
**STANDARD METHOD FOR MEASURING AND EVALUATING
CHEMICAL EMISSIONS
FROM BUILDING MATERIALS, FINISHES AND FURNISHINGS
USING DYNAMIC ENVIRONMENTAL CHAMBERS**

Foreword

The GREENGUARD Environmental Institute (GEI) began certifying indoor products for low chemical emissions in 2001. Testing procedures for the program were developed and applied by Air Quality Sciences to cover a breadth of product types and building applications. The science of measuring product emissions developed from research conducted by the Environmental Protection Agency, Department of Energy, the Department of Housing and Urban Development, the Consumer Product Safety Commissions, California Department of Health Services, the State of Washington Department of General Administration, and additional national and international researchers. Air Quality Sciences, Inc. was the first, in 1989, commercial facility worldwide to offer product testing and consulting services to end users and manufacturers of products. In 2000, Air Quality Sciences established the GREENGUARD Environmental Institute to 1) bring together performance based, field validated standards to define low emitting products and materials for the indoor environment; 2) provide a third party, non-industry and publicly available certification process for manufactured products; and 3) establish a public directory of certified products for architects, designers, specifiers, purchasers, and consumers.

The following standard test method incorporates the best-learned practices for testing and evaluating products for GREENGUARD Certification, including office furniture, paints and coatings, adhesives and sealants, wallboard and insulation, flooring, ceilings, window furnishings, and many other dry and wet materials. Elements of the method include sample handling and shipment, sample preparation, product loadings and descriptions, environmental chamber methodology, analytical measurements, exposure modeling and allowable levels, for the various GREENGUARD Certification Programs. Analytes for all programs include total volatile organic compounds (TVOC), individual VOCs, formaldehyde, and total aldehydes. All individual VOCs emitting from products are measured as prescribed by the Method, and each measured VOC is required to meet defined allowable levels.

The GREENGUARD for Children & Schools Standard that became publicly available in 2005, incorporated additional criteria to provide a higher margin of safety for young children and sensitive populations. This standard reduces allowable chemical levels and also requires that emissions meet the ½ CREL criteria of specified target chemicals as listed in the State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174) and adopted by the California Collaborative for High Performance Schools (CHPS). This method ensures that product testing and the calculations of estimated building concentrations meet or exceed the requirements of the State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174) for schools and commercial environments. Approval of GREENGUARD Children and Schools Certification as an acceptable alternate for the CA Collaborative for High Performance Schools (CHPS) EQ 2.2 Low-Emitting Material Credit was received March 8, 2007.

This standard test method, which incorporates the most current science of emissions testing, including global ISO requirements for environmental chamber testing, can be used for other emissions test programs requiring the measurement of chemical and particulate emissions and assessment of data. Various federal, state, municipal, and other publicly available programs or standards may apply this standard test method with appropriate acknowledgement.

Emissions data obtained using this method can be used for the California CHPS Program, the State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources

Using Small Scale Environmental Chambers” (CA/DHS/EHLB/R-174), CA Section 01350, BIFMA Furniture Emissions Standards, the German Blue Angel Programs, the Green Guide for Health Care, the National Association of Home Builders (NAHB), MBDC’s Cradle to Cradle Certification, LEED credits, Green Globes, and other private and government (e.g., CA and MN) product specification programs. GREENGUARD certified products meet these third party requirements.

This standard method is developed and maintained by the GREENGUARD Environmental Institute (GEI). The master document at GEI’s headquarters in Atlanta Georgia is the official document. This document is revised as new science, test protocols and allowable levels become available, and will be reviewed on an annual basis. Significant revisions will be reviewed through a consensus process of users and interested parties.

The GREENGUARD Environmental Institute’s standards and test methods are copyrighted by the GEI and should not be altered by any third party in any way. No part of this standard method may be used independently of its intended purpose. All rights, ownership and copyrights of this standard shall remain the sole and exclusive property of the GEI.

The GREENGUARD Environmental Institute provides this standard “as is” without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability or fitness for any purpose.

TABLE OF CONTENTS

SECTION 1	
BACKGROUND INFORMATION.....	1
1.0 Scope	2
1.1 Objectives and Use	3
1.2 References and Documents	3
1.3 Terminology	6
1.4 Definitions	7
1.5 Symbols	9
SECTION 2	
COLLECTION, PACKAGING, SHIPMENT, & DOCUMENTATION OF PRODUCT SAMPLES	10
2.0 Sample Collection	11
2.1 Personnel	11
2.2 Representative Sample	11
2.3 Sample Preservation	11
2.4 Location of Sampling	11
2.5 Sample Age.....	12
2.6 Customized Sample Preparation	12
2.7 Sample Collection Procedures	13
2.8 Packaging and Shipment of Samples	15
2.9 Chain-of-Custody Documentation.....	15
2.10 Receipt of Samples by Laboratory.....	16
2.11 Rejection of Samples by Laboratory	16
2.12 Storage of Samples by Laboratory Prior to Following Testing.....	16
SECTION 3	
LABORATORY SAMPLE PREPARATION AND ANALYSES	18
3.0 Test Specimen Preparation	19
3.1 Furniture Testing	19
3.2 Sample Preparation.....	20
3.3 Preparation of Paint Test Specimens	21
3.4 Preparation of Adhesive Product Test Specimens.....	22
3.5 Preparation of Caulking Product Test Specimens.....	23
3.6 Selection and Preparation of Dry Product Test Specimens	23
3.7 Preparation of Dry Product Test Specimen Assemblies.....	25
3.8 Preconditioning of Product Prior to Testing.....	26
3.9 Environmental Chamber Testing	26
3.10 Environmental Chamber Performance Requirements.....	27
3.11 Chemical Analyses	30
3.12 Calculations.....	32
SECTION 4	
TARGET CHEMICALS AND MAXIMUM ALLOWABLE CONCENTRATION	36
4.0 GREENGUARD Certification Allowable Limits.....	37
4.1 GREENGUARD Children & Schools Allowable Limits	38
4.2 VOCs with Existing TLVs and CA RELs	39

SECTION 5	
REQUIRED ELEMENTS OF THE LABORATORY TEST REPORT	49
5.0 Required elements of the Laboratory Test Report	50
SECTION 6	
TABLES	52
Table 6.1 Sample Collection and Testing Chronology for Products	53
Table 6.2 Chamber Conditions for 96-hr Test Period.....	53
Table 6.3 All Chronic Inhalation Reference Exposure Levels (RELs) Adopted by Cal/EPA OEHHA as of August 2006.....	53
Table 6.4 Parameters to be used for calculation of VOC concentrations in classrooms.....	57
ATTACHMENT 1 –	
GREENGUARD’s <i>Laboratory Qualifications and Proficiency Requirements</i>	
ATTACHMENT 2 –	
GREENGUARD’s <i>Office Furniture Test Requirements Specifications</i>	

SECTION 1 BACKGROUND INFORMATION

Scope

Building materials, finishes and indoor furnishings may emit a variety of volatile chemicals into the indoor air space of a building. The following methodology measures total volatile organic compounds (TVOC), individual volatile organic compounds (IVOCs), formaldehyde, and the other aldehyde emission levels from materials using test conditions defined to simulate product use in realistic commercial office, educational, healthcare and/or residential settings. The level of total or individual volatile organic chemical emissions is determined by observing the TVOC, IVOC, or aldehyde concentration in a dynamic environmental chamber under specified test conditions. The observed chamber concentration is then converted by a mathematical calculation to an emission rate, a product specific variable, and then modeled to obtain room concentration estimates.

The quantity of VOCs in the environmental chamber air is determined by gas chromatography/mass spectrometry. The methodology is generally applicable to volatile organic compounds with boiling points from 60°C to 290°C emitting from individual products. Emissions of selected aldehydes are measured using reverse-phase high-performance liquid chromatography (HPLC) with UV detection. Specialized analysis of chamber air samples may be conducted for other specific target chemicals as required for a specific product/project requirement.

- 1.0.1 The methodology provides a standard means of reproducibly and accurately testing building materials and products under a realistic, yet highly controlled, atmosphere.
- 1.0.2 The methodology with standardized measurement and analyses provides consistent testing of materials within a product group.
- 1.0.3 This protocol applies to any material belonging to a product category generally used within an enclosed indoor environment. This includes, for example, paints, other architectural coatings, sealants, adhesives, wall coverings, floor coverings, wood paneling, ceilings, furniture and furniture components used in public and commercial office buildings, schools, medical buildings, residences and other building types. The protocol applies to products that can be tested whole or by a representative component or material in an environmental chamber.
- 1.0.4 This methodology is applicable for newly manufactured products before they are used in construction or furnishing. Products taken from inventory or from within buildings can also be studied but data will not be considered representative of newly manufactured products.
- 1.0.5 This method establishes the procedures for product sample collection, emission testing and analysis, indoor air concentration modeling and associated documentation requirements.
- 1.0.6 This method also establishes performance criteria for specific chemicals of interest.
- 1.0.7 While this practice may list specific chemicals and associated maximum allowable concentrations, as required by criteria indoor air guidelines and specifications, it does not assess the human risk involve with use of the materials either as an installer and/or as an end user.
- 1.0.8 This practice does not purport to address safety concerns, if any, associated with the use of this practice. It is the responsibility of the user of this protocol to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Objectives and Use

1.0.9 Objectives

- 1.0.9.1 Measure VOCs, including aldehydes, and other potential pollutants from building materials, finishes, and indoor furnishings.
- 1.0.9.2 Provide compound-specific data on VOCs and their sources to manufacturers for assessing product emissions and developing improved products for indoor environments.
- 1.0.9.3 Obtain emission data for use by the GREENGUARD Certification Program, the California CHPS Program, the State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174), CA Section 01350, BIFMA Furniture Emissions Standards, the German Blue Angel Programs, the Green Guide for Health Care, the National Association of Home Builders (NAHB), MBDC's Cradle to Cradle Certification, LEED credits, Green Globes, and other government and private product specification programs.
- 1.0.9.4 Provide compound-specific data on VOC sources and assist in evaluating indoor air quality in buildings.
- 1.0.9.5 Provide emissions data for the development and use of models for prediction of indoor air concentrations of VOCs.
- 1.0.9.6 Identify irritants, odorants, and hazardous VOCs emitting from building materials, finishes and indoor furnishings and their emission parameters to assist in risk evaluations.
- 1.0.9.7 Rank and evaluate products within a category or across categories respect to their emission profiles, types, or chemicals and their levels.
- 1.0.9.8 Provide compound specific emission parameters for use in indoor exposure models.

1.0.10 Use

- 1.0.10.1 Small (0.05 – 1 m³) chamber evaluations are used to determine source emission rates and emissions factors from small products and small components of products.
- 1.0.10.2 Intermediate (approximately 1 – 6 m³ volume) chamber evaluations are used to determine source emission rates and emission factors from larger components and smaller pieces of office furniture (chairs, file cabinets, etc.).
- 1.0.10.3 Large (> 25 m³) chambers are used for the evaluation of large products, including assembled workstations.
- 1.0.10.4 Emission rates are used in indoor air quality models to predict indoor air concentrations of compounds emitted from the tested material. The concentrations observed in the chambers are not to be directly used as a substitute for concentrations expected in full-scale indoor environments.
- 1.0.10.5 Emission factors are used to compare emission levels among products at a specific exposure time point.

References and Documents

- ASTM D 5116*. Standard Guide for Small Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials / Products. *American Society for Testing and Materials, West Conshohocken, PA, 2006*.
- ASTM D 6670*. Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials / Products. *American Society for Testing and Materials, West Conshohocken, PA, 2001*.
- ASTM D 5197*. Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology). *American Society for Testing and*

- Materials, West Conshohocken, PA, 2003.*
- ASTM D 6196. Practice for the Selection of Sorbents and Pumped Sampling / Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air. *American Society for Testing and Materials, West Conshohocken, PA, 2003.*
- ASTM D 6345. Standard Guide for Selection of Methods for Active, Integrative Sampling of Volatile Organic Compounds in Air. *American Society for Testing and Materials, West Conshohocken, PA, 2001.*
- ASTM D 7339. Standard Test Method for Determination of Volatile Organic Compounds Emitted from Carpet using a Specific Sorbent Tube and Thermal Desorption / Gas Chromatography. *American Society for Testing and Materials, West Conshohocken, PA, 2001.*
- ASTM E 741. Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution. *American Society for Testing and Materials, West Conshohocken, PA, 2001*
- USEPA Report 600/8-89/-074. Research Triangle Park, NC, 1989.
- Research Triangle Institute.* Environmental Technology Verification (ETV) Test Protocol: Large Chamber Test Protocol for Measuring Emissions of VOCs and Aldehydes. *Research Triangle Park, NC, 1999.*
- Research Triangle Institute.* Environmental Technology Verification (ETV) Report: Emissions of VOCs and Aldehydes From Commercial Furniture, RTP, NC 1999.
- State of Washington Indoor Air Quality Specifications, Department of General Administration, Furniture Specification, January, 1994.
- ANSI/BIFMA M7.1-2007. Standard Test Method for Determining VOC Emissions From Office Furniture Systems, Components and Seating. September, 2007
- ANSI/BIFMA X7.1-2007. Standard for Formaldehyde and TVOC Emissions of Low-emitting Office Furniture Systems and Seating. September, 2007
- ASHRAE Standard 55-2004. Thermal Environmental Conditions for Human Occupancy. ASHRAE, Atlanta, GA, 2004.
- ASHRAE Standard 62.1-2007. Ventilation for Acceptable Indoor Air Quality, ASHRAE, Atlanta, GA, 2007.
- ACGIH, 2007 Threshold Limit Values for Chemical Substances and Biological Exposure Indices. *Cincinnati, OH, 2007.*
- Winberry, W. T., et al. Compendium of Methods for the Determination of Air Pollutants in Indoor Air. Office of Research and Development, USEPA, RTP, NC, April 1990.
- Bertoni, G., F. Bruner, A. Liberti, and C. Perrino.* Some Critical Parameters in Collection, Recovery, and Gas Chromatographic Analysis of Organic Pollutants in Ambient Air Using Light Adsorbents. *J. Chromatogr., v.203, pp.263-270, 1981.*
- Bruner, F., G. Bertoni, and G. Crescentini,* Critical Evaluation of Sampling and Gas Chromatographic Analysis of Halocarbons and Other Organic Air Pollutants. *J. Chromatogr. v.167, pp.399-407, 1978.*
- Mangani, F., A. Mastrogiacomo, and O. Marras,* Evaluation of the Working Conditions of Light Adsorbents and Their Use as Sampling Material for the GC Analysis of Organic Air Pollutants in Work Areas. *Chromatographia, v.15, pp.712-716, 1982.*
- Sparks, Leslie, Indoor Air Exposure Model, Version 2.0. Air and Energy Engineering Research Laboratory, USEPA, RTP, NC, April, 1991.
- GREENGUARD Product Certification Program Laboratory Qualifications and Proficiency Requirements, 2005, <http://www.greenguard.org>
- Cal/EPA, ARB list of Toxic Air Contaminants (TACs). The current version of this list is accessible at <http://www.arb.ca.gov/toxics/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
- Cal/DHS, Standard Practice for the Testing of Volatile Organic Emissions for Various Sources Using Small Scale Environmental Chambers, (CA/DHS/EHLB/R-174) The current version is accessible at <http://www.dhs.ca.gov/ps/deodc/ehlb/iaq/VOCS/Practice.htm>
- European Committee for Standardization. 2002. PrEN 13419-1. Building Products, Determination of the Emissions of Volatile Organic Compounds. Part 1: Emissions Test Chamber Method
- ISO 16000-3:2001. Indoor air - Part 3: Determination of formaldehyde and other carbonyl compounds – Active sampling method
- ISO 16000-6:2006. Indoor air – Part 6 Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID
- ISO 16000-9:2006. Determination of the emission of volatile organic compounds from building products and furnishing – Emission test chamber method
- ISO 16017-1:2000. Indoor, ambient and workplace air -- Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography -- Part 1: Pumped sampling
- ISO Guide 43-1:1997. Proficiency testing by interlaboratory comparisons – Part 1: Development and operation of proficiency testing schemes.
- ISO Guide 43-2:1997. Proficiency testing by interlaboratory comparisons – Part 2: Selection and use of proficiency testing schemes by laboratory accreditation bodies.
- OSHA Method #104:1994. For the Detection of Airborne Phthalates (Dimethyl Phthalate (DMP), Diethyl Phthalate (DEP), Dibutyl Phthalate (DBP), Di-2-Ethylhexyl Phthalate (DEHP), and Di-n-Octyl Phthalate (DNOP)).
- European Committee for Standardization. 2002. PrEN 13419-3. Building Products, Determination of the Emissions of Volatile Organic Compounds. Part 3: Procedure for Sampling, Storage of Samples and Preparation of Test Specimens
- Reference Specifications for Energy and Resource Efficiency, Section 01350 Special Environmental Requirements. The current version of this Specification is accessible at <http://www.eley.com/specs/index.htm> and http://www.chps.net/manual/documents/Sec_01350.doc
- 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>

Terminology

Acronyms and Abbreviations

ACH – Air changes per hour
ARB – Air Resources Board, Cal/EPA
ASTM – American Society for Testing and Materials
AQS – Air Quality Sciences, Inc.
BQL – Below quantifiable limit
BIFMA – The Business and Institutional Furniture Manufacturer’s Association
Cal/DHS – California Department of Health Services
Cal/EPA – California Environmental Protection Agency
CIWMB – California Integrated Waste Management Board, Cal/EPA
CHPS – Collaborative for High Performing Schools
COC – Chain of Custody
DL – Detection limit
DNPH – 2,4-Dinitrophenylhydrazine
EF – Emission factor
EPA – U.S. Environmental Protection Agency
GC/MS – Gas chromatography/mass spectrometry
GEI – GREENGUARD Environmental Institute
HAP – Hazardous Air Pollutant
HPLC – High performance liquid chromatography
IAQ – Indoor air Quality
ISO – International Standards Organization
IVOC – Individual volatile compounds
LOQ – Limit of quantitation, lower
MDF – Medium density fiberboard
MFC – Mass flow controller
MSDS – Material safety data sheet
OEHHA – Office of Environmental Health Hazard Assessment, Cal/EPA
OSB – Oriented strand board
Prop 65 – California Proposition 65
QL – Quantifiable limit
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
VCT – Vinyl composition tile
VOC – Volatile organic compound

Definitions

Absolute Humidity (AH) - The amount of water vapor present in a unit volume of air; expressed as grams of water per grams of air.

Accuracy - The degree of conformity of a value generated by a specific procedure to the assumed or accepted true value; includes both precision and bias.

Air Exchange Rate (ACH) - The volume of purified inlet air, adjusted to standard environmental conditions of 23°C and 50% RH, that enters the chamber environment in one hour divided by the volume of the chamber (typically expressed as hr^{-1}).

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.

Background Concentrations – VOC and aldehyde 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.

Chronic REL - Noncancer chronic reference exposure level developed by Cal/EPA OEHHA.

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

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

Emission Factor (EF) – A product specific factor typically describing the mass of a chemical emitted from a product per exposed area of the product per unit time ($\mu\text{g}/\text{m}^2\cdot\text{hr}$) or the mass of chemical emitted per weight per unit time ($\mu\text{g}/\text{g}\cdot\text{hr}$).

Emission Rate (ER) – The rate of emission of a specific compound is defined as the total $\mu\text{g}/\text{hr}$ of a chemical emitted from a product.

Humidity (H) – A measure of the amount of water vapor in the air.

Intermediate Environmental Chamber - A test apparatus consisting of an enclosed volume of between 1 m^3 to 6 m^3 with controlled environmental operational parameters used for the purpose of providing accurate and reproducible emission measurements from sources of indoor air pollutants.

Large Environmental Chamber - A test apparatus consisting of an enclosed volume of greater than 6 m^3 with controlled environmental operational parameters used for the purpose of providing accurate and reproducible emission measurements from sources of indoor air pollutants.

Loading - The physical act of placing the sample in the chamber, sealing the chamber door, and starting the test.

Loading Factor or Loading Ratio (L) - The ratio of the area of exposed surface(s) of the test specimen to the chamber volume (m^2/m^3).

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 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.

Precision - The degree of agreement of repeated measurements of the same property.

The precision of a method is expressed quantitatively as the standard deviation computed from the results of a series of controlled determinations.

Product Category – General group of similar products intended for a particular application and performance, such as adhesives, bedding, flooring, furniture, and paints and coatings.

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 (including specific chemicals and decay profile over time).

Product Loading – The ratio of the amount of material to be placed in the chamber to the volume of the chamber. Typically based on the area (m^2/m^3 of chamber volume), or mass (g/m^3) or unit ($1 \text{ unit}/m^3$).

Relative Humidity (RH) - The ratio of the amount of water vapor actually present in the air to the greatest amount possible at the same temperature; expressed as percent saturation.

Representative Product Sample – A product sample, which 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 an air sample from the emission test chamber.

Small Environmental Chamber - A test apparatus consisting of an enclosed volume of between a few liters and 1 m^3 (nominally 50-100 L or $0.05 - 1 \text{ m}^3$) with controlled environmental operational parameters used for the purpose of providing accurate and reproducible emission measurements from sources of indoor air pollutants.

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, sometimes backed up by higher surface area sorbent material to quantitatively capture the most volatile VOCs.

Test Specimen - Portion of representative sample prepared for emission testing in an emission test chamber following a defined procedure.

Total-ion-current 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.

Total Volatile Organic Compounds (TVOC) - The sum of those VOCs that elute between the retention times of n-hexane and n-hexadecane on a non-polar or equivalent capillary GC column. TVOC is estimated based on a toluene response factor.

Temperature (T) - Degree of hotness or coldness expressed in degrees Celsius.

Ventilation Rate – Same as air change rate

Volatile Organic Compound (VOC) - Those nonpolar and moderately polar organic chemicals with boiling points between 60°C and 290°C that are amenable to monitoring, based on sorbent collection /thermal desorption/GC/MS analysis. The volatility range of chemicals amenable to the method will depend on the sorbent cartridges and thermal desorption chromatographic system used by the laboratory.

Zero Time - Time establishing the beginning of an emission test or when product is placed in a chamber and door is sealed.

Symbols

Symbol	Description	Units
A	Projected surface area	m ²
C	Chamber concentration of VOC	µg/m ³
C _{P,t}	Predicted exposure concentration at time t	µg/m ³
EF	Emission factor	µg/m ² ·hr or µg/m·hr or µg/g·hr or µg/unit·hr
EF ₀	Initial emission factor	µg/m ² ·hr or µg/m·hr or µg/g·hr or µg/unit·hr
EF _t	Measured emission factor at time t	µg/m ² ·hr or µg/m·hr or µg/g·hr or µg/unit·hr
ER	Emission rate	µg/hr
k	Rate constant	hr ⁻¹
L	Product loading factor	m ² /m ³ or m/m ³ or g/m ³ or unit/m ³
N	Chamber air exchange rate	hr ⁻¹
N _e	Modeled air changes per hour	hr ⁻¹
Q	Area specific flow rate	m/hr
SER	Area specific emission rate	µg/m ² ·hr
T	Time after start of test	hr or day
t	Time	hr
V	Volume	m ³
vfB	Building ventilated volume fraction	Unitless

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

2.0 Sample Collection

Purpose

Guidelines are established for the collection, handling and documentation of product samples to ensure the samples tested are reliable, representative, uncontaminated, and well preserved.

2.1 Personnel

- 2.1.1 Personnel responsible for sample collection must perform the task carefully and conscientiously and according to specific instructions, if supplied. Improper sample collection may impact the integrity of the sample and invalidate analysis, data and use of data.
- 2.1.2 Individuals engaged in sample collection and handling must be qualified by training and experience and possess an understanding of the relevant practices and techniques or, at a minimum, be under the direct supervision of such an individual.

2.2 Representative Sample

- 2.2.1 Products selected or requested for testing are to be representative of similar products produced by the manufacturer. These products shall be treated no differently than similar products or components produced in the normal course of business and available in the marketplace.

2.3 Sample Preservation

- 2.3.1 Special care shall be taken to prevent contamination of the product sample from any external source, prior to, during and subsequent to the sample collection procedure.
- 2.3.2 Powder free latex gloves are recommended during collection and packaging of the sample. Latex gloves minimize the risk of sample contamination by perfumes, soaps, or other contaminants on the hands of sample collection personnel.
- 2.3.3 Product samples may be packaged in two ways: 1) using the manufacturers standard product packaging materials, including sealed containers (as provided to distributors and/or customers); or 2) using contaminant-free, airtight, specialized Mylar or polyethylene lined foil barrier bags provided by the laboratory (specialized sample bags). In each case, care shall be taken to ensure that the sample package is tightly sealed to minimize contamination from external sources or off gassing during shipment and storage. If the manufacturer's standard product packaging does not meet sealing requirements, then other specialized packaging must be used.
- 2.3.4 The product will remain in its packaging as received, or transferred to a specialized bag (see Section 2.3.3), foil bag or otherwise sealed to preserve the integrity of the sample, until immediately prior to loading into the environmental chamber. Until it is unpacked, it will be stored in an environmentally controlled indoor environment free of contamination with environmental control of 20° – 25°C and relative humidity no greater than 60% RH.

2.4 Location of Sampling

- 2.4.1 Generally, samples are to be collected directly from the manufacturing or packaging line. The most appropriate location is dependent on the product and packaging process employed by the manufacturer. Multi-component or large materials may be organized in a clean, environmentally controlled location while consolidation of all components occurs (referred to as a sample consolidation location). When collecting samples directly off the manufacturing line, the collection location shall be chosen to ensure easy access so that a representative selection of the material is obtained. Sample collection personnel shall document the sample collection location and any relevant observations. This information shall be included on the chain of custody (COC) form.

2.5 Sample Age

- 2.5.1 Samples shall be packaged no more than 1 hour following collection off the manufacturing line or immediately following completion of the manufacturer's product packaging process. However, the sample shall not be packaged until it has reached room temperature. If additional time is required for the product to reach room temperature beyond the one hour, note this on the chain of custody.
- 2.5.2 Samples shall be shipped from the manufacturing facility within 24 hours of collection and packaging, except for multi-component or large samples (such as furniture). In these cases, the sample must be shipped within two days of completion of product consolidation (for multi-component samples) or packaging (for large samples due to specialized packaging processes that may be needed). Manufacturing date will be that of the last component of a complex system.
- 2.5.3 Samples shall arrive at the testing laboratory within 7 days of shipment, although overnight shipment is recommended for small products.
- 2.5.4 Timing of sample collection shall be coordinated between the manufacturing facility and the testing laboratory to ensure that preparation and loading of samples can occur within 10 days of receipt at the laboratory.

The schedule for sample collection, shipping, specimen preparation, and testing is summarized below.

Dry/Wet Products

<i>Manufacturing Date</i>	Date product comes off of final manufacturing line
<i>Sample Collection</i>	Same as <i>Manufacturing Date</i>
<i>Shipment to Laboratory</i>	Within 24 hours of sample collection (see Section 2.5.2 for furniture or complex products)
<i>Arrival at Laboratory</i>	Not to exceed 7 days of shipment date
<i>Testing Date</i>	Not to exceed 10 days after arrival and product acceptance at laboratory

2.6 Customized Sample Preparation

- 2.6.1 If cutting or other preparation of a sample 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 provided to the testing laboratory. All cutting and other tools used to prepare test specimen shall be cleaned properly to avoid sample contamination. Packaging and shipment parameters for the manufacturer prepared specimen shall be in accordance with Sections 2.3 and 2.5.

2.7 Sample Collection Procedures

- 2.7.1 Tile and Plank Products - Tile and plank products are collected directly from the manufacturing or packaging line. If standard manufacturer packaging materials are not used, a minimum of four representative tiles, strips or planks, each with a minimum surface area of at least 64 square inches, shall be collected. The tiles, strips or planks shall be stacked tightly together face to back and immediately placed in specialized

packaging as described in Sections 2.3 and 2.5. Following packaging, the GREENGUARD COC must be fully completed. The white and yellow copies of the completed three-part form (Section 2.9) shall be attached to the outside of the sample package. The pink copy of the COC is a record retained by the manufacturer. No more than 1 hour shall elapse between the time of sample collection and packaging.

- 2.7.2 Sheet and Roll Goods - Sheet and roll goods are collected directly from the manufacturing or packaging line. Sheet and roll goods shall be cut at a minimum width of 12" across the entire width of the roll. Following cutting, the product shall be tightly rolled and immediately placed in specialized packaging as described in Sections 2.3 and 2.5 (unless such size material can be collected from the packaging line using the manufacturer's standard packaging materials). Wallcovering and other fabric may be collected as a full or partial production roll. In these cases, the roll shall have at least 10 layers of material and may be provided collected from the packaging line or placed in specialized packaging as described in Sections 2.3 and 2.5. Following packaging, the GREENGUARD COC must be fully completed. The white and yellow copies of the completed three-part form shall be attached to the outside of the sample package. The pink copy of the COC is retained as a record for the manufacturer. No more than 1 hour shall elapse between the time of collection and packaging.
- 2.7.3 Rigid Panel Products - Rigid Panel Products are collected directly from the manufacturing line. For large panel products, the entire panel may be shipped to the testing laboratory as long as the sample is appropriately sealed. As an alternative, smaller samples may be collected from the larger panel. These samples shall be collected at least 6 inches away from all edges of the larger panel. Within this boundary, the smaller panel samples shall be cut into approximate 12" x 12" squares. A minimum of four squares is required. The squares shall be stacked tightly together face to back and immediately placed in specialized packaging as described in Sections 2.3 and 2.5. Following packaging, the GREENGUARD COC must be fully completed. The white and yellow copies of the completed three-part form shall be attached to the outside of the sample package. The pink copy of the COC is retained as a record for the manufacturer. No more than 1 hour shall elapse between the time of collection and packaging.
- 2.7.4 Insulation - In order to best represent the finished product, air that may be exchanged in, and evacuated from, the packaging process should be simulated as much as possible. The cooling of the product is also a factor when the collection point is established. Creating realistic timeframes and conditions for sample collection ensures that the product is representative of insulation materials standard production procedures while still ensuring that the sample adequately represents the products highest-emitting state for the purposes of GREENGUARD Certification.
- 2.7.4.1 Batts and Rolls: Most, if not all of these materials are packaged in bags as an integral point of manufacturing. Further, air is generally evacuated from the package to reduce the physical size of the packaged product for shipping purposes. Samples shall be collected after 15 minutes (\pm 2 minutes) following packaging. The product should be removed from its original packaging and placed into the specialized packaging. Manufacturers who wish to continue to collect samples directly from the production line may continue to forego packaging and may establish an earlier point of

sample collection as long as the sample is cool. Samples shall be submitted per the following size requirements: 18" x 30", samples of the same material may be cut into smaller sizes (no smaller than 12" x 12") and placed in the same packaging.

2.7.4.2 Boards and Rigid Foam Products: As board products are generally boxed, opening the final package would be both difficult and cause excessive waste. In this case, the sample should be removed immediately from the production line and allowed to condition for 15 minutes (\pm 2 minutes) under standard laboratory conditions in the plant prior to packaging for emissions testing. Manufacturers who provide GREENGUARD Certified products for furniture panel applications will be expected to deliver product for the purposes of emissions testing in the same fashion as standard board products. Manufacturers who wish to continue to collect samples directly from the production line may continue to forego packaging and may establish an earlier point of sample collection. Samples shall be submitted per the following size requirements: 18" x 30", samples of the same material may be cut into smaller sizes (no smaller than 12" x 12") and placed in the same Mylar packaging bag.

2.7.4.3 Blowing Wools and Loose Fill Products: It has been determined that the collection of loose fills or blowing wools is not easily achieved directly from the production line, dependent on the manufacturer. The sample collection procedure shall be consistent with Batts and Rolls. Sample collection, in this case, requires collection of product from the compressed or evacuated product package, 15 minutes (\pm 2 minutes) following packaging. Manufacturers who wish to continue to collect samples directly from the production line may continue to forego packaging and may establish an earlier point of sample collection. Samples shall be submitted per the following size requirements: Loose fill insulation shall be placed in a specialized packaging bag, filling roughly 66% to 75% of the bag.

2.7.4.4 Spray Foam Insulation: As these products are applied in-situ, and do not come off a manufacturing line, the following collection processes have been instituted to most closely mimic those associated with spray foam installation.

2.7.4.4.1 Closed Cell Foam Insulation

2.7.4.4.1.1 Spray a 12" x 12" sample to thickness (based on stud size) – 1 or 2 passes 1.5"-2" thick

2.7.4.4.1.2 Wait 1 hr (or shortest time allowed before able to be cut)

2.7.4.4.1.3 Place in Mylar bag

2.7.4.4.2 Open Cell Foam Insulation

2.7.4.4.2.1 Spray a 12" x 12" sample to thickness – 3.5"- 4" for walls, 6" for attics

2.7.4.4.2.2 Scarf the sample (usually done within 15 minutes of spraying to remove excess foam)

2.7.4.4.2.3 Wait 24 hrs

2.7.4.4.2.4 Place in Mylar bag.

2.7.5 Containerized and Wet Products - Containerized and wet products can be supplied in original, standard 1-quart or 1-gallon consumer containers. Adhesives can be supplied in their consumer packaging such as an applicator tube or can (if less than 1 gallon). Alternatively, adhesive and paint samples can be collected in clean, unused paint cans (1-pint or 1-quart size). Special care is required to assure that 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. Following packaging, the GREENGUARD COC must be fully completed. The white and yellow copies of the completed three-part form (Section 2.9) shall be attached to the outside of the sample package. The pink copy of the COC is retained as a record for the manufacturer. Samples of containerized products sent to a laboratory shall also be accompanied by a Material Safety Data Sheet (MSDS) and a specification sheet that describe the products, list the major chemical ingredients, identify the intended uses and describe the application methods. Disposal recommendations should also be provided.

- 2.7.6 Furniture and Other Large Products - Furniture and other large products shall be collected immediately following manufacturing and packaging due to product size, the manufacturer's standard packaging materials and processes are often used for large products such as chairs, tables, and desks. This is typically shrink wrapped followed by placement in a cardboard box. For multi-component systems, a consolidation area must be established that is clean with controlled environmental conditions. As additional components are packaged, they shall be stored in the consolidation area until all components have been manufactured and packaged. Following packaging of individual samples or completion of consolidation of multi-component systems, the GREENGUARD COC must be fully completed. The white and yellow copies of the completed three-part form shall be attached to the outside of the sample package. The pink copy of the COC is retained as a record for the manufacturer.

2.8 Packaging and Shipment of Samples

- 2.8.1 Samples are shipped to the testing laboratory in sealed Mylar or polyethylene lined foil "barrier" bags (specialized bags) provided by the testing laboratory, in the manufacturer's standard packaging, or in otherwise sealed containers. The type of packaging used must ensure that the sample is tightly sealed to minimize contamination from external sources or offgassing during shipment and storage (also see Section 2.3).
- 2.8.2 Samples must be packaged to avoid cross contamination. Different types of products should be packaged individually for shipping.
- 2.8.3 Samples are to be shipped to the testing laboratory within 24 hours of collection and packaging except for multi-component or large samples (such as furniture). In these cases, the sample must be shipped within two days of completion of product consolidation and/or packaging. Products shall arrive at the testing laboratory within 7 days of shipment, although overnight shipment is recommended for small products.

2.9 Chain of Custody Documentation

- 2.9.1 The manufacturer is responsible for the completion of the GREENGUARD Product Documentation/Chain of Custody form. This form must be completed by the responsible manufacturer's employee/representative or by an independent third party pursuant to an agreement between the Licensee and the GEI. Each signatory shall retain a copy of this document.
- 2.9.2 The chain of custody form includes as a minimum the following information:
- 2.9.3 Manufacturer/Company Details – Name, Street Address, City, State/Province, Country, Zip/Postal Code

- 2.9.4 Contact Details – Contact Name, Title, Phone Number, Fax Number, Email Address
- 2.9.5 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
- 2.9.6 Shipping Details – Packed By, Shipping Date, Carrier, Airbill Number (Carrier and Airbill Number may be filled in by Laboratory upon receipt).
- 2.9.7 Ship to Laboratory – Name, Street Address, City, State/Province, Country, Zip/Postal Code, Phone Number, Fax Number
- 2.9.8 Laboratory Receiving Details – Received By, Received Date, Condition of Shipping Package, Condition of Sample, Assigned Laboratory Material Tracking Number
- 2.9.9 Signature Tracking Details – Relinquished By, Received By, Signature, Company, Date and Time

2.10 Receipt of Samples by Laboratory

- 2.10.1 Once the product sample is received by the laboratory, the packages will be checked against the shipping invoice to ensure all packages and components have been received.
- 2.10.2 The laboratory will visually inspect the shipping containers upon arrival to ensure they are intact and do not appear to have been contaminated during shipping.
- 2.10.3 The sample custodian shall note the condition of the package and container on the chain-of-custody form and sign and date the form.
- 2.10.4 If containers are damaged or missing, the laboratory will notify the manufacturer as soon as feasible.
- 2.10.5 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 2.11.
- 2.10.6 Valid samples are assigned a unique identifier and entered into an electronic data management system for sample and data tracking purposes.
- 2.10.7 The product is to remain in its original packaging (as received) until immediately prior to preparation for loading into the environmental chamber. It is to be stored in a normal indoor environment not expected to contaminate the product.

2.11 Rejection of Samples by Laboratory

- 2.11.1 The testing laboratory has the right to reject a product sample for testing due to, but not limited to, any of the following reasons:
- 2.11.2 Shipping package is severely damaged upon arrival.
- 2.11.3 Product container (i.e., external bag, foil package, can, tube, etc) is damaged upon arrival so that integrity of the sample is compromised.
- 2.11.4 Chain of Custody form is missing or incomplete.
- 2.11.5 Product sample arrives with insufficient time to initiate testing within the required time frame.
- 2.11.6 When a product sample is rejected, the testing laboratory shall inform the manufacturer immediately and provide the reason for rejection.
- 2.11.7 The manufacturer has the right to collect a new sample and resubmit it for testing, subject to the conditions described within this practice. All costs for recollection and shipment shall be the responsibility of the manufacturer.

2.12 Storage of Samples by Laboratory Prior to and Following Testing

- 2.12.1 Before Testing: Samples are stored in original, sealed packaging in a controlled environment not expected to contaminate the sample. This environment must be free of chemical contamination and environmentally controlled at 20° - 25°C and not greater than 60% RH.

2.12.2 After Testing: Following testing and report issuance, the product is stored for 30 days. After this time, the product is either returned to the manufacturer or disposed of depending on the request of the client. The yellow copy of the chain of custody form is returned or destroyed with the product.

**SECTION 3
LABORATORY SAMPLE PREPARATION
AND ANALYSES**

3.0 Test Specimen Preparation

- 3.0.1 For product assemblies such as wall paint primer and finish coat on gypsum board, wallcoverings and floor systems where the surface finish material is applied to a substrate, with or without the use of adhesives; the individual components of the assembly can 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 or Program recommended procedures.
- 3.0.1 Products manufactured to arrive on site preassembled such as finished raised flooring, adhesive impregnated wallpaper or adhesive applied floor tiles are tested as a single unit. The manufacturer is not required to submit separate samples of the primary material and adhesive for testing.
- 3.0.2 The test specimen dimensions given in this section are for illustrative purposes. The dimensions are optimized for small-scale test chambers with volumes of 50 to 100 L operating at 1 air change. Loading factors are established to be representative of actual building use and optimized for analytical measurement in the chambers. See Table 6.2 and Section 3.10.2 for more information.
- 3.0.3 For products not specifically detailed in this specification, it will be necessary to develop test preparation procedures. If procedures other than described in this section are used, they should be described and reported.
- 3.0.4 Sample specimen replicates should be prepared for analysis as part of the laboratory quality program. The fraction of duplicates is established by the laboratory's quality assurance plan, and should be a minimum of one duplicate for every ten samples prepared of a product type.
- 3.0.5 Completion of specimen preparation and placement of the test specimen in the environmental chamber is considered the starting time for the VOC emission test (i.e., zero time).
- 3.0.6 If special substrates and/or edge sealing materials are used for specimen preparation, emissions 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, and every attempt should be made to use materials that do not emit measurable amounts of any target VOC of concern.

3.1 Furniture Testing

- 3.1.1 Furniture testing falls into three general categories:
 - 3.1.1.1 Construction materials are typically tested in small chambers. Examples of these materials are foam cushions, textiles, mockup wood surfaces, etc. These items are typically tested for comparative purposes, according to a 24-hour evaluation protocol.
 - 3.1.1.2 Components such as seat cushions, worksurfaces and panels are either tested in whole in intermediate chambers, or cut so that a representative sample can fit into a small chamber. They may either be tested as part of a larger scale comparative study (24 hr single point test), or for full characterization (96 hour, 168 hour or longer emissions profile studies).
 - 3.1.1.3 Complete finished products, such as chairs, desks, workstations, and moveable walls, are typically tested in a large chamber. These are tested for full 168 hour or extended periods including 336 hour, or 720 hours, directly out of the original packaging.

3.2 Sample Preparation

- 3.2.1 Construction Materials - The details of preparation and loading of furniture construction materials vary with the type of material. The goal of the sample preparation step is to prepare an assembly that represents the material under conditions similar to those in which it is used in the furniture product.
- 3.2.1.1 Textiles - Unroll the sample, and, from the center, cut a section to the dimensions specified by the test protocol. Furniture textiles are typically cut to the dimensions required to yield a loading factor of 1 m²/m³. If the material is pre-cut to approximately the target dimensions, load as is. Place sample on metal plate and seal edges with non-emitting foil tape to expose the finished surface only. Place this material onto a flat plate or tray, making sure it is lying flat. Record product dimensions. Load into chamber within 5 minutes.
- 3.2.1.2 Foams/cushions and substrates (e.g. particleboard) - If the customer supplies a specimen which will fit into the small chamber as is, the product will be loaded into the chamber with all sides exposed. Otherwise, cut specimen to size and load in chambers with all sides exposed targeting a 0.4 m²/m³ loading. Record product dimensions. Load into chamber within 5 minutes.
- 3.2.1.3 Wood finish, finished wood and wood veneers, laminates/backers - These materials are generally tested with edges and the bottom sealed, exposing only finished surfaces. If the customer supplies a specimen which will fit into the small chamber as is, any unfinished surfaces will be sealed, and the product will be loaded into the chamber. If the specimen needs to be cut to size, target a loading factor of 0.4-1 m²/m³. Seal all cut surfaces and unfinished surfaces with non-porous, non-emitting materials such as foil tape. Record product dimensions. Load into chamber within 5 minutes.
- 3.2.2 Furniture Components - The details of preparation and loading of furniture components vary with the type of product. The goal of the sample preparation step is to prepare a sample representative of the final use configuration of the component. These are finished components that are used in a workstation/casegood system or chair/sofa.
- 3.2.2.1 Workstation Panels - Monolithic Panels (usually in a frame) are panel components that have both sides finished. If the customer supplies a specimen which will fit into the small chamber as is, load with both sides exposed and seal any unfinished edges/areas. Use a two-sided area for the loading factor. One-sided Panels (or Panel Tiles) are loaded with only the finished side exposed. If the customer supplies a specimen which will fit into the small chamber as is, the back is loosely wrapped in foil and any unfinished edges are sealed. A one-sided area is used for the loading factor. If the panel can be cut to fit into a small chamber, without losing the integrity of the sample, target a loading factor of 1 m²/m³ and expose, at most, only one finished edge. Alternatively load unperturbed in an intermediate sized chamber following the appropriate instructions above for the product type.
- 3.2.2.2 Worksurfaces – Cut to fit into a small chamber with a target a loading factor of 0.4-1 m²/m³. Load with the top, bottom and one finished edge exposed. Seal the unfinished edges with low emitting foil tape. However, if the backside is completely unfinished seal the back with low emitting foil and foil/tape. Use a one-sided area for the loading factor. Alternatively, larger, whole worksurfaces and tabletops can be loaded into an intermediate chamber. Expose the entire sample, except for holes or cutouts which would not normally be exposed in typical use situation. Seal the unfinished areas with low emitting material.
- 3.2.2.3 Storage Fronts – Cut to fit into a small chamber with a target a loading factor of 0.4-1 m²/m³, or use unperturbed sample, if the customer supplies a specimen which will fit into the small chamber as is. Lay sample flat on chamber floor when loading, do not

seal back or finished edges. Leave top side exposed and seal any unfinished cut-outs or edges or cut edges with low emitting material. For the loading factor use a one-sided area.

- 3.2.2.4 *Seat Cushions/Seat Backs* – Load in chamber with all finished sides exposed. Seal unfinished sides/areas with low emitting foil and /or foil tape. Record dimension of exposed areas and use the total exposed area in the loading factor calculation.
- 3.2.2.5 *Wood Seating Components* – Prior to loading, cut wood component (i.e. arm, leg) so that it is no longer than 6" in length. Seal any cut edges with foil tape. Place sample on x-supports in chamber. Record dimension of exposed areas and use the total exposed area in the loading factor calculation.
- 3.2.3 *Complete Furniture and Workstations* - Complete furniture, such as chairs, desks, movable walls and workstations, is unwrapped immediately prior to testing, and loaded, as is, into either an intermediate or large chamber. Workstations typically require assembly before loading into the large chamber. They are assembled as closely as possible to manufacturer instructions. The assembly is completed as much as possible outside the chamber in order to minimize contamination of the chamber interior with ambient air. Once all major sections are assembled, the product is loaded into the large chamber and final assembly performed. Emission factors are based on a unit basis, with the exception of movable walls. For movable walls, record the dimensions and use a 2-sided area. GREENGUARD furniture specifications are given in Attachment 2. As an option, furniture specifications presented in the BIFMA M7.1-2006 Test Method may be tested for panel-based workstations, desking systems and freestanding casegood systems. Exposure modeling will use the GREENGUARD prescribed ventilation rate based on a default occupancy and ASHRAE 62.1-2007 ventilation requirements and product/volume ratio.
- 3.2.3.1 *Movable Walls* - Load into appropriate chamber, standing on one edge; or, if not feasible, using x-support or other approved method of suspending. Record dimensions; for loading factor use two-sided area.
- 3.2.3.2 *Chairs, Tables, Workstations, Casegoods* – Load into appropriately sized chamber (intermediate for chairs, smaller tables and individual casegoods: large for workstations, casegood systems, or conference tables). Emission factors are based on a unit basis.
- 3.2.4 If products are being tested for a particular specification with instructions, specific directions are followed for sample preparation.
- 3.2.5 All personnel entering the large chamber must put on lint-free, clean room shoe covers. Always wear unpowdered latex gloves when handling any products to be tested in an emissions chamber.

3.3 Preparation of Paint Test Specimens

- 3.3.1 Paints are typically applied with a 3/8" nap roller, with a loading of 0.4-1 m²/m³. Unless a specific substrate is indicated, the paint is applied to a section of pre-conditioned ½" drywall, maintained for at least 24 hours at 20° - 25°C and no greater than 60% RH while ventilated with clean air. The emissions from the drywall material itself must be measured. This may be done either by testing the drywall substrate alone prior to applying the paint, or by testing a second piece of drywall simultaneously in a second chamber. The amount of paint applied is determined by the coverage for the specific paint, and specific gravity. For interior paints, the coverage is in the range of 350-450 ft²/gal. For consistency, use 350 ft²/gal unless specified otherwise by the customer.

- 3.3.1.1 Cut the 1/2" wallboard substrate to the appropriate dimensions to achieve the specified loading.
- 3.3.1.2 Seal the back and edges with sodium silicate or non-emitting foil tape and weigh the assembly.
- 3.3.1.3 One piece of wallboard is sealed, loaded and tested as a background.
- 3.3.1.4 Prior to application, the paint must be well mixed in the original container, with a shaker or stainless stir ladle.
- 3.3.1.5 Apply the product using a roller with 3/8" nap. Wet the surface of the roller uniformly with paint. Apply the paint to the substrate from the middle to the edge, until the surface is uniformly coated.
- 3.3.1.6 Rotate the substrate 90 degrees, and roll the roller back and forth across the entire surface.
- 3.3.1.7 Immediately weigh the assembly and calculate the weight of the paint by difference.
- 3.3.1.8 The final weight of the applied paint must be within 5% of the target weight specified above. If so, place on a flat surface, load into the chamber within 5 minutes, and record the time. If not, apply a second coat in the same manner, if required.
- 3.3.1.9 If the weight of applied paint is more than 5% over the target weight, discard and prepare a fresh piece.
- 3.3.1.10 The container with unused material is re-sealed within 5 minutes of sample preparation.
- 3.3.1.11 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 a conditioning environment between coats. The testing period begins immediately after application of the final coat.

3.4 Preparation of Adhesive Product Test Specimens

- 3.4.1 Adhesive is generally applied to an inert substrate such as a stainless steel plate, unless specifically designed to be applied to a porous substrate. The substrate should have dimensions that correspond to a surface loading ratio of $0.4 \pm 0.1 \text{ m}^2/\text{m}^3$. The adhesive is applied at a specified weight loading, using either a trowel or roller based on manufacturer's recommendations. The type of adhesive being tested determines the method and loading rate.
- 3.4.2 Do not use material from the surface of the product. Open and stir product with stainless ladle and remove test aliquot from at least 1" below the surface.
- 3.4.3 Weigh substrate before applying adhesive.
- 3.4.4 Application instructions using 1/4" nap roller:
 - 3.4.4.1 Pour some adhesive into a disposable tray, from which the surface of the roller can be wetted.
 - 3.4.4.2 Make a single pass on the substrate in one direction.
 - 3.4.4.3 Rotate the substrate 1/4-turn (90°) and make a subsequent final pass.
 - 3.4.4.4 Weigh the assembly to determine the total adhesive weight.
 - 3.4.4.5 Repeat the application until weight is within 10% of the target weight.
 - 3.4.4.6 Reject the sample if it is more than 10% over the target weight.
 - 3.4.4.7 Load the assembly in the environmental chamber within 5 minutes and record the time.
- 3.4.5 Application instructions using Trowel: (Standard applicator is a 1/8" x 1/8" x 1/8" u-notched trowel):
 - 3.4.5.1 Hold the trowel at a 45° angle to the plate making one pass across the plate to spread the adhesive;
 - 3.4.5.2 Rotate the plate 1/4-turn and make one additional pass.
 - 3.4.5.3 Weigh the assembly and repeat the application if necessary.

- 3.4.5.4 Visually inspect for even distribution of the adhesive.
- 3.4.5.5 Reject the sample if it is more than 10% over the target weight, or if there are areas of the plate that are not covered with adhesive or the application is visibly not evenly distributed.
- 3.4.5.6 Load the assembly in the environmental chamber within 5 minutes and record the time.
- 3.4.6 The container with the unused material is re-sealed within 5 minutes of sample preparation.

3.5 Preparation of Caulking Product Test Specimens

- 3.5.1 Apply a 11.5" \pm 1" long, bead of caulks, sealants, adhesives and other products supplied in tube applicators or containers onto an inert non-porous (metal) substrate. The bead diameter is typically 3/8" for most applicators.
 - 3.5.1.1 Weigh the substrate before applying caulk.
 - 3.5.1.2 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, lay down the caulk bead using a single, smooth stroke of the gun. Wipe any excess caulk from the exterior of the channel.
 - 3.5.1.3 Re-weigh the substrate after applying the caulk. The difference in weight before and after application determines the mass of applied caulk and coverage in grams of wet caulk per linear meter of a defined-size bead.
 - 3.5.1.4 Load the assembly in the environmental chamber within 5 minutes and record the time.

3.6 Selection and Preparation of Dry Product Test Specimens

- 3.6.1 The period of time required to unpack a product, prepare a product for testing and placement of the product in the test chamber should be minimized and be less than 1 hour in all situations. Any exceptions shall be reported, and time recorded for preparation and placement of the specimen for the start of the test.
- 3.6.2 All exposed surface dimensions of specimens shall be accurately measured (\pm 2 mm) after they are cut and prepared for testing. In many cases, it also will be necessary to measure the thickness of the specimen.
- 3.6.3 Specimen sizes are to be adjusted according to the chamber volume to achieve the specified loading factors which typically vary from 0.4 to 1.0 m²/m³. The loading is optimized to represent realistic building loading and to ensure that chamber concentrations expected are within the analytical range of the analysis.
- 3.6.4 *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.)
- 3.6.5 *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.
- 3.6.6 *Specimen preparation for sheet, tile type (resilient) and carpet flooring products:* The flooring material is unpackaged and placed on an inert surface to be cut to dimensions that correspond to a loading ratio of 0.41 m²/m³. Emissions from the edges of the flooring material may differ from the normally exposed surface, and edges must be sealed. This may be accomplished by placing the sample specimen into an appropriately sized stainless steel tray, and pressing flat to seal the bottom and edges

against the tray interior (if the material has an adhesive backing, the liner is peeled off prior to being placed into the stainless steel tray). The surface of the product must not be higher than the edge of the tray, and no more than 1/8" lower. Alternatively, the sample can be attached to a clean metal sheet to cover the back using low VOC metal tape to seal the edges as well.

3.6.6.1 Laminate and Wood Flooring:

3.6.6.1.1 Cut a minimum of two sections of material which, when assembled, provide a single piece with the dimensions to provide the target loading factor.

3.6.6.1.2 Assemble the pieces as appropriate for type of flooring (tongue & groove, snap seam, etc).

3.6.6.1.3 Seal back and cut edges to expose the top surface only.

3.6.6.2 Carpet and Resilient Flooring:

3.6.6.2.1 Load in tray, with the dimensions to provide the target loading factor, to expose the top surface only.

3.6.7 *Specimen preparation for vinyl wallcovering products:* Place sample on metal plate, seal edges with foil tape. The target chamber loading factor is 1 m²/m³.

3.6.8 *Specimen preparation for woven and nonwoven fabric type products:* Place sample on metal plate, seal edges with foil. The target chamber loading factor is 0.4-1 m²/m³.

3.6.9 *Specimen preparation for composite wood products:* Cut sample to target chamber loading factor of 0.4-1 m²/m³, being careful to avoid contamination of the specimen. For example, it may be necessary to use a paper or tape mask on the surface to minimize contamination from a mechanized saw. Attach to clean metal substrate with strips of low VOC metal tape so only the primary face is exposed.

3.6.10 *Specimen preparation for gypsum board and similar rigid wall panels:* Cut sample to target chamber loading factor of 1 m²/m³, being careful to avoid contamination of the specimen. For example, it may be necessary to use a paper or tape mask on the surface to minimize contamination from a mechanized saw. Attach to clean metal substrate with strips of low VOC metal tape so only the primary face is exposed.

3.6.11 *Specimen preparation for acoustical ceiling panels:* Cut a section of material to target a chamber loading factor, based on a 1-sided area, of 0.41 m²/m³. Load to expose the top, bottom and all edges, making sure to keep one factory finished edge intact. Use a 2-sided area for the loading factor calculation.

3.6.12 *Specimen preparation for insulation:* The target chamber loading factor for all insulation is 1 m²/m³.

3.6.12.1 Insulating materials are typically used in applications where only one side is exposed to the occupied space. This is simulated, for example, by placing the sample in an appropriately sized tray, and pressing snug to seal the bottom and edges. Thus, insulation materials are tested with one side exposed in the chamber. All edges and the opposite face are to be sealed. A 2 sided loading factor is used when it is determined all sides are exposed in the application.

3.6.12.2 Blowing Wool: Pour insulation into tray until the target weight of 3,177 g/m² or 0.65 lb/ft² is reached. A tray with the appropriate depth should be used such that the insulation is even with the top edge of the tray.

3.6.12.3 Batts and Blankets (Thermal Insulation): Cut insulation to fit tray. If insulation has a facing, load so that facing side is exposed in chamber. If insulation does not have a facing, it does not matter which side is exposed in chamber. A tray with the appropriate depth should be used such that the insulation is even with the top edge of the tray.

3.6.12.4 Duct Wrap/Pipe Insulation (Mechanical Insulation): Test outer surface of insulation

- that would be exposed during use. If flexible enough, open up cylinder so that the insulation will lay flat in a sample tray. If insulation is not flexible enough, wrap interior of the insulation with foil so that only the outer surface area is exposed to the chamber.
- 3.6.12.5 Duct Board, Duct Liners (HVAC Insulation): Cut insulation to fit tray so that the inner surface (airstream surface) is exposed to the chamber. A tray with the appropriate depth should be used such that the insulation is even with the top edge of the tray.
- 3.6.12.6 Flexible Duct (HVAC Insulation): If possible, lay flat in chamber so that the inner surface (airstream surface) is exposed to the chamber. This is usually the more rigid surface. If it is not possible to lay insulation flat, wrap the outside and edges of the insulation with foil before loading it into the chamber. Test with air flowing through the cylinder of insulation.
- 3.6.13 *Specimen preparation for laminates (all types), wood veneers, or backers (surfacing materials)*: The target chamber loading factor for all is $0.4\text{-}1\text{ m}^2/\text{m}^3$.
- 3.6.13.1 Thin Laminate ($< 1/2$ "): Load with only the top (finished) surface exposed; for the loading factor use top surface area
- 3.6.13.2 Thick Laminate ($\geq 1/2$ "):
- 3.6.13.2.1 Horizontal Application (i.e. worksurfaces) – load with top, bottom and one edge exposed; for the loading factor use the top surface area
- 3.6.13.2.2 Vertical Application (i.e. bathroom partitions) – load with top, bottom and two edges exposed; for loading factor use the combined top and bottom areas.

3.7 Preparation of Dry Product Test Specimen Assemblies

- 3.7.1 *Laminates (all types) wood veneers, or backers applied with adhesives*: Apply laminate or veneer to an MDF or particleboard core using the manufacturer's recommended adhesive and procedures with a target loading of $0.4\text{-}1\text{ m}^2/\text{m}^3$. All edges should be sealed and top surface exposed. 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 and all sides exposed and calculated in the loading.
- 3.7.2 *Sheet and tile type resilient flooring applied with adhesives*: Prepare product to meet $0.41\text{ m}^2/\text{m}^3$ and place in a stainless steel tray. Place the tray, as per Section 3.6.6, to expose top surface only.
- 3.7.3 *Carpet tile and broadloom carpet applied with adhesives*: Prepare product to meet $0.41\text{ m}^2/\text{m}^3$ and place in a stainless steel tray. Place the tray, as per Section 3.6.6, to expose top surface only.
- 3.7.4 *Vinyl and other wallcovering products applied with adhesives*: Apply wallcovering to $1/2$ " gypsum board substrate (Section 3.3.1) using the manufacturer's recommended adhesive and procedures. Prior to preparation of the test specimen, gypsum board substrate shall be pre-conditioned for at least 24 hours at $20^\circ\text{ - }25^\circ\text{C}$ and no greater than 60% RH while ventilated with clean air. Place assembly on a stainless steel sheet to cover entirely the back surface. Attach assembly to stainless steel with strips of low VOC metal tape so that required loading and exposed surface area is achieved.
- 3.7.5 Specimen sizes are to be adjusted according to the chamber volume to achieve the specified loading factors ranging from $0.4\text{-}1\text{ m}^2/\text{m}^3$.
- 3.7.6 Other substrates such as particleboard underlayment, plywood or other materials may be used. However, these materials will also contribute VOCs and complicate the studies, since they too will be emitters of VOCs. Their VOC emissions must be obtained in separate tests so that the product test results may take the substrate contributions into account.
- 3.7.7 If data on the total assembled system as well as component contributions is required

information, then the complete assembly will have to be tested as well as each component. All component pieces must be tested simultaneously in order to avoid aging effects on the individual component, which could later affect the emissions of the complete assembly.

- 3.7.8 The assembly is loaded into the environmental chamber, approximately centered on the bottom surface, and the environmental chamber is sealed.

3.8 Preconditioning of Products Prior to Testing

If needed, the product is left in the chamber for 10 days (or other required conditioning time) prior to the start of chamber sampling protocol.

3.9 Environmental Chamber Testing

3.9.1 Facilities

3.9.1.1 Chemical Emissions - A facility designed and operated to measure organic emissions and emission rates from building materials and indoor finishes and furnishings should contain environmental test chambers, conditioning chambers, sample storage areas, purification systems, monitoring and control systems, sample collection and analysis equipment, standards generation and calibration systems, data acquisition systems, and data modeling and reporting systems.

3.9.2 Equipment

3.9.2.1 Environmental Test Chamber Requirements - The chamber and analytical requirements are fully defined in the referenced document "GREENGUARD Product Certification Program Laboratory Qualifications and Proficiency Requirements", which is based upon the referenced ASTM documents D5116-06 for Small Scale Chamber Tests and 6670-01 for Full Scale Chamber Tests, and the referenced EPA ETV Large Chamber Test Protocol.

3.9.3 Chamber Sizes:

3.9.3.1 For testing of small products, materials, and furniture finished components and construction materials, chambers of 0.05 - 0.10 m³ are generally used.

3.9.3.2 Intermediate sized components such as seat backs and cushions, are tested in 0.5-2 m³ sized chambers.

3.9.3.3 For testing of chairs and other small office furniture, intermediate chambers of 5-6 m³ are generally used.

3.9.3.4 Large furniture and workstation testing require full scale chambers with an interior volume between 20 and 35 m³ that can accommodate a full workstation in its entirety when assembled according to manufacturers' specifications.

3.10 **Environmental Chamber Performance Requirements** (The chamber requirements are fully defined in the referenced document "GREENGUARD Product Certification Program Laboratory Qualifications and Proficiency Requirements" – Attachment 1).

3.10.1 *Principle:* The principle of the test is to determine the specific emission rates or emission factors of VOCs emitted from prepared specimens of building products. The test is conducted in an environmental chamber at specified constant conditions of temperature, relative humidity, ventilation rate and product loading factor. 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 state-state form

of the mass-balance model. The chamber test is conducted following the guidance of ASTM Standard D 5116, "Guide for Small Chamber Environmental Chamber Determination of Organic Emissions from Indoor Materials/Products", ASTM D 6670, "Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products", and/or the USEPA ETV, "Large Chamber Test Protocol for Measuring Emissions of VOCs and Aldehydes".

3.10.2 *Test Conditions:* The test shall be conducted at the conditions and within the limits specified in Table 6.2. Standard test conditions for chamber tests are 1 air change (ACH) and inlet air conditions controlled at $23 \pm 1^\circ\text{C}$ and $50 \pm 5\%$ RH. Standard conditions for the purpose of calibrating flow measurement devices and calculating all flow rates shall be 23°C (298 K) and one atmosphere pressure (101.3 kPa). The chamber shall be ventilated at 1 ± 0.05 air changes per hour. The loading factor shall be optimized to produce a value that is close to the value for many materials in both the classroom and office building scenarios.

3.10.3 *Duration:* The chamber test shall last 168 hours, but may be extended to a longer period to capture on going emissions patterns, emitting VOCs, and their levels. Chamber tests of shorter duration, such as 24 or 96 hour, may be used for profile testing or other standard requirements. Sealing of the chamber following insertion of the product specimen into the chamber establishes the zero time or start of the test.

3.10.4 *Apparatus and Facilities:* The apparatus and facilities shall be constructed to maintain the test specimen at the specified conditions within a non-contaminating and environmentally controlled environment $20^\circ - 25^\circ\text{C}$ and humidity no greater than 60%.

3.10.5 *Clean air supply and flow control:* A clean air generator or high purity air is 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 $\pm 2\%$ at 1 Lpm, or better, and capable of continuously maintaining the flow within $\pm 5\%$ of the specified value. MFCs are calibrated periodically according to the Laboratory's quality assurance plan. At a minimum, flow measurement devices shall be calibrated on an annual basis against NIST traceable standards. At a minimum, the air exchange rate shall be monitored immediately before the product is placed in the chamber (at the same time background contamination checks are made) by accurately measuring the air flow into the chamber. ACH (h^{-1}) is then calculated as air flow (m^3/h) divided by chamber volume (m^3). The accuracy of this air exchange rate must be confirmed (with $\pm 10\%$ accuracy) using procedures similar to those presented in ASTM Method E741 for tracer gas application. Alternatively, ASTM Method E741 may be used as the primary method for determining the air exchange rate. The frequency of ACH verification is prescribed by the Laboratory's quality assurance standards and should occur whenever flow changes are made to chamber air and at a minimum of twice per year, if conditions are not changed. Supply air contamination shall not exceed $10 \mu\text{g m}^{-3}$ and $2 \mu\text{g m}^{-3}$ for any individual VOC. Use of pressurized cylinders is not permitted.

3.10.6 Chamber and materials:

3.10.6.1 Environmental test chambers shall be constructed of inert, smooth, electropolished surfaces such as stainless steel. Glass is inappropriate because of adsorption effects.

3.10.6.2 All joints and openings shall be sealed. All seals shall be made of non-VOC emitting and non-VOC adsorbing/absorbing materials.

- 3.10.6.3 The air within the chamber shall be free of any obstructions or contamination such as humidifiers or refrigeration coils. Internally or externally mounted fans may be used to keep the chamber air well mixed if it can be demonstrated through the use of quality control samples that the fans do not contaminate the chamber air samples or irreversibly absorb/adsorb formaldehyde or representative VOCs (toluene and n-decane). The internal chamber air shall only come in contact with inert materials.
- 3.10.6.4 The surfaces and seals of the chamber shall be sufficiently chemically inert such that formaldehyde at the level of 0.005 ppm and representative VOCs at the level of 10 $\mu\text{g}/\text{m}^3$ are not irreversibly retained on the interior surfaces.
- 3.10.7 Background concentrations in the empty chamber ventilated at 1.0 air changes per hour shall not exceed 2 $\mu\text{g m}^{-3}$ for any individual VOC or aldehyde, and 10 $\mu\text{g m}^{-3}$ for TVOC or respirable particles.
- 3.10.8 Temperature and humidity control: The temperature of the chamber shall be maintained at $23 \pm 1^\circ\text{C}$ throughout the test period. All surfaces of the chamber shall be held at the same temperature so that the temperature inside the chamber is uniform. The humidity of the chamber air shall be maintained at $50 \pm 5\%$ RH. The humidity can be established by controlling the humidity of the inlet air. Water used in bubblers to saturate gas streams shall be free of organic solvents and contaminants (i.e., HPLC grade or equivalent). Wet products may temporarily result in deviations from humidity control during testing.
- 3.10.9 Monitoring and data acquisition: Instrumentation must be available to control and monitor the temperature and humidity with adequate accuracy, precision, and sensitivity to control these parameters and to document that the emission test is conducted within the control limits stated above. The measurements shall be made at the inlet air stream, inside the chamber or immediately at the chamber exhaust using electronic probes. The probes shall be calibrated periodically according to the laboratory's quality assurance plan. At a minimum, these probes shall be calibrated on an annual basis against NIST traceable standards.
- 3.10.10 Procedures
- 3.10.10.1 *Chamber cleaning and preparation:* Prior to the actual testing, clean chambers by wiping down the inner surfaces with deionized water. Soap or detergent is not recommended because of contamination and residue left on chamber materials. Chambers are then dried and purged at standard test conditions for a minimum of twelve hours, or 12 ACH's prior to use.
- 3.10.10.2 *Background measurement:* Prior to sample loading, collect chamber air background samples for VOC's and aldehydes to determine the levels of TVOC, IVOCs and formaldehyde in the clean chamber. VOC and aldehyde samples are to be collected to provide lower quantitation limits of at least 2 $\mu\text{g m}^{-3}$ for individual VOCs and 10 $\mu\text{g m}^{-3}$ for TVOC.
- 3.10.10.3 *Specimen loading:* The time for basic sample preparation shall be minimized and shall never exceed 10 minutes. Once the product has been prepared, it is to be loaded into the environmental chamber within five minutes. For extensive sample preparation where assemblies or multiple applications are used, the time between the preparation and loading in the chamber should be minimized. The process, along with times, should be documented. Load the product into the environmental chamber, approximately centered on the bottom surface, or on x-supports or a wire rack if the bottom is to also be exposed. There shall be sufficient space for

chamber air to circulate freely around the exposed face of the specimen. Immediately after loading, the environmental chamber is sealed.

- 3.10.10.4 *Chamber air leakage:* Air tightness is determined on an annual basis by capping the inlet and exhaust manifold and introducing a known concentration of a tracer gas such as SF₆ or CO. The concentration is monitored over a period of time. The ending concentration shall be within 3% of the initial concentration. Additionally, the air leakage of specific chambers can be determined periodically after loading a test specimen, if appropriate. This can be 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. The exhaust flow rate shall be within 10% of the inlet flow rate by this method.
- 3.10.10.5 *Replicate tests:* A fraction of the tests shall be conducted in replicate using specimens prepared from the same product sample. The fraction of duplicates is determined by the laboratory's quality assurance plan and should be no less than 1 out of every 20 samples for those products appropriate for replicate measurement.
- 3.10.11 Air Sampling
- 3.10.11.1 *Sampling schedule:* For standard GREENGUARD Certification tests, chamber air samples shall be collected for VOCs and aldehydes centered around the elapsed times of 6, 24, 48, 72, 96 (or 120) and 168 hours after initiating the chamber test, or as otherwise dictated by the test program or specification requirements. Air collection with shorter or extended sampling periods maybe warranted for quarterly testing or specialized program/data requirements
- 3.10.12 Sampling Media
- 3.10.12.1 VOC sampling media for individual VOCs and TVOC shall consist of thermally desorbed, solid-phase sorption tubes containing Tenax-TA. Refer to ASTM documents D6196 and D 6345, and U.S. EPA Methods TO-1 and TO-17. 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-butane through n-octadecane, although TVOC is based on response from n-hexane through n-hexadecane (C₆ - C₁₆). 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. Before use, samplers shall be conditioned by thermal desorption. Samplers taken from refrigerated storage shall be warmed to room temperature prior to use.
- 3.10.12.2 Sampling media for formaldehyde, acetaldehyde and other low molecular weight 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 document D 5197 for guidance. Samplers shall be warmed to room temperature prior to use.
- 3.10.12.3 *Flow control:* Sampling flow rates shall be regulated with electronic mass flow controllers with an accuracy of ±2 % full scale, or better, and capable of continuously maintaining the flow during sampling within ±5 % of the specified value.
- 3.10.12.4 *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 4 in is 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 acetone 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 is assigned to each air sample.

- 3.10.12.5 *Duplicate samples*: A fraction of the air samples shall be collected in duplicate. The fraction of duplicates is determined by the laboratory's quality assurance plan and recommended to be no less than 1 out of every 10 samples. For 168-hour tests, duplicate air samples are collected at the 24, 72 and 168 hour times points.
- 3.10.12.6 *Sample 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 sample tubes as storage blanks.

3.11 Chemical Analyses

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

3.11.2 Analytical Instruments

- 3.11.2.1 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 range of VOCs expected. 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.
- 3.11.2.2 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.

3.11.3 Methods for Individual VOCs

- 3.11.3.1 The analytical methods for individual VOCs shall be based on ASTM D 6196, "Standard Practice for Selection of Sorbents, Sampling and Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air." Other relevant practices are EPA Methods TO17, "Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes" and TO-1, "Determination of Volatile Organic Compounds in Ambient Air Using Tenax Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS)" or equivalent methods. Standards and chamber samples shall be analyzed using identical conditions.
- 3.11.3.2 The analytical methods for formaldehyde, acetaldehyde and other low molecular weight aldehydes shall be based on ASTM Standard D 5197, "Standard Test Method for Formaldehyde and other Carbonyl Compounds in Air (Active Sampler Methodology)" or an equivalent method. It is recognized that unsaturated low molecular weight aldehydes such as acrolein are not accurately determined by this method. Higher molecular weight aldehydes approximately beginning with butanal can be analyzed by the method for individual VOCs.
- 3.11.3.3 Phthalate analysis is based on OSHA Method 104 for phthalates with a quantifiable

level of 10 µg based on a standard 240 L air collection volume. Samples are collected by drawing known volumes of air through OVS-Tenax sampling tubes. Samples are desorbed with toluene and analyzed by GC using a flame ionization detector (FID). The phthalate target list includes: diethylhexyl phthalate, butyl benzyl phthalate, di-n-octyl phthalate, dibutyl phthalate, diethyl phthalate, dimethyl phthalate.

3.11.4 TVOC Method

3.11.4.1

TVOC measurements are made by adding all individual VOC responses obtained by the mass spectrometer between the elution times of n-hexane and n-hexadecane and calibrating the total mass relative to toluene.

3.11.5 Identification of Individual VOCs

3.11.5.1 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 lists (Section 4.1) shall be identified and levels reported.

3.11.5.2 If no high quality match is obtained, the unknown spectrum is compared to spectra contained in the latest version of the NIST/USEPA/NIH mass spectral library. 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.

3.11.5.3 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.

3.11.6 Analytical Calibrations

3.11.6.1 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. 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 calibration standards or perform full calibrations at least once every month or more frequently to ensure accuracy for the analyses.

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

3.11.6.3 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. Analyze calibration standards or perform full calibrations at least once every month or more frequently to ensure accuracy for the analyses.

3.11.7 Quantifiable Limit (QL)

3.11.8 A lower QL 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 QL that is higher than this absolute value may be defined based on practical considerations.

- 3.11.8.1 For TVOC, the lower QL is $10 \mu\text{g m}^{-3}$, or better.
- 3.11.8.2 The lower QL for VOCs appearing on list of chemicals of concern or allowable emission levels is $2 \mu\text{g m}^{-3}$, or better.
- 3.11.8.3 The lower QL for non- listed VOCs is $2 \mu\text{g m}^{-3}$, or better.
- 3.11.8.4 A QL 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.

3.12 Calculations

3.12.1 Emission Factor Calculations:

3.12.2 Conversion from chamber concentration (C) ($\mu\text{g/m}^3$) to emission factor (EF) ($\mu\text{g/m}^2\cdot\text{hr}$)

3.12.2.1 During the sampling period, the products are treated as a constant-emission source.

The chamber concentration is considered to be at a steady-state during the sampling period. Thus, the emission factor is directly calculated from the chamber concentration as:

$$EF = C \times \left(\frac{N}{L} \right)$$

where,

- EF = emission factor ($\mu\text{g/m}^2\cdot\text{hr}$) or ($\mu\text{g/unit}\cdot\text{hr}$)
- C = chamber concentration ($\mu\text{g/m}^3$) (less any background concentration of chamber)
- N = chamber air exchange rate (hr^{-1})
- L = product loading (m^2/m^3)

3.12.2.2 For large units, such as furniture panel systems, casegoods, and seating, loading is consider as a unit of 1 per volume (m^3).

3.12.3 Exposure Modeling

3.12.3.1 The emission rates of individual VOCS, TVOC, formaldehyde, and total aldehydes are used in a computer exposure model to determine potential air concentrations of the pollutants. The computer model uses the measured emission rate changes over the one-week time period to determine the change in air concentrations that would consequently occur.

3.12.3.2 For GREENGUARD Annual Certification tests, the 168 hour time point is used to determine compliance. The constant emission factor (as determined at 168 hour) is used to determine compliance with the GREENGUARD Criteria by calculating an exposure concentration (Section 3.12.3.3). The building parameters including ventilation rate and material loading used in the calculations are detailed in Table 6.4.

3.12.3.3 For products with constant emission factors, the predicted exposure concentrations ($C_{P,t}$) ($\mu\text{g/m}^3$) are calculated from the measured emission factors as:

$$C_{P,t} = EF_t \left(\frac{A}{V} \right) \left(\frac{1}{N} \right)$$

where,

- $C_{P,t}$ = predicted exposure concentration at time t ($\mu\text{g/m}^3$)
- EF_t = measured emission factor at time t ($\mu\text{g/m}^2\cdot\text{hr}$) or ($\mu\text{g/m}\cdot\text{hr}$) or ($\mu\text{g/g}\cdot\text{hr}$) or ($\mu\text{g/unit}\cdot\text{hr}$)

- A = product area exposed in room (m² or m or g or unit)
- V = room volume (m³)
- N = room air change per hour (hr⁻¹)

3.12.3.4 For GREENGUARD's Children and Schools Certification for products with constant emission factor, the predicted exposure concentrations are calculated according to the equation of 3.12.3.3 with the addition of a ventilated volume fraction Vf_B which is assumed to be 0.9, unless otherwise measured or specified.

$$C_{P,t} = EF_t \left(\frac{A}{V} \right) \left(\frac{1}{N} \right) \left(\frac{1}{Vf_B} \right)$$

3.12.3.5 For data requiring modeling for longer term exposure predictions, various models are available. For products with decreasing emission sources, the emission factor can be modeled according to the first-order decay:

$$EF_m = EF_0 e^{-kt}$$

where,

- EF_m = modeled emission factor (µg/m²·hr) or (µg/m·hr) or (µg/g·hr) or (µg/unit·hr)
- EF_0 = initial emission factor (µg/m²·hr) or (µg/m·hr) or (µg/g·hr) or (µg/unit·hr)
- k = rate constant (hr⁻¹)
- t = time (hr)

or a power law decay:

$$EF_m = EF_0 t^{-k}$$

where,

- EF_m = modeled emission factor (µg/m²·hr) or (µg/m·hr) or (µg/g·hr) or (µg/unit·hr)
- EF_0 = initial emission factor (µg/m²·hr) or (µg/m·hr) or (µg/g·hr) or (µg/unit·hr)
- k = rate constant (hr⁻¹)
- t = time (hr).

Regression analysis will be used to determine the model that best fits the data. The use of least squares fitting, a mathematical procedure for finding the best-fitting curve to a given set of points by minimizing the sum of the squares of the offsets of the points from the curve, will dictate the appropriate model for the given product.

3.12.3.6 The predicted exposure concentrations ($C_{P,t}$) (µg/m³) are calculated from the modeled emission factors as:

$$C_{P,t} = EF_{m,t} \left(\frac{A}{V} \right) \left(\frac{1}{N} \right)$$

where,

- $C_{P,t}$ = predicted exposure concentration at time t (µg/m³)
- $EF_{m,t}$ = modeled emission factor at time t (µg/m²·hr) or (µg/m·hr) or (µg/g·hr) or (µg/unit·hr)
- A = product area exposed in room (m² or m or g or unit)
- V = room volume (m³)
- N = room air change per hour (hr⁻¹)

3.12.3.7 Product areas and ventilation rates for schools and office spaces are presented in Table 6.4 of Section 6.

3.12.3.7.1 For the GREENGUARD Certification Program, office ventilation rates are based on the ASHRAE 62.1-2007 ventilation standard for acceptable indoor air quality. The office ventilation rate is based on the ASHRAE parameters of 5 CFM per person and 0.06 CFM/ft² for office spaces in commercial buildings. These parameters are applied to the GREENGUARD office size (32 m³) for a single occupant, which results in a ventilation rate of 0.72 ACH. The air change rate to building volume ratio is identical to State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174) requirements and will result in equivalent or more stringent estimated building concentrations.

3.12.3.7.1.1 Furniture (Seating, Workstations and Casegood Systems) - For all seating and casegoods tested, as well as tested GREENGUARD defined workstations, the GREENGUARD office volume (32 m³) is used. If the smaller BIFMA defined workstation is tested, a room volume of 16.3 m³ is employed. The BIFMA M7.1 Method defines the application of a ventilation rate of 15.0 m³/hr (an ACH of 0.92 hr⁻¹) for one workstation in 16.3 m³ volume of space. For the same room volume, GREENGUARD specifies a ventilation rate of 11.7 m³/hr (an ACH of 0.72 hr⁻¹) for one workstation. BIFMA specifies a clean air ventilation rate of 24.8 m³/hr for a chair and a ventilation rate or 34.7 m³/hr for a casegood system or component. For both seating and casegoods, the GREENGUARD ventilation rate of 23.0 m³/hr will always be used. In all cases, the GREENGUARD model is more stringent, and thus, products meeting the GREENGUARD Certification Emission Criteria will automatically meet BIFMA's requirements.

3.12.3.7.2 For the GREENGUARD Children and Schools Program, the classroom testing and modeling requirements of State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174) are required. These parameters are applied to a classroom (40' x 24' x 8.5' or 231 m³) with an occupancy of 27 students and ventilation rate of 0.9 ACH. Classroom ventilation rates determined using the ASHRAE 62.1-2007 ventilation standard for acceptable indoor air quality are based on the ASHRAE parameters of 10 CFM per person and 0.12 CFM/ft² for classrooms in educational environments. These parameters applied to the 40' x 24' x 8.5' (or 231 m³) classroom, with an occupancy of 27 students, result in a ventilation rate of 2.8 ACH. To account for older schools, times of inactive ventilation, and to harmonized with State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174), ACH of 0.9 ACH is applied. It is assumed if applicable, that only 90% of the room volume of 231 m³ is ventilated at this rate due to occupancy and furnishings, and room content. The classroom ventilation rates and product areas are identical to those required by CHPS IEQ Credit 2.2 and specified by State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174).

For Products that are to be certified under the GREENGUARD Children and Schools Program and are considered to be office environment specific, the office modeling requirements as outlined in the DHS "Standard Practice for Testing of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB-174) are required as outlined in Table 7.5 of the DHS Practice.

Predicted exposure modeling requirements of the DHS Practice Section 3.12.3.4 are applicable. If the GREENGUARD Program office model parameters are found to be more conservative in application, Table 6.4, they may be used for exposure model. If loading parameters are not provided in the DHS Practice, the GREENGUARD Program loadings will be used.

3.12.4 *Conversion to ppm*

3.12.4.1 For formaldehyde, the conversion from $\mu\text{g}/\text{m}^3$ to ppm is obtained by use of the partial molar volume of formaldehyde via the following formula:

$$\text{ppm} = [(\mu\text{g}/\text{m}^3) \times (24.45 \text{ m}^3/\text{mol})] / [(\text{gram molecular weight of formaldehyde}) \times (1000)]$$

3.12.4.2 For total aldehydes, The conversion from $\mu\text{g}/\text{m}^3$ to ppm is obtained by summation of the partial molar volumes of all aldehydes via the following formula:

$$\text{ppm} = \Sigma[(\mu\text{g}/\text{m}^3) \times (24.45 \text{ m}^3/\text{mol})] / [(\text{gram molecular weight of aldehyde X}) \times (1000)]$$

3.12.5 The model measurements are made with the following assumptions: air within open office areas of the building is well-mixed at the breathing level zone of the occupied space; environmental conditions are maintained at 50% relative humidity and 23°C (73°F); there are no additional sources of these pollutants; and there are no sinks or potential re-emitting sources within the space for these pollutants.

SECTION 4
TARGET CHEMICALS AND MAXIMUM ALLOWABLE
CONCENTRATIONS

4.0 GREENGUARD Certification

Allowable Limits for GREENGUARD Product Certification: Requirements met at 168 hours (7 days)⁺ with no preconditioning.

	Insulation, Wallcoverings, Flooring, Paints and Coatings, General Construction Materials, Adhesives/Sealants, Ceiling Systems, Doors, Air Filters, Textiles, Visual Display Products, Window Treatments, Workstations, Casegood Systems, and Movable Walls	OEM Materials, Surfacing Materials, Bedding, Seating, Individual Casegoods, Tables, Workstation Components
Individual VOCs ¹	≤ 0.1 TLV	≤ 0.1 TLV
Formaldehyde	≤ 0.05 ppm	≤ 0.025 ppm
4-Phenylcyclohexene	≤ 0.0065 mg/m ³	≤ 0.0033 mg/m ³
Styrene	≤ 0.07 mg/m ³	≤ 0.035 mg/m ³
Total VOCs ²	≤ 0.5 mg/m ³	≤ 0.25 mg/m ³
Total Aldehydes ³	≤ 0.1 ppm	≤ 0.05 ppm
Respirable Particles ⁴	≤ 0.05 mg/m ³	≤ 0.05 mg/m ³
Listing of measured carcinogens and reproductive toxins as identified by California Proposition 65, the U.S. National Toxicology Program (NTP), and the International Agency on Research on Cancer (IARC) must be provided.		
Any pollutant regulated as a primary or secondary outdoor air pollutant must meet a concentration that will not generate an air concentration greater than that promulgated by the National Ambient Air Quality Standard (U.S. EPA, code of Federal Regulations, Title 40, Part 50).		

⁺All products are required to meet the criteria at 168 hours with no preconditioning.

¹ Any VOC not listed must produce an air concentration level no greater than 1/10 the Threshold Limit Value (TLV) industrial work place standard (Reference: American Conference of Government Industrial Hygienists, 6500 Glenway, Building D-7, Cincinnati, Ohio 45211-4438).

² Defined to be the total response of measured VOCs falling within the C₆ – C₁₆ range, with responses calibrated to a toluene surrogate.

³ Defined to be the total response of a specific target list of aldehydes (2-butenal; acetaldehyde; benzaldehyde; 2,5-dimethylbenzaldehyde; 2-methylbenzaldehyde; 3-and/or 4-methylbenzaldehyde; butanal; 3-methylbutanal; formaldehyde; hexanal; pentanal; propanal), with each individually calibrated to a compound specific standard.

⁴ Particles applicable to fibrous, particle-releasing products with exposed surface area in air streams (a forced air test with specific test method) and for wood finishing (sanding) systems.

4.1 GREENGUARD Children & Schools

Allowable Limits for GREENGUARD Children & Schools Certification: Requirements to be met no sooner than 168 hours (7 days) with no preconditioning.

4.1.1 Required for GREENGUARD and “State of CA DHS’s “Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers” (CA/DHS/EHLB/R-174)/CHPS Programs¹

Individual VOCs	≤ ½ CA chronic REL
Formaldehyde	≤ 0.0135 ppm/13.5 ppb

4.1.2 Required for GREENGUARD Programs ONLY

Individual VOCs ²	≤ 1/100 TLV
Total VOCs ³	≤ 0.22 mg/m ³
Total Aldehydes ⁴	≤ 0.043 ppm/43 ppb
Total Phthalates ⁵	≤ 0.01 mg/m ³
Total Particles (≤ 10 µm) ⁶	≤ 0.02 mg/m ³

¹ Required as per the State of CA DHS's "Standard Practice for the Testing of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174), specifically Sections 4.3 and 6.1.1 and 9 (carpets only) for CHPS compliance for classrooms. All current criteria target chemicals as specified by CA OEHHA and DHS for all products types will be measured for acceptance. These criteria are adopted by the State of CA Office of Environmental Health Hazard Assessment (OEHHA) and posted at http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html or in revisions of State of CA's DHS's Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174) document. Product compliance will be determined at a time point no sooner than 168 hours. Data time points less than 336 hours must demonstrate that emissions have peaked before the compliance time point.

² Any VOC not listed must produce an air concentration level no greater than 1/100 the Threshold Limit Value (TLV) industrial work place standard (Reference: American Conference of Government Industrial Hygienists, 6500 Glenway, Building D-7, Cincinnati, Ohio 45211-4438) and/or no greater than 1/2 the CA Chronic Reference Exposure Level (CREL) (http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html - (CRELs) Adopted by the State of California Office of Environmental Health Hazard Assessment (OEHHA), February 2005).

³ Defined to be the total response of measured VOCs falling within the C₆ – C₁₆ range, with responses calibrated to a toluene surrogate.

⁴ Defined to be the total response of a specific target list of aldehydes (2-butenal; acetaldehyde; benzaldehyde; 2,5-dimethylbenzaldehyde, 2-methylbenzaldehyde; 3-and/or 4-methylbenzaldehyde; butanal; 3-methylbutanal; formaldehyde; hexanal; pentanal; propanal), with each individually calibrated to a compound specific standard..

⁵ Defined to be the total response of a specific target list of phthalates including dibutyl (DBP), diethylhexyl (DEHD), diethyl (DEP), butylbenzyl (BBP), di-octyl (DOP), and dimethyl (DMP) phthalates (conducted using a modified phthalate specific analytical method, OSHA 104).

⁶ Particles applicable to fibrous, particle-releasing products with exposed surface area in air streams (a forced air test with specific test method).

4.2 VOCs with Existing TLVs and CA CRELs

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
CHEMICALS WITH TLV and CREL			
1,1-Dichloroethylene (Vinylidene chloride)	75-35-4	200	35
1,2-Butylene oxide (1,2-Epoxybutane)	106-88-7	59 [†]	10
1,2-Dibromoethane (Ethylene dibromide) 1,2-dibromo)	106-93-4		0.4
1,2-Dichloroethane (Ethylene dichloride)	107-06-2	400	200
1,3-Butadiene	106-99-0	44	10
1-Chloro,2,3-epoxy-propane (Epichlorohydrin)	106-89-8	19	1.5
2-Ethoxyethanol (Ethylene glycol monoethyl ether)	110-80-5	180	35
2-Ethoxyethyl acetate (Ethylene glycol monoethyl ether acetate)	111-15-9	270	150
Acetaldehyde	75-07-0	450*	9**
Acrylonitrile (Vinyl cyanide)	107-13-1	43	2.5
Benzene	71-43-2	16	30
Carbon disulfide	75-15-0	310	400
Chlorobenzene (Monochlorobenzene)	108-90-7	460	500
Cresol, All isomers	1319-77-3	220	300
Dichloromethane (Methylene chloride)	75-09-2	1740	200
Diethanolamine	111-42-2	20	1.5
Diethylene dioxide (1,4-Dioxane)	123-91-1	720	1500
Dimethylbenzene (Xylene o-,m-,p-isomer)	1330-20-7	4340	350
Dimethylformamide	68-12-2	300	40
Ethyl chloride (Chloroethane)	75-00-3	2640	15000
Ethylbenzene	100-41-4	4340	1000
Ethylene glycol	107-21-1	1000*	200
Formaldehyde	50-00-0	3.7*	16.5***
Glutaraldehyde	111-30-8	2*	0.04
Hexane (n-Hexane)	110-54-3	1760	3500
Isophorone (2-Cyclohexen-1-one, 3,5,5-trimethyl-)	78-59-1	280*	1000
Isopropanol (2-Propanol)	67-63-0	4920	3500
Maleic anhydride	108-31-6	4	0.35
Methyl alcohol (Methanol)	67-56-1	2600	2000
Methyl bromide (Methane, bromo)	74-83-9	39	2.5
Methyl Cellosolve [®] (2-Methoxyethanol)	109-86-4	160	30
Methyl Cellosolve [®] acetate (2-Methoxyethyl acetate; Ethylene glycol methyl ether acetate)	110-49-6	240	45
Methyl chloroform (1,1,1-Trichloroethane)	71-55-6	19100	500
Methyl-tert-butyl ether (MTBE; tert-Butyl methyl ether)	1634-04-4	1800	4000
m-Xylene (meta-Xylene)	108-38-3	4340	350
Naphthalene	91-20-3	520	4.5

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
o-Xylene (Xylene, ortho)	95-47-6	4340	350
p-Dichlorobenzene (1,4-Dichlorobenzene)	106-46-7	600	400
Phenol	108-95-2	190	100
Phthalic anhydride (1,3-Isobenzofurandione)	85-44-9	61	10
Propylene	115-07-1	8600	1500
Propylene glycol-1-methyl ether (1-Methoxy-2-propanol)	107-98-2	3690	3500
Propylene oxide (1,2-Epoxypropane)	75-56-9	48	15
p-Xylene (para-Xylene)	106-42-3	4340	350
Styrene, monomer (Phenylethylene; Vinyl benzene)	100-42-5	850	450
Tetrachloroethylene (Perchloroethylene)	127-18-4	1700	17.5
Tetrachloromethane (Carbon tetrachloride)	56-23-5	310	20
Toluene (Toluol)	108-88-3	1880	150
Trichloroethylene	79-01-6	2690	300
Trichloromethane (Chloroform)	67-66-3	490	150
Trichloronitromethane (Chloropicrin)	76-06-2	6.7	0.2
Triethylamine (N,N-Diethylethanamine)	121-44-8	41	100
Vinyl acetate (Acetic acid ethenyl ester)	108-05-4	350	100
CHEMICALS WITH TLV Only			
CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	
1-Bromopropane	106-94-5	500	
1-Chloro-1-nitropropane	600-25-9	100	
1-Chloro-2-propanol	127-00-4	40	
1-Hexene	592-41-6	1720	
1-Methylbutyl acetate (2-Pentyl acetate; sec-Amyl acetate)	626-38-0	2660	
1-Nitropropane	108-03-2	910	
2-Aminoethanol (Ethanamine)	141-43-5	75	
2-Aminopyridine (2-Pyridinamine)	504-29-0	20	
2-Butanone (Methyl ethyl ketone [MEK])	78-93-3	5900	
2-Butoxyethanol (Ethylene glycol monobutyl ether)	111-76-2	970	
2-Butoxyethyl acetate (Ethylene glycol monobutyl ether acetate)	112-07-2	1300	
2-Chloro-1-propanol	78-89-7	40	
2-Diethylaminoethanol	100-37-8	96	
2-Ethylhexanoic acid	149-57-5	50	
2-Hydroxypropyl acrylate (2-Propenoic acid, 2-hydroxypropyl ester)	999-61-1	28	
2-Isopropoxyethanol (Ethylene glycol isopropyl ether)	109-59-1	1060	
2-Methylbutyl acetate	624-41-9	2660	

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
2-Methylpentane	107-83-5	17600	
2-N-Dibutylaminoethanol	102-81-8	35	
2-Nitropropane	79-46-9	360	
3-Methyl pentane (Pentane, 3-methyl)	96-14-0	17600	
3-Pentyl acetate	620-11-1	2660	
4-Methoxyphenol (Mequinol)	150-76-5	50	
4-Vinyl cyclohexene	100-40-3	4.4	
Acetic acid	64-19-7	250	
Acetophenone (Ethanone, 1-phenyl) (9CI)	98-86-2	490	
Acetylsalicylic acid (Aspirin)	50-78-2	50	
Acrolein (2-Propenal)	107-02-8	2.3*	
Acrylamide (2-Propenamide)	79-06-1	0.3	
Acrylic acid (2-Propenoic acid)	79-10-7	59	
Acrylic acid, ethyl ester (Ethyl acrylate)	140-88-5	200	
Acrylic acid, methyl ester (Methyl acrylate; 2-Propenoic acid, methyl ester)	96-33-3	70	
Acrylic acid, n-butyl ester (n-Butyl acrylate; 2-Propenoic Acid, butyl ester)	141-32-2	110	
Adipic acie (Hexanedioic acid)	124-04-9	50	
Adiponitrile	111-69-3	88	
Aldrin	309-00-2	2.5	
Allyl alcohol (2-Propen-1-ol)	107-18-6	11.9	
Allyl chloride (1-Propene, 3-chloro)	107-05-1	30	
Allyl glycidyl ether (AGE; Oxirane, [(2-propenyloxy)methyl]-)	106-92-3	47	
Allyl propyl disulfide	2179-59-1	30	
∇-Chloroacetophenone (Phenacyl chloride)	532-27-4	3.2	
∇-Methylstyrene (iso-Propenylbenzene; (1-Methylethenyl)benzene)	98-83-9	2420	
∇-Pinene	80-56-8	1120	
Aniline	62-53-3	76	
Anisidine (o,p-isomers)	29191-52-4	5	
ANTU (∇-Naphthylthiourea)	86-88-4	3	
Benzotrichloride (Benzyl trichloride; Benzene, (trichloromethyl)-)	98-07-7	8*	
Benzoyl chloride	98-88-4	28*	
Benzyl acetate	140-11-4	610	
Benzyl chloride (Benzene, (Chloromethyl))	100-44-7	52	
bis(2-Dimethylaminoethyl) ether (DMAEE)	3033-62-3	3.3	
bis(Chloromethyl) ether	542-88-1	0.047	
Bromochloromethane (Chlorobromomethane)	74-97-5	10600	
Bromotrifluoromethane (Trifluorobromomethane)	75-63-8	60900	
Butanethiol (n-Butyl mercaptan)	109-79-5	18	
Camphor, synthetic	76-22-2	120	

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
Caprolactam	105-60-2	50	
Chlorinated diphenyl oxide	31242-93-0	5	
Chloroacetaldehyde	107-20-0	32*	
Chloroacetone (2-Propanone, 1-chloro)	78-95-5	38*	
Chloroacetyl chloride	79-04-9	2.3	
Chlorodifluoromethane (FC-22)	75-45-6	35400	
Chlorodiphenyl (42 % chlorine)	53469-21-9	10	
Chlorodiphenyl (54% chlorine)	11097-69-1	5	
Chloropentafluoroethane	76-15-3	63200	
Crotonaldehyde (2-Butenal)	4170-30-3	8.6*	
Crufomate	299-86-5	50	
Cumene (Benzene, 1-methylethyl-)	98-82-8	2460	
Cyclohexane	110-82-7	3440	
Cyclohexanol	108-93-0	2060	
Cyclohexanone	108-94-1	500	
Cyclohexene	110-83-8	10100	
Cyclohexylamine	108-91-8	410	
Cyclopentadiene	542-92-7	2030	
Cyclopentane	287-92-3	17200	
)-3-Carene	13466-78-9	1120	
Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone)	123-42-2	2380	
Dichloroacetic acid	79-43-6	26.4	
Dichloroacetylene	7572-29-4	3.9*	
Dichlorodifluoromethane (FC-12)	75-71-8	49500	
Dichlorodiphenyltrichloroethane (DDT)	50-29-3	10	
Dichloroethyl ether (bis[2 Chloroethyl] ether)	111-44-4	290	
Dichlorofluoromethane (FC-21)	75-43-4	420	
Dicyclopentadiene	77-73-6	270	
Diethyl ether (Ethyl ether)	60-29-7	12100	
Diethyl ketone	96-22-0	7050	
Diethyl phthalate	84-66-2	50	
Diethylamine	109-89-7	150	
Diethylene triamine	111-40-0	42	
Difluorodibromomethane	75-61-6	8580	
Diglycidyl ether (DGE)	2238-07-5	5.3	
Dihydroxybenzene (Hydroquinone)	123-31-9	20	
Diisopropylamine	108-18-9	210	
Dimethoxymethane (Methylal)	109-87-5	31100	
Dimethyl disulfide	624-92-0	19.3	
Dimethylaniline (N,N-Dimethylaniline)	121-69-7	250	
Dimethylethoxysilane	14857-34-2	21	
Dinitolmide	148-01-6	50	
Dinitrobenzene	100-25-4	10	

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
Dinitrotoluene	25321-14-6	2	
Diphenylamine	122-39-4	100	
Dipropyl ketone (4-Heptanone)	123-19-3	2330	
Dipropylene glycol methyl ether [bis-(2-Methoxypropyl) ether; DPGME]	34590-94-8	6060	
Divinyl benzene	1321-74-0	530	
Dodecyl mercaptan (1-Dodecanethiol)	112-55-0	8	
Enflurane	13838-16-9	5660	
EPN (O-Ethyl-O-[4nitrophenyl]phenylthiophosphonate)	2104-64-5	0	
Ethanethiol (Ethyl mercaptan)	75-08-1	13	
Ethyl acetate	141-78-6	14400	
Ethyl amyl ketone (3-Heptanone, 5-methyl-)	541-85-5	1310	
Ethyl bromide (Bromoethane)	74-96-4	220	
Ethyl butyl ketone (3-Heptanone)	106-35-4	2340	
Ethyl cyanoacrylate (Ethyl 2-cyanoacrylate)	7085-85-0	10	
Ethyl formate (Formic acid, ethyl ester)	109-94-4	3030	
Ethyl tert-butyl ether (ETBE)	637-92-3	210	
Ethylene chlorohydrin (2-Chloroethanol)	107-07-3	33*	
Ethylene glycol dinitrate	628-96-6	3.1	
Ethylenimine	151-56-4	8.8	
Ethylidene norbornene	16219-75-3	250*	
Formamide (Methanamide)	75-12-7	180	
Formic acid (Methanoic acid)	64-18-6	94	
Furfural (2-Furaldehyde)	98-01-1	79	
Furfuryl alcohol (2-Furanmethanol)	98-00-0	400	
Heptane (n-Heptane)	142-82-5	16400	
Hexachlorobenzene (HCB)	118-74-1	0.02	
Hexachlorobutadiene	87-68-3	2.1	
Hexachlorocyclopentadiene	77-47-4	1.1	
Hexachloroethane	67-72-1	97	
Hexachloronaphthalene	1335-87-1	2	
Hexafluoroacetone	684-16-2	6.8	
Hexane, other isomers		17600	
Hexylene glycol	107-41-5	1210*	
Hydrogenated terphenyls	61788-32-7	49	
Indene	95-13-6	480	
Isoamyl alcohol (1-Butanol, 3-methyl)	123-51-3	3610	
Isobutyl acetate (Isobutyl acetate)	110-19-0	7130	
Isobutyl alcohol (1-Propanol, 2-methyl)	78-83-1	1520	
Isobutyl nitrite	542-56-3	42*	
Isooctyl alcohol	26952-21-6	2660	
Isopentane	78-78-4	17700	

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
Isopentyl acetate (Isoamyl acetate; 3-Methylbutyl acetate)	123-92-2	2660	
Isophorone diisocyanate	4098-71-9	0.45	
Isopropyl acetate	108-21-4	4180	
Isopropyl ether (Diisopropyl ether)	108-20-3	10400	
Isopropyl glycidyl ether (IGE)	4016-14-2	2380	
Isopropylamine (2-Propanamine)	75-31-0	120	
m-Dinitrobenzene	99-65-0	10	
Mesityl oxide	141-79-7	600	
Methacrylic acid (2-Propenoic acid, 2-methyl)	79-41-4	700	
Methyl 2-Cyanoacrylate (Mecrylate)	137-05-3	10	
Methyl acetylene-propadiene mixture	MAPP	16400	
Methyl amyl alcohol (Methyl isobutyl carbinol ; 4-Methyl-2-pentanol)	108-11-2	1040	
Methyl ethyl ketone peroxide	1338-23-4	15*	
Methyl formate (Formic acid, methyl ester)	107-31-3	2460	
Methyl isoamyl ketone (2-Hexanone, 5-methyl)	110-12-3	2340	
Methyl isobutyl ketone (Hexone)	108-10-1	2050	
Methyl isopropyl ketone (2-Butanone, 3-methyl)	563-80-4	7050	
Methyl methacrylate (Methacrylic acid, methyl ester)	80-62-6	2050	
Methyl n-amyl ketone (2-Heptanone)	110-43-0	2330	
Methyl n-butyl ketone (2-Hexanone)	591-78-6	200	
Methyl propyl ketone (2-Pentanone)	107-87-9	7050	
Methyl silicate	681-84-5	60	
Methyl vinyl ketone (3-Buten-2-one)	78-94-4	6*	
Methylacrylonitrile (2-Propenenitrile, 2-methyl-)	126-98-7	27	
Methylamine	74-89-5	64	
Methylcyclohexane	108-87-2	16100	
Methylcyclohexanol	25639-42-3	2340	
Methylhydrazine	60-34-4	0.19	
Methylisocyanate	624-83-9	0.47	
Monochloroacetic acid	79-11-8	19.4	
Morpholine	110-91-8	710	
m-Phenylenediamine	108-45-2	1	
m-Toluidine	108-44-1	88	
m-Xylene ∇, ∇'-diamine	1477-55-0	1*	
N,N-Dimethylacetamide	127-19-5	360	
n-Amyl acetate (1-Pentyl acetate; Acetic acid, pentyl ester)	628-63-7	2260	
n-Butanol (N-Butyl alcohol)	71-36-3	610	
n-Butyl acetate	123-86-4	7130	
n-Butyl glycidyl ether (BGE)	2426-08-6	1330	

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
n-Butyl lactate (Propanoic acid, 2-hydroxy-, butyl ester)	138-22-7	300	
n-Butylamine	109-73-9	150*	
N-Ethylmorpholine	100-74-3	240	
Nicotine (Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)-)	54-11-5	5	
N-Isopropylaniline	768-52-5	110	
Nitrapyrin (2-Chloro-6-(trichloromethyl) pyridine)	1929-82-4	100	
Nitrobenzene	98-95-3	50	
Nitroethane	79-24-3	3070	
Nitromethane	75-52-5	500	
Nitrotoluene, m-isomer (3-Nitrotoluene)	99-08-1	110	
Nitrotoluene, o-isomer (2-Nitrotoluene)	88-72-2	110	
Nitrotoluene, p-isomer (4-Nitrotoluene)	99-99-0	110	
N-Methyl aniline (Monomethyl aniline)	100-61-8	22	
Nonane	111-84-2	10500	
n-Propyl acetate	109-60-4	8350	
n-Propyl alcohol (n-Propanol)	71-23-8	4920	
n-Propyl nitrate (Nitric acid, propyl ester)	627-13-4	1070	
n-Valeraldehyde	110-62-3	1760	
N-Vinyl-2-Pyrrolidinone (1-Vinyl-2-pyrrolidinone)	88-12-0	2.3	
o-Anisidine (Benzenamine, 2-methoxy-)	90-04-0	5	
o-Chlorobenzylidene malononitrile	2698-41-1	3.9*	
o-Chlorostyrene	2039-87-4	2830	
o-Chlorotoluene (Toluene, 2-chloro)	95-49-8	2590	
Octachloronaphthalene	2234-13-1	1	
Octane, All isomers	111-65-9	14010	
Octane, All isomers	540-84-1	14010	
o-Methylcyclohexanone	583-60-8	2290	
o-Nitrobenzene (Dinitrobenzene)	528-29-0	10	
o-Phenylenediamine	95-54-5	1	
o-sec-Butylphenol	89-72-5	310	
o-Toluidine	98-53-4	88	
Pentachloronaphthalene	1321-64-8	5	
Pentachloronitrobenzene	82-68-8	5	
Pentachlorophenol	87-86-5	5	
Perchloromethyl mercaptan	594-42-3	7.6	
Phenothiazine	92-84-2	50	
p-Nitroaniline	100-01-6	30	
p-Nitrochlorobenzene (p-Chloronitrobenzene)	100-00-5	6.4	
p-Phenylenediamine	106-50-3	1	
Propanoic acid, 2-chloro- (2-Chloropropionic acid)	598-78-7	4.4	
Propargyl alcohol	107-19-7	23	

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
Propiolactone, beta	57-57-8	15	
Propionaldehyde	123-38-6	480	
Propionic acid	79-09-4	300	
Propoxur	114-26-1	5	
Propylene glycol dinitrate (PGDN)	6423-43-4	3.4	
Propyleneimine (2-Methylazridine)	75-55-8	47	
Propyne (Methyl acetylene)	74-99-7	16400	
p-Toluidine (p-Aminotoluene)	106-49-0	88	
Pyridine	110-86-1	31	
sec-Butanol (sec-Butyl alcohol)	78-92-2	3000	
sec-Butyl acetate (Acetic acid, 1-methylpropyl ester)	105-46-4	9500	
sec-Hexyl acetate	108-84-9	2950	
Stoddard solvent	8052-41-3	5250	
tert-Amyl methyl ester (TAME)	994-05-8	800	
tert-Butanol (tert-Butyl alcohol)	75-65-0	3030	
tert-Butyl acetate	540-88-5	9500	
tert-Pentane	463-82-1	17700	
Tetrachloronaphthalene	1335-88-2	20	
Tetrafluoroethylene	116-14-3	82	
Tetrahydrofuran	109-99-9	0	
Tetramethyl succinonitrile	3333-52-6	28	
Tetranitromethane	509-14-8	0.4	
Thioglycolic acid	68-11-1	38	
Toxaphene (Chlorinated camphene)	8001-35-2	5	
Trichloronaphthalene	1321-65-9	50	
Triethanolamine	102-71-6	50	
Trimethyl benzene	25551-13-7	1230	
Trimethyl benzene, All isomers	108-67-8	1230	
Trimethyl benzene, All isomers	526-73-8	1230	
Trimethyl benzene, All isomers	95-63-6	1230	
Triphenyl amine	603-34-9	50	
Vinyl bromide (Ethene, bromo-)	593-60-2	22	
Vinyl chloride (Chloroethylene)	75-01-4	26	
Vinyl fluoride	75-02-5	19	
Vinyl toluene (Methyl styrene, All isomers)	25013-15-4	2420	
Xylidine, mixed isomers	1300-73-8	25	
Vinyl cyclohexene dioxide (7-Oxabicyclo[4.1.0]heptane, 3-oxiranyl)	106-87-6	5.7	
1,1,1,2-Tetrachloro-2,2-difluoroethane (FC-112a)	76-11-9	41700	
1,1,2-Trichloroethane	79-00-5	550	
1,1,2,2-Tetrachloro-1,2-difluoroethane (FC-112)	76-12-0	41700	
1,1,2,2-Tetrachloroethane	79-34-5	69	

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
Acetylene tetrabromide (1,1,2,2-Tetrabromoethane)	79-27-6	140	
Dichlorotetrafluoroethane (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	76-14-2	69900	
1,1,2-Trichloro-1,2,2-trifluoroethane (FC-113)	76-13-1	76700	
1,2,3-Trichloropropane	96-18-4	600	
1,2,4-Trichlorobenzene	120-82-1	370*	
3-Amino-1,2,4-triazole (Amitrole; 3-Amino-s-triazole)	61-82-5	2	
1,3,5-Triglycidyl-s-triazinetrione	2451-62-9	0.5	
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)	93-76-5	100	
2,4,6-Trinitrophenylmethylnitramine (Tetryl)	479-45-8	15	
Picric acid (2,4,6-Trinitrophenol)	88-89-1	1	
Tetryl (2,4,6-Trinitrophenylmethylnitramine)	479-45-8	15	
2-Chloro-1,3-butadiene (∑-Chloroprene)	126-99-8	360	
Quinone (p-Benzoquinone; 2,5-cyclohexadiene-1,4-dione)	106-51-4	4.4	
1,1-Dichloro-1-nitroethane	594-72-9	120	
1,1-Difluoroethylene (Vinylidene fluoride)	75-38-7	13100	
1,1-Dimethylhydrazine	57-14-7	0.25	
Biphenyl (Diphenyl; 1,1'-Biphenyl (9CI))	92-52-4	13	
p-tert-Butyltoluene (Toluene, 4-t-butyl (Benzene,1-(1,1-dimethylethyl)-4-methyl))	98-51-1	61	
tert-Amyl acetate (1,1-Dimethylpropyl acetate)	625-16-1	2660	
1,2-Diaminoethane (Ethylenediamine)	107-15-3	250	
1,2-Dichloropropane (Propylene dichloride)	78-87-5	3470	
Dimethylphthalate (1,2-Benzenedicarboxylic acid, dimethyl ester)	131-11-3	50	
o-Dichlorobenzene (1,2-Dichlorobenzene)	95-50-1	1500	
Pyrocatechol (Catechol ;1,2-Benzenediol)	120-80-9	230	
1,3-Dichloropropene	542-75-6	45	
1,3-Dioxalane	646-06-0	610	
m-Phthalodinitrile (1,3-Benzenedicarbonitrile)	626-17-5	50	
Toluene-2,6-diisocyanate (Benzene, 1,3-diisocyanato-2-methyl)	91-08-7	0.36	
1,4-Dichloro-2-butene	764-41-0	0.25	
1,6-Hexanediamine (Hexamethylenediamine)	124-09-4	23	
2,2-Dichloropropionic acid	75-99-0	50	
2,2-Dimethylbutane (Hexane)	75-83-2	17600	
2,3-Dimethylbenzene (Hexane)	79-29-8	17600	
2,3-Epoxy-1-propanol (Glycidol)	556-52-5	61	
2,4-Dichlorophenoxyacetic acid (2,4-D)	94-75-7	100	
2,6-Dimethyl-4-heptanone (Diisobutyl ketone)	108-83-8	1450	

CHEMICAL	CAS NUMBER	1/100 TLV ^a (µg/m ³)	1/2 Chronic ^b REL (µg/m ³)
Butylated hydroxytoluene (BHT; 2,6-Di-tert-butyl-p-cresol)	128-37-0	20	
4,4'-Diaminodiphenylmethane (4,4'-Methylenedianiline)	101-77-9	8.1	
4,4'-Thiobis(6-tert-butyl-m-cresol)	96-69-5	100	
4,6-Dinitro-o-cresol	534-52-1	2	
1,3-Dichloro-5,5-dimethyl hydantoin	118-52-5	2	

^a - ACGIH, 2004 Threshold Limit Values for Chemical Substances and Physical Agents, Cincinnati, OH

^b - http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html - Chronic Reference Exposure Levels (CRELs) adopted by the State of California Office of Environmental Health Hazard Assessment (OEHHA), February 2005 (Acetaldehyde allowed full CREL)

* - Indicates the Short Term Exposure Limit (STEL) or Ceiling value

† - AIHA 2005 Workplace Environmental Exposure Level (WEEL)

** - Full REL value allowed per CA DHS.

*** 1/2 OEHHA staff recommended indoor air limit formaldehyde used for GREENGUARD Children and School Certification as noted in 4.1.1

**SECTION 5
REQUIRED ELEMENTS OF THE LABORATORY
TEST REPORT**

5.0 The Report of the Test Results Should Contain the Following Sections:

- 5.0.1 *Laboratory identification:* Name, address, phone number and other contact information for the laboratory.
- 5.0.2 *Manufacturer, product and sample identification:*
- 5.0.2.1 Manufacturer
 - 5.0.2.2 Product name, product number, product category and subcategory (if applicable)
 - 5.0.2.3 Manufacturer's ID number and other identification numbers (if applicable)
 - 5.0.2.4 Manufacturing date, collection date, shipment date and date of arrival at laboratory (on chain of custody)
 - 5.0.2.5 Laboratory sample ID or tracking number.
- 5.0.3 *Testing conditions:* Chamber volume, air change rate, temperature, relative humidity, 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 (if applicable), and test period start date and end date.
- 5.0.4 *Chamber methodology:* Referenced methods/practices followed to operate chambers; description of the chamber used, how air flows through the chamber, supply air contaminant levels (either in report or readily available upon request).
- 5.0.5 *Data analysis procedures:* Analytical methods used to determine measured chamber concentrations and to derive emission factors from measured chamber concentrations; methodology and parameters used to calculate room concentrations from the emission factors including the assumed product area, room volume, and ventilation rate and ventilated volume fraction.
- 5.0.6 *Test results:* For GREENGUARD Certification tests, for all time points list chamber concentration emission factors of the TVOC, individual VOCs, formaldehyde, total aldehyde and other individual aldehydes quantified. For seating, workstations and casegood systems, also report duplicate measurement data for the 72 and 168 hours points per the BIFMA M71. Method.
- Provide the following information:*
- 5.0.6.1 CAS numbers for individual VOCs.
 - 5.0.6.2 Identify those VOCs with chronic RELs and VOCs on the other lists of toxic substances including:
 - CA Proposition 65 http://www.oehha.ca.gov/prop65/prop65_list/newlist.html;
 - CA Toxic Air Contaminants (TACs) <http://www.arb.ca.gov/toxics/taclist.htm>;
 - Class I and II carcinogens http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html.
 - 5.0.6.3 Provide estimated concentrations for modeled building scenarios for TVOC, formaldehyde, and total aldehydes at all time points, and for target list chemicals at the 168 hour time point.
 - 5.0.6.4 Indicate non-listed VOCs which were quantitated using surrogate compound standards instead of authentic standards.
- 5.0.7 Certification of the Report with date including authorized laboratory.
- 5.0.8 Report any additional facts, which may have influenced the test results. These may include, but are not limited to, the following:

- 5.0.8.1 Dates of most recent internal and external calibrations, methods and compounds used
 - 5.0.8.2 Dates of most recent proficiency evaluation(s) and corrective actions taken, if any
 - 5.0.8.3 Any deviations of laboratory parameters from specified values
 - 5.0.8.4 Details of specimen preparation not covered above (i.e., application methods for paints and adhesives and preparation of assemblies)
 - 5.0.8.5 Mass quantity and coverage (g m^{-2}) of paint and adhesive
 - 5.0.8.6 Any other relevant observations.
- 5.0.9 Attach a copy of the completed and signed chain-of-custody (COC) form with the laboratory report.

SECTION 6 TABLES

Table 6.1 Sample collection and testing chronology for products

1.0.11 Event	Schedule
<i>Dry Products (e.g., resilient flooring, carpet, wallcovering, etc.) and Containerized products (e.g., adhesive, sealant, paint, etc.)</i>	
Manufacturing date	Date product comes off of final manufacturing line
Sample collection	Same as <i>Manufacturing date</i>
Shipment to laboratory	Within 24 hours of sample collection*
Arrival at laboratory	Not to exceed 7 days from shipment date
Commence laboratory testing	Not to exceed 10 days after arrival and product acceptance at laboratory

* Complex furniture and other products with multiple components must be assembled within 2-day period and shipped.

Table 6.2 Chamber conditions for 168 hr test period

1.0.12 Parameter	Symbol	Units	Value
Chamber volume	V	m ³	0.05 – 26
Loading factor**	L	m ² /m ³	0.4 – 1.0 (variable, depends on product type and usage and expected levels of VOCs in chambers)
Air change rate	a	hr ⁻¹	1.0 ± 0.05
Temperature	T	°C	23 ± 1
Relative humidity	RH	%	50 ± 5

** Specimen sizes are to be adjusted according to the chamber volumes to achieve the specified loading factor range.

Table 6.3 All chronic inhalation Reference Exposure Levels (RELs) adopted by Cal/EPA OEHHA as of August 2006.

Substance (CAS #)	Listed in CAPCOA - 1993	Chronic Inhalation REL (µg/m ³)	Hazard Index Target(s)	Human Data
Acetaldehyde* (75-07-0)	<input checked="" type="checkbox"/>	9	Respiratory system	
Acrolein (107-02-8)	<input checked="" type="checkbox"/>	0.06	Respiratory system; eyes	
Acrylonitrile (107-13-1)	<input checked="" type="checkbox"/>	5	Respiratory system	
Ammonia (7664-41-7)	<input checked="" type="checkbox"/>	200	Respiratory system	<input checked="" type="checkbox"/>
Arsenic (7440-38-2) & arsenic compounds	<input checked="" type="checkbox"/>	0.03	Development; Cardiovascular system; Nervous system	
Benzene (71-43-2)	<input checked="" type="checkbox"/>	60	Hematopoietic system; development; nervous system	<input checked="" type="checkbox"/>

<i>Substance (CAS #)</i>	<i>Listed in CAPCOA - 1993</i>	<i>Chronic Inhalation REL ($\mu\text{g}/\text{m}^3$)</i>	<i>Hazard Index Target(s)</i>	<i>Human Data</i>
Beryllium (7440-41-7) and beryllium compounds	<input checked="" type="checkbox"/>	0.007	Respiratory system; immune system	<input checked="" type="checkbox"/>
Butadiene (106-99-0)		20	Reproductive system	
Cadmium (7440-43-9) & cadmium compounds	<input checked="" type="checkbox"/>	0.02	Kidney; respiratory system	<input checked="" type="checkbox"/>
Carbon tetrachloride (56-23-5)	<input checked="" type="checkbox"/>	40	Alimentary system; development; nervous system	
Carbon disulfide (75-15-0)		800	Nervous system; reproductive system	<input checked="" type="checkbox"/>
Chlorinated dioxins (1746-01-6) & dibenzofurans (5120-73-19)	<input checked="" type="checkbox"/>	0.00004	Alimentary system (liver); reproductive system; development; endocrine system; respiratory system; hematopoietic system	
Chlorine (7782-50-5)	<input checked="" type="checkbox"/>	0.2	Respiratory system	
Chlorine dioxide (10049-04-4)		0.6	Respiratory system	
Chlorobenzene (108-90-7)	<input checked="" type="checkbox"/>	1000	Alimentary system; kidney; reproductive system	
Chloroform (67-66-3)	<input checked="" type="checkbox"/>	300	Alimentary system; kidney; development	
Chloropicrin (76-06-2)	<input checked="" type="checkbox"/>	0.4	Respiratory system	
Chromium hexavalent: soluble except chromic trioxide	<input checked="" type="checkbox"/>	0.2	Respiratory system	
Chromic trioxide (as chromic acid mist)	<input checked="" type="checkbox"/>	0.002	Respiratory system	<input checked="" type="checkbox"/>
Cresol mixtures (1319-77-3)	<input checked="" type="checkbox"/>	600	Nervous system	
Dichlorobenzene (1,4-) (106-46-7)	<input checked="" type="checkbox"/>	800	Nervous system; respiratory system; alimentary system; kidney	
Dichloroethylene (1,1) (75-35-4)	<input checked="" type="checkbox"/>	70	Alimentary system	
Diesel Exhaust*		5	Respiratory system	
Diethanolamine (111-42-2)		3	Cardiovascular system; nervous system	
Dimethylformamide (N,N-) (68-12-2)		80	Alimentary system ; respiratory system	<input checked="" type="checkbox"/>
Dioxane (1,4-) (123-91-1)	<input checked="" type="checkbox"/>	3,000	Alimentary system; kidney; cardiovascular system	
Epichlorohydrin (106-89-8)	<input checked="" type="checkbox"/>	3	Respiratory system; eyes	
Epoxybutane (1,2-) (106-88-7)		20	Respiratory system; cardiovascular system	
Ethylbenzene (100-41-4)		2,000	Development; alimentary system (liver); kidney; endocrine system	
Ethyl chloride (75-00-3)	<input checked="" type="checkbox"/>	30,000	Development; alimentary system	
Ethylene dibromide (106-93-4)	<input checked="" type="checkbox"/>	0.8	Reproductive system	<input checked="" type="checkbox"/>

<i>Substance (CAS #)</i>	<i>Listed in CAPCOA - 1993</i>	<i>Chronic Inhalation REL ($\mu\text{g}/\text{m}^3$)</i>	<i>Hazard Index Target(s)</i>	<i>Human Data</i>
<u>Ethylene dichloride</u> (107-06-2)	<input checked="" type="checkbox"/>	400	Alimentary system (liver)	
<u>Ethylene glycol</u> (107-21-1)		400	Respiratory system; kidney; development	<input checked="" type="checkbox"/>
<u>Ethylene glycol monoethyl ether</u> (110-80-5)	<input checked="" type="checkbox"/>	70	Reproductive system; hematopoietic system	
<u>Ethylene glycol monoethyl ether acetate</u> (111-15-9)	<input checked="" type="checkbox"/>	300	Development	
<u>Ethylene glycol monomethyl ether</u> (109-86-4)	<input checked="" type="checkbox"/>	60	Reproductive system	
<u>Ethylene glycol monomethyl ether acetate</u> (110-49-6)	<input checked="" type="checkbox"/>	90	Reproductive system	
<u>Ethylene oxide</u> (75-21-8)	<input checked="" type="checkbox"/>	30	Nervous system	
<u>Fluoride</u> including Hydrogen Fluoride		13 F 14 HF	Bone and teeth; respiratory system	<input checked="" type="checkbox"/>
<u>Formaldehyde</u> (50-00-0)	<input checked="" type="checkbox"/>	3	Respiratory system; eyes	<input checked="" type="checkbox"/>
<u>Glutaraldehyde</u> (111-30-8)	<input checked="" type="checkbox"/>	0.08	Respiratory system	
<u>Hexane (n-)</u> (110-54-3)		7000	Nervous system	
<u>Hydrazine</u> (302-01-2)	<input checked="" type="checkbox"/>	0.2	Alimentary system; endocrine system	
<u>Hydrogen chloride</u> (7647-01-0)	<input checked="" type="checkbox"/>	9	Respiratory system	
<u>Hydrogen cyanide</u> (74-90-8)	<input checked="" type="checkbox"/>	9	Nervous system; endocrine system; cardiovascular system	<input checked="" type="checkbox"/>
<u>Hydrogen sulfide</u> (7783-06-4)	<input checked="" type="checkbox"/>	10	Respiratory system	
<u>Isophorone</u> (78-59-1)		2000	Development; liver	
<u>Isopropanol</u> (67-63-0)		7,000	Kidney; development	
<u>Maleic anhydride</u> (108-31-6)	<input checked="" type="checkbox"/>	0.7	Respiratory system	
<u>Manganese</u> & manganese compounds	<input checked="" type="checkbox"/>	0.2	Nervous system	<input checked="" type="checkbox"/>
<u>Mercury</u> & mercury compounds (inorganic)	<input checked="" type="checkbox"/>	0.09	Nervous system	<input checked="" type="checkbox"/>
<u>Methanol</u> (67-56-1)	<input checked="" type="checkbox"/>	4,000	Development	
<u>Methyl bromide</u> (74-83-9)	<input checked="" type="checkbox"/>	5	Respiratory system; nervous system; development	
<u>Methyl chloroform</u> (71-55-6)	<input checked="" type="checkbox"/>	1,000	Nervous system	
<u>Methyl isocyanate</u> (624-83-9)		1	Respiratory system; reproductive system	
<u>Methyl t-butyl ether</u> (1634-04-4)		8,000	Kidney; eyes; alimentary system (liver)	

<i>Substance (CAS #)</i>	<i>Listed in CAPCOA - 1993</i>	<i>Chronic Inhalation REL ($\mu\text{g}/\text{m}^3$)</i>	<i>Hazard Index Target(s)</i>	<i>Human Data</i>
<u>Methylene chloride</u> (75-09-2)	<input checked="" type="checkbox"/>	400	Cardiovascular system; nervous system	<input checked="" type="checkbox"/>
<u>Methylene dianiline</u> (4,4'-) (101-77-9)	<input checked="" type="checkbox"/>	20	Eyes; alimentary system (hepatotoxicity)	
<u>Methylene Diphenyl Isocyanate</u> (101-68-8)		0.7	Respiratory system	
<u>Naphthalene</u> (91-20-3)	<input checked="" type="checkbox"/>	9	Respiratory system	
<u>Nickel & compounds</u> (except nickel oxide)	<input checked="" type="checkbox"/>	0.05	Respiratory system; hematopoietic system	
<u>Nickel oxide</u> (1313-99-1)		0.1	Respiratory system; hematopoietic system	
<u>Phenol</u> (108-95-2)	<input checked="" type="checkbox"/>	200	Alimentary system; cardiovascular system; kidney; nervous system	
<u>Phosphine</u> (7803-51-2)	<input checked="" type="checkbox"/>	0.8	Respiratory system; alimentary system; nervous system; kidney; hematopoietic system	
<u>Phosphoric acid</u> (7664-38-2)		7	Respiratory system	
<u>Phthalic anhydride</u> (85-44-9)	<input checked="" type="checkbox"/>	20	Respiratory system	<input checked="" type="checkbox"/>
<u>Propylene</u> (115-07-1)		3,000	Respiratory system	
<u>Propylene glycol monomethyl ether</u> (107-98-2)		7,000	Alimentary system (liver)	
<u>Propylene oxide</u> (75-56-9)	<input checked="" type="checkbox"/>	30	Respiratory system	
<u>Selenium and selenium compounds</u> (other than hydrogen selenide)	<input checked="" type="checkbox"/>	20	Alimentary system; cardiovascular system; nervous system	<input checked="" type="checkbox"/>
<u>Silica (crystalline, respirable)</u>		3	Respiratory system	<input checked="" type="checkbox"/>
<u>Styrene</u> (100-42-5)	<input checked="" type="checkbox"/>	900	Nervous system	<input checked="" type="checkbox"/>
<u>Sulfuric acid</u> (7664-93-9)		1	Respiratory system	
<u>Tetrachloroethylene*</u> (perchloroethylene) (127-18-4)	<input checked="" type="checkbox"/>	35	Kidney; alimentary system (liver)	
<u>Toluene</u> (108-88-3)	<input checked="" type="checkbox"/>	300	Nervous system; respiratory system; development	
<u>Toluene diisocyanates</u> (2,4-&2,6-)	<input checked="" type="checkbox"/>	0.07	Respiratory system	<input checked="" type="checkbox"/>
<u>Trichloroethylene</u> (79-01-6)	<input checked="" type="checkbox"/>	600	Nervous system; eyes	<input checked="" type="checkbox"/>
<u>Triethylamine</u> (121-44-8)		200	Eyes	
<u>Vinyl acetate</u> (108-05-4)		200	Respiratory system	
<u>Xylenes</u> (m-, o-, p-)	<input checked="" type="checkbox"/>	700	Nervous system; respiratory system	<input checked="" type="checkbox"/>

Table 6.4 Parameters to be used for calculation of VOC concentrations in offices and classrooms

Parameter	Unit of Measure	GG Office Model	GG Children and Schools Model* (Classroom)
Room Length	ft	10	40
Room Width	ft	14	24
Room Height	ft	8	8.5
Room Volume	m ³	32	231
Air Change Rate (hr ⁻¹)	hr ⁻¹	0.72	0.9
Area Loadings by Application			
Floor/Ceiling	m ²	13.1	89.2
Wallcoverings/Paints	m ²	28.1	94.6
Thermal Insulation, Walls	m ²	28.1	94.6
Thermal Insulation, Ceiling	m ²	13.1	89.2
Desk/Seating (children's)	Units	NA	27
Shelving/Bookcases/Counter Tops	m ²	20	7.81
Millwork (Doors)	m ² / Unit	1.89 / 1	1.89 / 1
Wallbase (10 in) Schools (4 in) Office	m ²	2.7	9.68
Teacher's Desk / Chair	Unit	NA	1
Window Treatments	m ²	4.1	4.46
HVAC Duct Material	m ²	5.5	39.1
Desk (Worksurface) Surface Area	m ²	3.2	12.3
Tackboards/Markerboards	m ²	3.0	9.9
Office Furniture Workstation or System Unit	Unit	1	NA
Casegood, freestanding large product	Unit	1	NA
Office Seating	Unit	1	NA

NA = Not Available

* For Products specific to office environments, certification requires modeling according to the DHS document for office parameters in Table 7.5 of the DHS Practice or GREENGUARD specific parameters if they are more conservative or for products in which loading parameters are not provided in the DHS Practice.