wall area	m^2	33.4
Occupancy	Unit	1
ASHRAE Outdoor air flow rate[1]	m^3/h	20.7
Effective outdoor air change rate[1]	1/h	0.68

1. Based on ASHRAE 62.1-2007, Table 6-1, for offices. The minimum ventilation requirement is 2.5 L/s-person (5 cfm/person) and 0.3 L/s-m^2 floor area (0.06 cfm/ft^2). The minimum total flow rate of outdoor air is then 20.7 m^3 h^{-1} (5.76 L/s or 12.2 cfm). This produces a ventilation rate of 0.68 h^{-1} for occupied hours.

Table 4-5 Product quantities and specific air flow rates to be used for estimation of VOC concentrations in a standard private office

Product Type	Area		Area-Specific Air Flow Rate	
Flooring (all types)	m^2	11.1	m/h	1.86
Ceiling (all types)	m^2	11.1	m/h	1.86
Wall paint & wallcoverings[1]	m^2	33.4	m/h	0.62
Thermal insulation				
Ceiling	m^2	11.1	m/h	1.86
Wall[2]	m^2	ND	m/h	ND
Ceiling & Wall[2]	m^2	ND	m/h	ND
Wall base (4-inch)	m^2	1.27	m/h	16.3
Door & other millwork	m^2	1.89	m/h	11.0
Window treatments	m^2	1.49	m/h	13.9

1. The net wall area is 33.4 m^2 based on the total wall area minus the area of one door and one window.
2. The material area for thermal insulation in walls has not been fully defined (ND).

4.3.6 **Modeling parameters for products not specifically addressed in data tables**: There are a number of products for which data on standard applications are not readily available; many adhesives, caulks, sealants, and wallboard finishing products fall into this category. For these products, the loading shall be determined based on (a) the surface area of the system (i.e., ceiling, wall, or floor) in the selected standard environment (i.e., classroom, private office, or single-family residence), where the product is applied, and (b) the product's standard application specifications. For example, flooring adhesive shall be modeled using the entire floor area of the space and the manufacturer's published application rate for that adhesive (e.g., g m^{-2}). Parameters used to establish the loading shall be made part of the test report record and made available through the certification report if the modeling parameters are defined by a certification/verification organization (Section 6.1.4).

5 QUALITY ASSURANCE AND QUALITY CONTROL

5.1 Mandatory Practices on Quality Management

5.1.1 Laboratories conducting testing and evaluation of VOC emissions shall be maintained under a *Quality Management System* (QMS).

5.1.2 At the minimum, the QMS shall include the following elements:

- Quality system objectives and policies, plus conflicts of interest, ethics, etc.
- Laboratory organization management.
- Personnel qualifications and training.
- Document review and management.
- Sample management, including handling and chain of custody.
- Reagent and standard preparation.
- Maintenance and calibration of instrumentation and measurement systems.
- Quality assurance/quality control (QA/QC) plan for laboratory operations.
- Data and records management.
- Performance and system audits.
- Corrective actions request systems.

5.1.3 QMS performance shall be audited on an annual basis according to ISO/IEC 17025:2005.

5.1.4 Documentation of the QMS and annual laboratory audits shall be available for review by clients and certification bodies.

5.2 Mandatory Laboratory Practices

5.2.1 Laboratory's QMS and applicable test procedures shall be conducted in accordance with ISO/IEC 17025:2005.

5.2.2 Laboratories shall devise and implement methods for verifying the overall accuracy or bias of their chamber testing performance. Known, realistic concentrations of compounds of interest in chamber air should be generated by procedures that are independent of the sampling and analytical methods used for chamber tests. The possibilities include certified gas mixtures, gravimetrically calibrated diffusion and permeation sources, and injection and vaporization of liquid mixtures. The overall bias for a compound is defined as the relative or statistical difference between the measured air concentration and the independently determined, or theoretical, air concentration of the compound.

5.2.3 Laboratories shall participate in proficiency test (PT) programs. These PT programs may be in the form of interlaboratory studies with a sufficient number of participants to allow statistical analysis of the results. Custom PT programs may be developed using an

accredited supplier of VOC standards in various forms such as calibration gas cylinders and spiked thermal desorption tubes.

5.3 Measurement Uncertainty

5.3.1 Measurement uncertainty (accuracy) and precision limits for test chamber conditions and test results are listed in **Table 5-1**.

Table 5-1 Guidelines for measurement uncertainty and precision of chamber conditions and VOC measurements

Parameter	Measurement Uncertainty	Precision
Temperature, ^{o}C	±0.5	±1.0
Relative humidity, %	±5	±5
Air flow rate, %	±3	±5
Exposed area of test specimen, %	±1	±2
Time, %	±1	±2
VOC Concentration, %RSD[1]	--	±15
VOC Emission factor, %RSD[1]	--	±20

1. %RSD= Relative standard deviation = estimate of the standard deviation / mean x 100%.

5.3.1.1 The measurement uncertainty and precision of parameters such as temperature, relative humidity and air flow rate shall be maintained and verified by periodic performance checks and calibration of instrumentation according to the laboratory's QMS.

5.3.1.2 Precision for VOC measurements shall be determined from a laboratory's continuous assessment of duplicate VOC samples collected during tests. Precision for VOC emission factors shall be estimated based on propagation of the precisions of the individual measurements used to calculate emission factors. Alternately, precision for VOC emission factors can be estimated from an assessment of duplicate tests of product specimens.

6 REQUIRED ELEMENTS OF THE LABORATORY TEST REPORT

6.1 Required elements of the Laboratory Test Report

6.1.1 **Laboratory identification**: Name, address, phone number and other contact information for the laboratory.

6.1.2 **Manufacturer, product and sample identification**:

- Manufacturer and manufacturer contact name address and phone number
- Product name, product number, product category and subcategory (if applicable)
- Other manufacturer's identification numbers (if applicable)
- Manufacturing location, manufacturing date, collection date, shipment date and date of arrival at laboratory
- Laboratory sample ID or tracking number.

6.1.3 **Test methods and conditions**: Chamber volume, inlet air flow rate, average temperature and range, average relative humidity and range, exposed area of test specimen (or other relevant test specimen measurement parameter), chamber loading factor, test specimen preparation details, conditioning period start date and duration, and test period start date and duration, and sampling and analytical methods (including TVOC method).

6.1.4 **Data analysis procedures**: Equations and procedures used to derive emission factors from measured chamber concentrations; Equations, procedures and parameters used to calculate building concentrations from the emission factors including: the selected standardized building scenario(s), the assumed product area (or other relevant product measurement parameter), and the area- or unit-specific air flow rate. For products not specifically addressed in data tables (e.g., adhesives and caulks), also attach the manufacturer's published application specifications used to estimate VOC concentrations (Section 4.3.6).

6.1.5 **Test results**: For the 96-h results, list of all target VOCs (individual toxic and abundant VOCs, including formaldehyde and acetaldehyde – see Section 4.1) and TVOC quantified in the chamber with their chamber concentrations and corresponding emission factors. For the 24-h and 48-h results, list only the formaldehyde and TVOC quantified in the chamber with their chamber concentrations and corresponding emission factors.

Provide the following information:

- CAS numbers for individual VOCs
- Indicate which non-listed VOCs were quantified using surrogate compounds in lieu of pure compounds.
- Identify those VOCs with CRELs and those VOCs on the other lists of toxic substances (Section 4.1).
- Provide estimated concentration for the selected standardized building scenario(s) for all listed and non-listed compounds.

6.1.6 **Photographs:** Include a photographic image of each test specimen.

6.1.7 **Additional information:** Report any additional facts and deviations, which may have influenced the test results. These include but are not limited to the following:

- Dates of most recent internal and external audits, proficiency evaluation(s) and corrective actions taken, if any
- Product sample manufacturing dates, collection dates, and shipment dates
- Any deviations from method and specified parameters and values
- Details of specimen preparation not covered above (e.g., application methods for paints and adhesives or preparation of assemblies)
- Mass quantity and coverage (g m^{-2}) of paint and adhesive
- Any other relevant observations.

6.1.8 **Chain of Custody:** Attach a copy of the completed and signed chain-of-custody (COC) form with the laboratory report.

6.1.9 **Certification of the Report:** Name, position, signature and date of authorized laboratory personnel attesting to accuracy of provided information.

7 TESTING OF FREESTANDING FURNITURE

7.1 Test Method for Freestanding Furniture

ANSI/BIFMA M7.1-2007 test method (including specimen collection and preparation, chamber testing, and air sampling) and the power-law modeling procedure described in that method are hereby recognized as the test method for pupil desks and chairs, office furniture and office seating unless otherwise specified below. Testing of furniture items shall meet the following requirements for the determination of the emissions of the VOCs of concern defined in Section 4.1.

7.1.1. Tests of pupil desks and chairs, office furniture and office seating units are to be conducted in mid- and full-scale chambers according to ANSI/BIFMA M7.1-2007. Office workstation components (i.e., panel, work surface and storage) may be tested individually in mid-scale chambers or combined in a full-scale chamber. As defined in BIFMA e3-2008, small chamber testing of component pieces of workstations per the ANSI/BIFMA M7.1-2007 method is acceptable if there is third-party oversight in selecting representative components and in applying the calculations in ANSI/BIFMA M7.1-2007 (Section 10.6.1 and 10.6.2) to estimate the emission factor of a product.

7.1.2. Air samples are to be analyzed for individual VOCs following procedures that are equivalent to the procedures described in Section 3.9.

7.1.3. VOC emission factors per furniture unit are calculated from chamber concentrations measured at 72 h and 168 h. VOC emission factors at 14 days (336 h) are projected by application of the power-law model to the measured data. The 72-h and 168-h emission factors are averaged if the decay coefficient, b, is >-0.2 and <0.2 (BIFMA e3-2008).

7.1.4. Alternatively, tests can be conducted over 336-h in mid- and full-scale chambers with full speciation of VOCs in the duplicate samples collected at 336-h to directly obtain the required emission factors.

7.2 Concentration Modeling for Furniture and Office Seating

7.2.1 **Pupil desks and chairs:** Classroom pupil furniture consisting of desk units and seating units are modeled for the standard classroom scenario defined in Section 4.3.4. The specific air flow rate for a pupil desk unit and for a pupil seating unit is specified in **Table 4-3**.

7.2.2 **Open-plan office workstations:** Single-occupant open plan office workstations are modeled to the open-plan office environment defined in ANSI/BIFMA M7.1-2007. The parameters that define the standard open-plan office are listed in **Table 7-1**. The area specific air flow rates for the standard workstation and its components are presented in **Table 7-2**. These parameters shall be used to calculate estimated indoor VOC concentrations attributable to a workstation or its components for a standard open-plan office environment. If office workstation components are tested individually, the contributions of the components may be summed to estimate the indoor VOC concentration for the full workstation.

Table 7-1 Standard open-plan office defined in ANSI/BIFMA M7.1-2007

Parameter	Unit of Measure	Parameter Value
Length	m	2.44
Width	m	2.44
Floor (ceiling) area (64 ft^2)[1]	m^2	5.94
Ceiling height (9 ft)[1]	m	2.74
Volume	m^3	16.3
Occupancy[1]	unit	1
ASHRAE Outdoor air flow rate[1]	m^3/h	15.0
Effective outdoor air change rate	1/h	0.92

1. Based on research conducted for BIFMA (Carter and Zhang, 2007), the typical open-plan office environment for a single occupant is defined as a space without walls with a 5.94 m^2 (64-ft^2) floor area and a 2.74-m (9-ft) ceiling. It contains a single workstation system. The minimum required outdoor ventilation rate calculated from ASHRAE 62.1-2007, Table 6-1 is 15.0 $m^3 h^{-1}$ (4.17 L/s or 8.84 cfm).

Table 7-2 Product quantities and specific air flow rates to be used for estimation of VOC concentrations in a standard open-plan office

Product Type	Area or Quantity		Area- or Unit-Specific Air Flow Rate	
Open-plan workstation [1]	m^2	21.76	m/h	0.69
Vertical panel	m^2	11.08	m/h	1.35
Work surface	m^2	6.103	m/h	2.46
Storage	m^2	4.569	m/h	3.36

1. The standard open-plan workstation defined in ANSI/BIFMA M7.1-2007 (Appendix 2, Table A2.1) is used. It consists of vertical panel, work surface and storage components. The total workstation surface area is 21.76 m^2 apportioned as 11.08 m^2 panel, 6.103 m^2 work surface, and 4.569 m^2 storage areas (refer to ANSI/BIFMA M7.1 for area calculation conventions). These areas are based on 90th percentile furniture surface area conditions.

7.2.3 **Private office workstations:** Private office workstations are not addressed within the current scope of this Standard Method.

7.2.4 **Office seating units:** ANSI/BIFMA M7.1-2007 specifies one seating unit with an air flow rate of 24.8 $m^3 h^{-1}$. For this method, assume two (2) identical seating units and utilize the average air flow rate for seating defined in ANSI/BIFMA M7.1. Thus, the unit specific air flow rate for each seating unit is 12.4 $m^3 h^{-1}$. This is consistent with the credit criteria for seating in CHPS 2009 and BIFMA e3-2008.

7.3 Compliance with Maximum Allowable Concentrations

To be compliant with the method, the modeled concentration for a tested furniture item (i.e., a pupil desk unit, a pupil seating unit, an office workstation, or an office seating unit) shall not exceed the maximum allowable concentrations established in Section 4.3.

8 GUIDELINES FOR USE OF STANDARD METHOD AS BASIS FOR A BUILDING PRODUCT CLAIM

In the past, product manufacturers have used test results as the basis for a single-attribute claim regarding one or a group of their products (i.e., a low VOC emissions product claim). Claims certification and verification organizations have also deemed to use these test results as part of their own process for substantiating manufacturers' claims. Whenever this *Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers* is to be used to make, certify or verify a building product claim, the following guidelines are recommended to ensure the integrity of the process.

8.1 Manufacturer and Third-Party Claims

8.1.1 Claims made by manufacturers regarding their own products shall be made following the principles of ISO 14021 (2001) for self-declared environmental labels and declarations. These requirements include that such claims be: based on scientific evidence; accurate; verifiable; and updated if circumstances alter their accuracy. Information on the procedures, criteria and data used to support such claims shall be made available to interested parties upon request.

8.1.2 Certification/verification organizations involved in substantiating manufacturers' claims shall operate in accordance with ISO Guide 65 (1996). Program documentation, quality manuals, and information on the procedures, criteria and data used to substantiate manufacturers' claims shall be made available to interested parties upon request.

8.2 Laboratory Selection

Manufacturers or certification/verification organizations shall utilize only laboratories demonstrating competency to perform the method as described in Section 5. Laboratories shall be independent entities with no direct connection to the manufacturer or potential conflict of interest with respect to the manufacturer.

8.3 Breadth of Claim

8.3.1 A claim that extends beyond the individual product that is tested shall only be made if there is clear evidence justifying that tested items are representative of this product or related products. Such evidence shall be documented and the documentation shall be made available to interested parties upon request (see Section 8.7 and 8.8).

8.3.2 For products that meet the 9 $\mu g\ m^{-3}$ requirement for formaldehyde earlier than January 1, 2012, a claim of "*compliance with 9 $\mu g\ m^{-3}$ formaldehyde CREL*" may be made together with the claim of compliance with the Standard Method.

8.4 Modifications of Method

While certification/verification organizations may modify some of the procedures described in this method to meet their program objectives, modifications that alter essential compliance, undercut, or otherwise weaken the objectives of the method shall not be made.

8.4.1 Certification/verification organizations may require additional procedures or measurements not addressed by the method.

8.4.2 In order for a certification/verification organization to make a claim of essential compliance with the method, modifications shall be documented, including detailed evidence of the basis. This documentation shall be made readily available to program participants, the public and any other interested parties.

8.5 Acceptable Alternative to Method

Test results meeting all the requirements described in this Method at no less than 168 hours (7 days) instead of the 336 hour (14-day) testing required by this Method are acceptable provided that: (a) the specimen remains in the same chamber for the duration of the 168-hr test; (b) samples for formaldehyde and TVOCs are collected and their corresponding chamber concentrations and emission factors are reported at a minimum of three time points between 24 and 120 hours, spaced at least 24 hours apart (e.g., 24, 48, 72, 96 and 120-hr); (c) full speciation of VOCs is performed at 168-hr according to the requirements described in this method; (d) chamber concentrations of VOCs of concern are determined to be constant or declining with time at 168 hour.

8.6 Quality Control

The manufacturer shall have a documented quality control (QC) plan for the production of the selected building product. This QC plan shall be under the supervision of a member of the manufacturer's senior management team. The manager shall ensure that the QC plan provides for adequate supervision and control to be exercised at all stages and locations of manufacture so that the finished units are consistently produced. It may be necessary for the manufacturer to conduct in-plant quality control testing and/or perform other documented procedures to demonstrate continuing compliance.

8.7 Product Sample Selection

8.7.1 Guidelines are established herein for the selection of test samples by manufacturers and certification/verification organizations that intend to use the test results as the basis for a product-wide claim.

8.7.1.1 The manufacturer and certification/verification organization shall have a pre-defined, written sampling plan.

8.7.1.2 The manufacturer and certification/verification organization, as applicable, shall select the test sample from typical production operations. The sample shall be randomly selected from a production lot that is large enough to ensure that it is representative of the processes involved and of the quality that the manufacturer routinely introduces into the market.

8.7.1.3 The sample shall be in the condition in which it is offered for sale and shall not be a pre-production model or a sales sample.

8.7.1.4 If there are significant differences in manufacturing (e.g., different suppliers, variations among different plants, etc.) that may affect the emissions of VOCs from a product, then the sample shall be selected from the lot or group expected to give the worst results for the test. Preliminary testing may be needed to make this "worst-case" determination.

8.7.1.5 A range of product models, brands and/or styles with varying characteristics may be grouped together for testing purposes if the products can be expected to have virtually the same performance during testing and use. A test group shall only include models which are made using the same production methods and are comprised of the same product ingredients (formulation). The test sample shall be selected from the model in the group that can be expected to give the worst results for the test taking into consideration special attributes, materials, methods of manufacturing, suppliers, etc.

8.7.1.6 The manufacturer and/or a certification/verification organization, if applicable, shall document and maintain a record of the procedures used to select the test sample and, if applicable, the procedures used for the selection of a worst-case lot, group, or model in the form of calculations, test results, formulations, written explanations and other supportive data.

8.8 Retesting

The manufacturer or certification/verification organization shall establish the schedule for routine laboratory retesting of samples appropriate to provide representative products. Often, the minimum frequency is dictated by building rating systems that award credits for using products with low VOC emissions. Biennial or even annual retesting often is required. The full retesting of samples may be less frequent if a certification/verification organization implements a robust routine quality control testing program and demonstrates its equivalency to full test for the purpose of substantiating manufacturers' claims. Detailed evidence of such equivalency shall be documented. The documentation shall be available to program participants, the public and any other interested parties. In addition, changes in formulation, manufacturing process, or supplier that can alter the VOC emissions characteristics of a product shall trigger additional retesting to maintain the validity of a claim based on the method.

APPENDIX A LIST OF STAKEHOLDER REVIEWERS

Name	Affiliation
Martin Bennett	Materials Analytical Services, LLC (MAS)
Anthony Bernheim	AECOM
Robert Blaisdell	Office of Environmental Health Hazard Assessment (OEHHA)
Charles D. Byers	USG Corporation
Randal Carter	Steelcase Inc.
Amy Costello	Armstrong World Industries, Inc.
Larry Dykhuis	Herman Miller
William Freeman	Resilient Floor Covering Institute (RFCI)
Phil Gattis	Community Playthings
Ken Gould	Owens Corning
Stowe Hartridge-Beam	Scientific Certification Systems (SCS)
Doug Hensel	California Dept. of Housing and Community Development
Al Hodgson	Berkeley Analytical
Pat Hooper	Hooper Associates
Frank Hurd	Carpet and Rug Institute (CRI)
Josh Jacobs	GREENGUARD Environmental Institute (GEI)
Peggy Jenkins	California Air Resources Board (CARB)
Richard Lam	Office of Environmental Health Hazard Assessment (OEHHA)
Tom Lent	Healthy Building Network
Hal Levin	Building Ecology Research Group
Stephany I. Mason	Air Quality Sciences, Inc. (AQS)
Ken McIntosh	Carpet and Rug Institute (CRI)
Reinhard Oppl	Eurofins Product Testing A/S
Bill Orr	Collaborative for High Performance Schools (CHPS)
Steve Pfeiffenberger	Armstrong World Industries, Inc.
Tom Phillips	California Air Resources Board (CARB)
Bruce Ray	Johns Manville (JM)
Robert Raymer	California Building Industry Association
Jan Stensland	Inside Matters
Raja Tannous	Berkeley Analytical
Steven Trinkel	Kimball International
Denise Van Valkenburg	MASCO RetailCabinetGroup
Anna Wechselberger	Haworth Inc
Stan Wolfersberger	Owens Corning

APPENDIX B NEW SINGLE-FAMILY RESIDENCE SCENARIO

This is an informative appendix and not part of the required portion of this Standard Method. It is the intent of the CDPH-IAQ to further review and develop the Single Family Residence Scenario for inclusion in final form in Version 2.0 of the Standard Method.

Lack of residential scenario(s) is a major gap in the application of *Standard Practice* (2004). A preliminary new single-family residence model has been developed. It is based on the assumed dimensions of a median size new detached single-family home. The parameters that define the standard new single-family residence are listed in **Table B-1**. The surface areas of major product categories and unit quantities of other components in the standard new-single family residence are given in **Table B-2** along with the calculated correspondent area-specific air flow rates or unit-specific air flow rates.

Table B-1 Definition of new single-family residence.

Parameter	Unit of Measure	Parameter Value
Floor area (2,272-ft^2) [1]	m^2	211
Ceiling height (8.5 ft) [2]	m	2.59
Volume	m^3	547
ASHRAE Outdoor air flow rate [3]	m^3/h	127
Effective outdoor air change rate [3]	1/h	0.23
No. Bedrooms [4]	Unit	4
No. Full Baths [4]	Unit	2
No. Other Rooms [4]	Unit	3

1. Statistics on new homes completed in the U.S. are published by the U.S. Census Bureau (U.S. Census Bureau, 2008). For 2008, the median size for new detached single-family homes is 206 m^2 (2,215 ft^2). The Buildings Energy Data Book, Table 2.2.10 (U.S. DOE, 2008) summarizes data from the National Association of Home Builders (NAHB) on the materials used in the construction of a 211 m^2 (2,272-ft^2) single family home in 2000. The home in 2000 is selected for this scenario since it has associated material quantities and is nearly identical to the median 2008 home.
2. According to the NAHB consumer preference survey conducted in 2007, the 2.44-m (8-ft) and 2.74m (9-ft) ceiling height are most preferred by consumers. A 2.59-m (8.5-ft) average height is therefore assumed yielding a volume of 547 m^3 (19,310 ft^3). Summary of the 2007 NAHB consumer preference survey results is accessible at http://www.nahb.org/fileUpload_details.aspx?contentTypeID=3&contentID=51299&subContentID=137332.
3. The measured median outdoor air change rate (24-hr measurement) for homes without mechanical outdoor air ventilation systems is 0.26 h^{-1} in a recent study with a randomly selected sample of 108 new CA homes (Offermann , 2009). The ventilation flow rate requirement is 127 $m^3 h^{-1}$ (75 cfm) using Table 4.1a or 102 $m^3 h^{-1}$ (60 cfm) using Equation 4.1a of ASHRAE Standard 62.2-2007. The higher value of 127 $m^3 h^{-1}$, correspondent to an outdoor air change rate of 0.23 h^{-1}, is used. It is close to the measured median outdoor air change rate for new CA homes.
4. Due to incomplete data, it is necessary to estimate the home configuration. The most frequent number of bedrooms is three, but many floor plans for homes of this size contain a fourth bedroom or a bedroom/den. Thus, the home is assumed to consist of four bedrooms, two full baths and three other rooms.

Table B-2 Product quantities and specific air flow rates to be used for estimation of VOC concentrations in standard new single-family residence.

Product Type	Area or Quantity [1]		Area Specific Air Flow Rate	
Flooring (all types) [2]	m^2	211	m/h	0.602
Ceiling	m^2	217	m/h	0.585
Walls & wallcoverings	m^2	562	m/h	0.226
Interior wallboard paint [3]	m^2	779	m/h	0.163
Thermal insulation [4]	m^2	284	m/h	0.447
Acoustic insulation (comprehensive acoustic upgrade)[5]	m^2	343	m/h	0.370
Windows[6]	unit/m^2	19/38.0	m/h	3.34
Exterior doors[7]	unit/m^2	4/7.56	m/h	16.8
Interior doors[8]	unit/m^2	12/37.2	m/h	3.41
Closet doors[9]	unit/m^2	6/44.6	m/h	2.85

1. Material areas or quantities are taken from the Buildings Energy Data Book (U.S. DOE, 2008) accessible at http://buildingsdatabook.eren.doe.gov/.
2. In reference to this interim update, 100% coverage (211 m^2) shall be used as the default parameter for modeling residential floorings. We recognize that some stakeholders have proposed that representative coverage rates may be appropriate to account for partial coverage of specific flooring types. For example, product usage data has been published by NAHB (NAHB 2008 Builder Practices Report); the material quantities used in the construction of new homes in 2008 (as a percentage of total finished floor areas) are given for carpets (52%), hardwood (20%), ceramic tile (16%), vinyl (9%) and other flooring types. Material areas for specific flooring types and their impact on indoor concentration will be evaluated and considered in the next update.
3. The value is calculated as sum of ceiling and wall area.
4. 284 m^2 is sum of ceiling and wall thermal insulations. Material area for ceiling insulation and material area for wall insulation will be listed separately as subcategories in next document update if there are published scientific literatures to determine these numbers.
5. For optional comprehensive acoustic upgrade only. The value is calculated as sum of insulation required for partition walls and floors.
6. The surface area is estimated for a window-to-floor area ratio of 18%, assuming the total window area is three times of the openable window area and using the measured median openable window area/floor area of 0.06 taken from the recent CA home study (Offermann, 2009).
7. The surface area is estimated for 1.89 m^2/door (one side), interior surface exposed.
8. The surface area is estimated for 1.55 m^2/door (one side), both faces exposed.
9. The surface area is estimated for 3.72 m^2/door (one side), both faces exposed.
10. Usage of 15 kitchen cabinets and 5 other cabinets is also reported in the Buildings Energy Data Book (U.S. DOE, 2008), which corresponds to unit specific flow rate of 8.47 m^3/h and 25.4 m^3/h for kitchen cabinets and other cabinets, respectively. Material areas and area specific flow rates for cabinetry will be determined in next document update.