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

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Foreword

The GREENGUARD Environmental Institute (GEI) an ISO\IEC Guide 65 accredited Certification Body and accredited ANSI Standards Developer, began certifying indoor products for low chemical emissions in 2001. Testing procedures for the program were initially developed and applied 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, Air Quality Sciences, Inc, California Department of Public Health, 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 and test methods to define and measure 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 (Method) incorporates the best-learned practices for testing and evaluating products for third party certification and specification programs such as GREENGUARD Certification, the California Department of Public Health Standard Method V1.1-2010, “Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1 (CDPH Standard Test Method V1.1-2010)”, BIFMA Furniture Emissions Standards, the German Blue Angel Programs, the Green Guide for Health Care, the National Association of Home Builders (NAHB) Green standards, MBDC’s Cradle to Cradle, Collaborative High Performance School Program (CHPs), LEED , Green Globes, and other private and government programs.

The Method is applicable to office furniture, paints and coatings, adhesives and sealants, wallboard and insulation, flooring, ceilings, window furnishings, and 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. Analytes include total volatile organic compounds (TVOC), individual VOCs, formaldehyde, total aldehydes, and specialized pollutants as defined by specific programs. All individual VOCs or pollutants emitting from products are measured as prescribed by the Method, and each measured analyte is required to meet defined allowable levels as specified by the certification or specification programs.

This 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.

The GREENGUARD Children & Schools Standard that became publicly available in 2005, incorporated criteria to provide a higher margin of safety for young children and sensitive populations. This standard minimizes allowable chemical levels and also requires that emissions meet the ½ CREL criteria of specified target chemicals as listed in the CDPH Standard Test Method V1.1-2010, as recognized and referenced by the national Collaborative for High Performance Schools (CHPS) programs and USGBC LEED programs. This test

method ensures that product testing and calculations of estimated building concentrations meet or exceed the requirements of the CDPH Standard Method V1.1 “Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers Version 1.1” dated February 2010 with applicable emissions criteria as defined by the specific standard. Approval of GREENGUARD Children & Schools Certification and this test method as an acceptable alternate for the Collaborative for High Performance Schools (CHPS) EQ 2.2 Low-Emitting Material Credit was received March 8, 2007.

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. Method revisions are publicly posted for comments by interested parties, users, and other stakeholders and final revisions are made according GREENGUARD’s ISO\IEC Guide 65 procedures.

TABLE OF CONTENTS

SECTION 1
BACKGROUND INFORMATION 1
1.0 Scope 2
1.1 Objectives and Use 3
1.2 References and Documents 4
1.3 Acronyms and Abbreviations 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 17

SECTION 3
LABORATORY SAMPLE PREPARATION AND ANALYSES 18
3.0 Test Specimen Preparation 19
3.1 Furniture Testing 19
3.2 Sample Preparation 19
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 26
3.11Chemical Analyses 30
3.12 Calculations 32

SECTION 4
TARGET CHEMICALS AND
MAXIMUM ALLOWABLE CONCENTRATIONS 36
4.0 GREENGUARD Indoor Air Quality Product Certification 37
4.1 GREENGUARD Children & Schools and CDPH/EHLB/Standard Method V1.1. 38
4.2 Individual VOC ACGIH TLV and CA CREL Criteria Limits 39

SECTION 5
REQUIRED ELEMENTS OF THE LABORATORY TEST REPORT 48
5.0 Required elements of the Laboratory Test Report 49

SECTION 6
TABLES 51
Table 6.1 Chamber Conditions for Test Period 52
Table 6.2 Parameters to be used for calculation
of VOC concentrations in offices and classrooms 52

Appendix 1
Appendix 2
Appendix 3
Appendix 3, Attachment 1
Appendix 4

SECTION 1
BACKGROUND INFORMATION

Scope

1.0.1 This 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 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.

1.0.3 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.

1.0.4 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.

1.0.5 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.

1.0.6 Emissions of selected aldehydes are measured using reverse-phase high-performance liquid chromatography (HPLC) with UV detection.

1.0.7 Specialized analysis of chamber air samples are conducted for other specific target chemicals as required for a specific product/project requirement.

1.0.8 The methodology with standardized measurement and analyses provides consistent testing of materials within a product group.

1.0.9 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 are to be tested whole or by a representative component or material in an environmental chamber.

1.0.10 This methodology is applicable for newly manufactured products before they are used in construction or furnishing. (See Appendix 2 for more information.)

1.0.11 This method establishes the procedures for product sample collection, emission testing and analysis, indoor air concentration modeling and associated documentation requirements.

1.0.12 This method also establishes performance criteria for specific chemicals of interest.

1.0.13 While this practice lists specific chemicals and associated maximum allowable concentrations, as required by criteria indoor air procedures 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.

1.0.14 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 required safety and health practices and determine the applicability of regulatory limitations prior to use.

Objectives and Use

1.0.15 Objectives

1.0.15.1 Measure VOCs, including aldehydes, and other potential pollutants from building materials, finishes, and indoor furnishings.

1.0.15.2 Provide compound-specific data on VOCs and their sources to manufacturers for assessing product emissions and developing improved products for indoor environments.

1.0.15.3 Obtain emission data for use by Third Party Certification Programs such as the GREENGUARD Certification Program, the California CHPS Program, the State of CA DPH's CDPH/EHLB/Standard Method V1.1 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1" dated February 2010, 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.

1.0.15.4 Provide compound-specific data on VOC sources and assist in evaluating indoor air quality in buildings.

1.0.15.5 Provide emissions data for the development and use of models for prediction of indoor air concentrations of VOCs.

1.0.15.6 Identify irritants, odorants, and hazardous VOCs emitting from building materials, finishes and indoor furnishings and their emission parameters to assist in risk evaluations.

1.0.15.7 Rank and evaluate products within a category or across categories respect to their emission profiles, types, or chemicals and their levels.

1.0.15.8 Provide compound specific emission parameters for use in indoor exposure models.

1.0.16 Use

1.0.16.1 Small (0.05 – 1 m^3) chamber evaluations are used to determine source emission rates and emissions factors from small products and small components of products.

1.0.16.2 Intermediate (approximately 1 – 6 m^3 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.).

1.0.16.3 Large (> 25 m^3) chambers are used for the evaluation of large products, including assembled workstations.

1.0.16.4 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.

1.0.16.5 Emission factors are used to compare emission levels among products at a specific exposure time point.

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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
CDPH – California Department of Public Health
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-Dintrophenylhydrazine
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 ($\mu g/m^2 \cdot hr$) or the mass of chemical emitted per weight per unit time ($\mu g/g \cdot hr$).

Emission Rate (ER) – The rate of emission of a specific compound is defined as the total $\mu g/hr$ 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 have similar VOC emissions profiles (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 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 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.

Third Party Certification - Conformity assessment activity that is performed by a person or body that is independent of the person or organization that provides the object, and of user interests in that object.

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	$\mu g/m^3$
$C_{P,t}$	Predicted exposure concentration at time t	$\mu g/m^3$
EF	Emission factor	$\mu g/m^2 \cdot hr$ or $\mu g/m \cdot hr$ or $\mu g/g \cdot hr$ or $\mu g/unit \cdot hr$
EF_o	Initial emission factor	$\mu g/m^2 \cdot hr$ or $\mu g/m \cdot hr$ or $\mu g/g \cdot hr$ or $\mu g/unit \cdot hr$
EF_t	Measured emission factor at time t	$\mu g/m^2 \cdot hr$ or $\mu g/m \cdot hr$ or $\mu g/g \cdot hr$ or $\mu g/unit \cdot hr$
ER	Emission rate	$\mu g/hr$
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	$\mu g/m^2 \cdot hr$
T	Time after start of test	hr or day
t	Time	hr
V	Volume	m^3

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

2.0 Sample Collection

Purpose

Procedures 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 are to perform the task carefully and conscientiously and according to specific instructions, if supplied. (See Appendix 2 for more information.)

2.1.2 Individuals engaged in sample collection and handling are to 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. (See Appendix 2 for more information.)

2.3.3 Product samples are to 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 is to be used.

2.3.4 The product is to 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 is to be stored in an environmentally controlled indoor environment free of contamination with environmental control of 20º – 25ºC and relative humidity no greater than 60% RH.

2.4 Location of Sampling

2.4.1 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 are to 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 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 1 day of collection and packaging, except for multi-component or large samples (such as furniture). In these cases, the sample shall 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. Containerized products (paints, sealants, adhesives, and other wet products) shall be collected and shipped within three months of production.

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 Products

Manufacturing Date	Date product comes off of final manufacturing line
Sample Collection	Same as *Manufacturing Date*
Shipment to Laboratory	Within 1 day of sample collection (see Section 2.5.2 for furniture or complex products)
Arrival at Laboratory	Not to exceed 7 days of shipment date
Testing Date	Not to exceed 10 days after arrival and product acceptance at laboratory

Containerized Wet Products

Manufacturing Date	Date product comes off of final manufacturing line
Sample Collection	Within 3 months of production
Shipment to Laboratory	Within 1 day of sample collection
Arrival at Laboratory	Not to exceed 7 days of shipment date
Testing Date	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 is to 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 COC is to be fully completed. Two copies of the completed form (Section 2.9) shall be attached to the outside of the sample package. A third 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). Alternatively, wallcovering and other fabric shall be collected as a full or partial production roll. In these cases, the roll shall have at least 10 layers of material and be provided collected from the packaging line or placed in specialized packaging as described in Sections 2.3 and 2.5. Following packaging, the COC is to be fully completed. Two copies of the completed form shall be attached to the outside of the sample package. The third 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 is to be shipped to the testing laboratory as long as the sample is sealed as recommended. As an alternative, smaller samples are to 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 COC is to be fully completed. Two copies of the completed form shall be attached to the outside of the sample package. A thrid 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 is to 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. (See Appendix 2 for more information.)

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 (± 2 minutes) following packaging. The product is to be removed from its original packaging and placed into the specialized packaging. Alternatively, samples are to be collected directly from the production line as long as the sample is cool. Samples shall be submitted per the following size requirements: 18" x 30", samples of the same material are to 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 is to be removed immediately from the production line and allowed to condition for 15 minutes (± 2 minutes) under standard laboratory conditions in the plant prior to packaging for emissions testing. Manufacturers who provide Third Party Certification products for furniture panel applications are to be expected to deliver product for the purposes of emissions testing in the same fashion as standard board products. Alternatively, samples are to be collected directly from the production line as long as the sample is cool. Samples shall be submitted per the following size requirements: 18" x 30", samples of the same material are to 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 (± 2 minutes) following packaging. Alternatively, samples are to be collected directly from the production line as long as the sample is cool. 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 are to be supplied in original, standard 1-quart or 1-gallon consumer containers. Adhesives are to be supplied in their consumer packaging such as an applicator tube or can (if less than 1 gallon). Alternatively, adhesive and paint samples are to 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 COC is to be fully completed. Two copies of the completed form (Section 2.9) shall be attached to the outside of the sample package. A third 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, identify the major chemical ingredients, identify the intended uses and describe the application methods. Disposal recommendations are also to 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 use 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 is to 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 COC is to be fully completed. Two copies of the completed form shall be attached to the outside of the sample package. A third 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 is to ensure that the sample is tightly sealed to minimize contamination from external sources or off gassing during shipment and storage (also see Section 2.3).

2.8.2 Samples are to be packaged to avoid cross contamination. Different types of products are to 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 is to 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 Product Documentation/Chain of Custody form. This form is to be completed by the responsible

manufacturer's employee/representative or by an independent third party pursuant to an agreement between the Licensee and the laboratory evaluating products to this standard. Each signatory shall retain a copy of this document.

2.9.2 The chain of custody form is to include, 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 are to be checked against the shipping invoice to ensure all packages and components have been received.
2.10.2 The laboratory is to 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 is to 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 is to be free of chemical contamination and environmentally controlled at 20º - 25ºC 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 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 are to 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 are to 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 are to 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 is to 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 Furniture construction materials are typically tested in small chambers. Examples of these materials are foam cushions, textiles, mockup wood surfaces, etc. (See Appendix 2 for more information.)

3.1.1.2 Furniture 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. (See Appendix 2 for more information.)

3.1.1.3 Complete finished products, such as chairs, desks, workstations, and moveable walls, are tested whole an intermediate or large chamber. (See Appendix 2 for more information.)

3.2 Sample Preparation

3.2.1 *Furniture 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 m^2/m^3. 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 is to 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 m^2/m^3 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 are to be sealed, and the product is to be loaded into the chamber. If the specimen needs to be cut to size, target a loading factor of 0.4-1 m^2/m^3. 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 is to be cut to fit into a small chamber, without losing the integrity of the sample, target a loading factor of 1 m^2/m^3 and expose, at most, only one finished edge. Alternatively, load unperturbed in an intermediate sized chamber following the 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 m^2/m^3. 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 may 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 m^2/m^3, 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 casegoods 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. The furniture specifications as presented in ANSI/BIFMA M7.1-2007 Appendix 2, pages 33-38 are the primary or default areas and configurations required for testing of both open plan and private office workstation systems. Alternative configurations are to meet these surface area requirements or be more conservative. Additional furniture specifications for individual casegoods such as tables and bookcases are given in Appendix 1. Exposure modeling for seating and open plan workstation systems is based on the single occupancy models for seating and open plan systems, respectively, as defined by ANSI/BIFMA M7.1-2007. Other furniture, including casegood systems and individual furniture items, will use a 12' x 15' x 9' "furniture" private office model (see Appendix 3 for more information) with the prescribed ventilation rate based on a default occupancy and ASHRAE 62.1-2010 ventilation requirements.

3.2.3.1 *Movable Walls* - Load into either an intermediate or large 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 either an intermediate or large 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 are to 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 m^2/m^3. 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 20º - 25°C and no greater than 60% RH while ventilated with clean air. The emissions from the drywall material itself are to be measured. This is to 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 ft^2/gal. For consistency, use 350 ft^2/gal unless specified otherwise by the customer.

3.3.1.1 Cut the 1/2" wallboard substrate to the recommended 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 is to 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 is to 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 is to have dimensions that correspond to a surface loading ratio of 0.4 ± 0.1 m^2/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 is to 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 45º 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.

3.4.5.7 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" ±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 are to 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 (±2 mm) after they are cut and prepared for testing. In many cases, it also is 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 m^2/m^3. 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 is 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 m^2/m^3. Emissions from the edges of the flooring material may differ from the normally exposed surface and, thus, edges are to 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 shall not be higher than the edge of the tray, and no more than 1/8" lower. Alternatively, the sample is to 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 recommended 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 m^2/m^3.

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 m^2/m^3.

3.6.9 *Specimen preparation for composite wood products:* Cut sample to target chamber loading factor of 0.4-1 m^2/m^3, 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 m^2/m^3, 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 m^2/m^3. 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 m^2/m^3.

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/m^2 or 0.65

lb/ft² is reached. A tray with the appropriate depth is to 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 0.4-1 m^2/m^3.

3.6.13.1 Thin Laminate (< ½"): Load with only the top (finished) surface exposed; for the loading factor use top surface area

3.6.13.2 Thick Laminate (≥ ½"):

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 0.4-1 m^2m^3. All edges are to be sealed and top surface exposed. If a specimen of required 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 m^2/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 m^2/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 ½" 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 20º - 25°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 0.4-1 m^2/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 are to 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 is to be tested as well as each component. All component pieces are to 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 per the referenced standard or specification, the product is left in the chamber for 10 days (or other required conditioning time) prior to the start of the 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 requirements are defined in ASTM documents D5116 for Small Scale Chamber Tests and 6670 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 m^3 are generally used.

3.9.3.2 Intermediate sized components such as seat backs and cushions, are tested in 0.5-2 m^3 sized chambers.

3.9.3.3 For testing of chairs and other small office furniture, intermediate chambers of 5-6 m^3 are generally used.

3.9.3.4 Large furniture and workstation testing require full scale chambers with an interior volume between 20 and 35 m^3 that can accommodate a full workstation in its entirety when assembled according to manufacturers' specifications.

3.10 **Environmental Chamber Performance Requirements-** Chamber requirements are defined in ASTM documents D5116 for Small Scale Chamber Tests and 6670 for Full Scale Chamber Tests, and the referenced EPA ETV Large Chamber Test Protocol.

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 ±1ºC and 50 ±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. Testing shall be extended to 336 hours if needed to demonstrate compliance with the emissions criteria, as allowed by the referenced specification. (See Appendix 2 for more information.) 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 20º - 25ºC 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 ± 2 % at 1 Lpm, or better, and capable of continuously maintaining the flow within ± 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 is to be confirmed (with ±10% accuracy) using procedures similar to those presented in ASTM Method E741 for tracer gas application. Alternatively, ASTM Method E741 is to 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 µg m^{-3} and 2 µg 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 not recommended 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 µg/m³ 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 µg m^{-3} for any individual VOC or aldehyde, and 10 µg m^{-3} for TVOC or respirable particles.

3.10.8 Temperature and humidity control: The temperature of the chamber shall be maintained at 23 ± 1°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 ± 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 is to 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 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 µg m^{-3} for individual VOCs and 10 µg 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 is to be minimized. The process, along with times, is to 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 SF_6 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 is to be determined periodically after loading a test specimen, if required. This is to 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 recommended for replicate measurement.

3.10.11 Air Sampling

3.10.11.1 *Sampling schedule:* For standard Third Party Certification tests, chamber air samples shall be collected and analyzed for VOCs (individual and total) and aldehydes (individual and total) (as detailed in Section 3.11) centered around the elapsed times of 6, 24, 48, 72, 96 (or 120), 168 and, if required, 336 hours after initiating the chamber test. Phthalate samples are collected and analyzed at the 168 hour time point. (See Appendix 2 for more information.)

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 D6345, 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 (C_6 - C_{16}). Minimal losses of analytes (i.e., < 5%) due to breakthrough shall occur. (See Appendix 2 for more information.) 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 inches 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 acetontrile that may be present in the DNPH cartridge. The total sampling flow rate at any time shall not exceed 75% of the inlet flow rate. The start and stop times and the sampling flow rates shall be recorded. A unique identification number 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 time 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 µg 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 are to 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. See Appendix 4 for guidance on primary authentic calibration lists.

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 is to be defined based on practical considerations.

3.11.8.1 For TVOC, the lower QL is 10 µg 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 µg m^{-3}, or better.

3.11.8.3 The lower QL for non- listed VOCs is 2 µg 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) (µg/m^3) to emission factor (EF) (µg/m^2·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 (µg/m^2·hr) or (µg/unit·hr)

C = chamber concentration (µg/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 considered 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- or two-week time period to determine the change in air concentrations that would consequently occur.

3.12.3.2 For Third Party Annual Certification tests, the 168 or 336 hour time point is used to determine compliance. The constant emission factor (as determined at 168 or 336

hours) is used to determine compliance with the Third Party Certification Criteria by calculating an exposure concentration (Section 3.12.3.3). The building parameters including ventilation rate and material loading for major product types used in the calculations are detailed in Table 6.2. Surface areas for other specialized product types shall be documented in test reports. If specialized environments are designed to model unique product types or exposure scenarios, they must be approved by a third party certifier and a brief description of that environment shall be included in test reports.

3.12.3.3 For products with constant emission factors, the predicted exposure concentrations ($C_{P,t}$) (µg/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 (µg/m³)
EF_t = measured 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})

3.12.3.4 For data requiring modeling for longer term exposure predictions, various models are available. For products with decreasing emission sources, the emission factor is to 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.

3.12.3.5 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})

3.12.3.6 The default models for offices and classrooms are detailed below.

3.12.3.7.1 Office Modeling: 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 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 similar to the State of CA CDPH/EHLB/Standard Method V1.1 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1" dated February 2010. The specific office model used is determined by the standard or specification being tested for.

3.12.3.7.1.1 Furniture (Seating, Workstations and Casegood Systems) - For all seating and open plan workstation units, the single occupancy exposure models as presented in ANSI/BIFMA M7.1-2007 are used, with clean air ventilation rates of 24.8 m^3/hr and 15.0 m^3/hr, respectively for seating and open plan systems. The ANSI/BIFMA M7.1 Method defines the application of a ventilation rate of 15.0 m^3/hr (an ACH of 0.92 hr^{-1}) for one open plan workstation in 16.3 m³ volume of space. For casegood systems and individual furniture items, a single occupancy "furniture" private office model (46 m^3 and 0.59 ACH) with a clean air ventilation rate of 27.1 m^3/hr is used. This single occupancy model is more conservative than the private office model in ANSI/BIFMA M7.1-2007 which has a clean air ventilation rate of 34.7 m^3/hr and thus, products meeting the Table 4 Certification Emission Criteria using this exposure model will automatically meet the ANSI/BIFMA X7.1-2007 requirements.

3.12.3.7.2 Classroom modeling uses the requirements and parameters in CDPH/EHLB/Standard Method V1.1 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1. 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 0.82 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 harmonize with the State of CA CDPH/EHLB/Standard Method V1.1 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1, an ACH of 0.82 ACH is applied. The classroom ventilation rates and product areas are identical to those required by CHPS IEQ Credit 2.2 and specified by the State of CA CDPH/EHLB/Standard Method V1.1 "Standard Method for the Testing and

Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1.

3.12.3.7.3 Alternative models, as dictated by a standard or specification are allowed, provided the modeling parameters are defined, reported and readily available.

3.12.4 *Conversion to ppm*

3.12.4.1 For formaldehyde, the conversion from µg/m^3 to ppm is obtained by use of the partial molar volume of formaldehyde via the following formula:

ppm = [(µg/m^3) x (24.45 m^3/mol)] / [(gram molecular weight of formaldehyde) x (1000)]

3.12.4.2 For total aldehydes, The conversion from µg/m^3 to ppm is obtained by summation of the partial molar volumes of all aldehydes via the following formula:

ppm = Σ[(µg/m^3) x (24.45 m^3/mol)] / [(gram molecular weight of aldehyde X) x (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 23ºC (73ºF); 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

Note: There are numerous Third Party Certifications available that define applicable chemical criteria. Examples presented here are not exhaustive.

4.0 GREENGUARD Indoor Air Quality Product Certification

Allowable Limits for GREENGUARD Indoor Air Quality 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/m³	≤ 0.0033 mg/m³
Styrene	≤ 0.07 mg/m³	≤ 0.035 mg/m³
Total VOCs[2]	≤ 0.5 mg/m³	≤ 0.25 mg/m³
Total Aldehydes[3]	≤ 0.1 ppm	≤ 0.05 ppm
Respirable Particles[4]	≤ 0.05 mg/m³	≤ 0.05 mg/m³
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) are to be provided.		
Any pollutant regulated as a primary or secondary outdoor air pollutant is to 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 with an American Conference of Government Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) shall produce an air concentration level no greater than 1/10 the TLV (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 $C_6 – C_{16}$ 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 and CDPH/EHLB/Standard Method V1.1.

Allowable Limits for GREENGUARD Children & Schools Certification: Requirements to be met no sooner than 168 hours (7 days) and no greater than 336 hours (14 days) with no preconditioning of the product. Compliance may be achieved at time points prior to 336 hours, so long as it is demonstrated that emissions have already peaked.

4.1.1 Required for GREENGUARD Children & Schools and "CDPH/EHLB/Standard Method V1.1 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1" dated February 2010 and CHPS Programs

Individual VOCs[1]	≤ ½ CA chronic REL
Formaldehyde[2]	≤ 0.0135 ppm/13.5 ppb

4.1.2 Required for GREENGUARD Children & Schools ONLY

Individual VOCs[3]	≤ 1/100 TLV
Total VOCs[4]	≤ 0.22 mg/m^3
Total Aldehydes[5]	≤ 0.043 ppm/43 ppb
Total Phthalates[6]	≤ 0.01 mg/m^3
Total Particles (≤ 10 µm)[7]	≤ 0.02 mg/m^3
1-Methyl-2-pyrrolidinine[8]	≦ 0.16 mg/m^3

[1] Any VOC with a Chronic Reference Exposure Limit (CREL) shall produce an air concentration no greater than ½ the CREL as required per the State of CA DPH's CDPH/EHLB/Standard Method V1.1 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1" dated February 2010,Table 4-1.

[2]Per the State of CA DPH's CDPH/EHLB/Standard Method V1.1 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1" dated February 2010 until December 31, 2011. Starting January 1st 2012, the formaldehyde limit may change to the full CREL level of 9 µg/m3 (7.3 ppb) if the program standard recognizes this value.

[3] Any VOC with an ACGIH TLV shall produce an air concentration level no greater than 1/100 the TLV (Reference: American Conference of Government Industrial Hygienists, 6500 Glenway, Building D-7, Cincinnati, Ohio 45211-4438.)

[4] Defined to be the total response of measured VOCs falling within the C_6 – C_{16} range, with responses calibrated to a toluene surrogate.

[5] 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..

[6] 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).

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

[8.] Based on the CA Prop 65 Maximum Allowable Dose Level for inhalation of 3,200 µg/day and an inhalation rate of 20 m^3/day.

4.2 Individual VOC ACGIH TLV and CA CREL Criteria Limits

CHEMICALS WITH TLV and CREL CRITERIA LIMITS			
CHEMICAL	**CAS NUMBER**	**1/100 TLV[a] (µg/m³)**	**1/2 Chronic[b] REL (µg/m³)**
1,1-Dichloroethylene (Vinylidene chloride)	75-35-4	200	35
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*	70
Benzene	71-43-2	16	30
Carbon disulfide	75-15-0	310	400
Chlorobenzene (Monochlorobenzene)	108-90-7	460	500
Dichloromethane (Methylene chloride)	75-09-2	1740	200
Diethylene dioxide (1,4-Dioxane)	123-91-1	720	1500
Dimethylformamide	68-12-2	300	40
Ethylbenzene	100-41-4	4340	1000
Ethylene glycol	107-21-1	1000*	200
Formaldehyde	50-00-0	3.7*	9**
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
2-Methoxyethanol	109-86-4	160	30
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
Naphthalene	91-20-3	520	4.5
p-Dichlorobenzene (1,4-Dichlorobenzene)	106-46-7	600	400
Phenol	108-95-2	190	100
Propylene glycol-1-methyl ether (1-Methoxy-2-propanol)	107-98-2	3690	3500
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
Vinyl acetate (Acetic acid ethenyl ester)	108-05-4	350	100
Xylenes (m-, o-, and p- combined)	108/38-3/95-47-6/106-42-3	4340	350

CHEMICALS WITH TLV CRITERIA LIMITS Only		
CHEMICAL	**CAS NUMBER**	**1/100 TLV[a] (µg/m³)**
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 (Ethanolamine)	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
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
Acetylsalicyclic 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
Acrylonitrile (Vinyl cyanide)	107-13-1	43
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

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)
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
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
Cresol, All isomers	1319-77-3	220
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

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)
Dichloroethyl ether (bis[2 Chloroethyl] ether)	111-44-4	290
Dichlorofluoromethane (FC-21)	75-43-4	420
Dicyclopentadiene	77-73-6	270
Diethanolamine	111-42-2	20
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
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	0.001
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

Glutaraldehyde	111-30-8	2*
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
Hexafluroacetone	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
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
Maleic anhydride	108-31-6	4
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

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)
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
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

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)
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
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
Phthalic anhydride (1,3-Isobenzofurandione)	85-44-9	61
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
Trichloronitromethane (Chloropicrin)	76-06-2	6.7
Triethanolamine	102-71-6	50
Triethylamine (N,N-Diethylethanamine)	121-44-8	41
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

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)
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
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-Butylene oxide (1,2-Epoxybutane)	106-88-7	59[†]
1,2-Diaminoethane (Ethylenediamine)	107-15-3	250
1,2-Dichloroethane (Ethylene dichloride)	107-06-2	400
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

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)
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
Butylated hydroxytoluene (BHT; 2,6-Di-tert-butyl-p-cresol)	128-37-0	20
4,4'-Diaminodiphenylmethane (4,4'-Methylenedianilline)	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, 2011 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), December 2008 and recognized as VOCs by the *State of CA DPH's CDPH/EHLB/Standard Method V1.1 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1" dated February 2010.*

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

† - AIHA 2010 Workplace Environmental Exposure Level (WEEL)

** - Full REL value allowed per CA CDPH.

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 Third Party 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/id/taclist.htm;

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 shall 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 Chamber conditions for test period

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	ºC	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 6.2 Parameters to be used for calculation of VOC concentrations in offices and classrooms

Parameter	Unit of Measure	Office Model*	Classroom Model
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	0.82
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
Millwork (Doors)	m^2 / Unit	1.89 / 1	1.89 / 1
Wallbase (10 in) Schools (4 in) Office	m^2	2.7	9.68
Window Treatments	m^2	4.1	4.46
HVAC Duct Material	m^2	5.5	39.1
Tackboards/Markerboards	m^2	3.0	9.9
Shelving/Bookcases/Counter Tops	m^2	20	7.81
Desk (Worksurface) Surface Area	m^2	3.2	12.3
Office Furniture Workstation or System Unit	Unit	1	NA
Casegood, freestanding large product	Unit	1	NA
Office Seating	Unit	1	NA
Teacher's Desk / Chair	Unit	NA	1
Desk/Seating (children's)	Units	NA	27

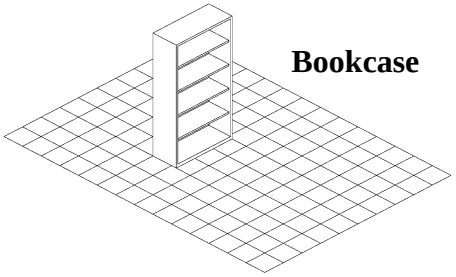
NA = Not Applicable

* Note: Where the private office requirements for non-furniture office products outlined above are found to be less stringent than the private office modeling parameters outlined in CDPH/EHLB/Standard Method V1.1 “Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.1” and compliance with the CDPH standard using the office scenario is required, the private office scenario in Table 4.4 of CDPH/EHLB/Standard Method V1.1 is used.

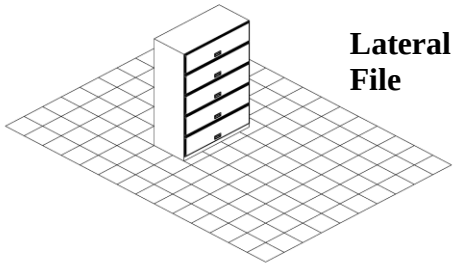
Appendix 1

OFFICE FURNITURE
TEST
REQUIREMENT SPECIFICATIONS

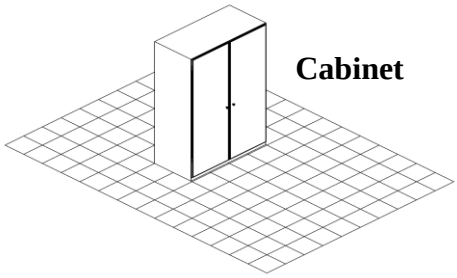
INDIVIDUAL CASEGOODS



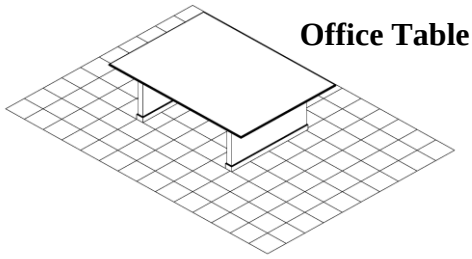
Bookcase



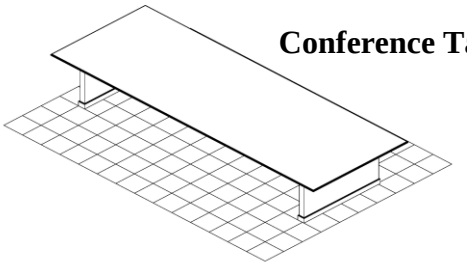
Lateral File



Cabinet



Office Table



Conference Table

MINIMUM COMPONENT REQUIREMENTS

Required Component	Nominal Dimensions
5 High Bookcase	76" high x 36" wide x 15" deep
5 Drawer Lateral File	66" high x 42" wide x 20" deep
Double Door Cabinet with Shelves	80" high x 48" wide x 24" deep
Office Table	Surface Area = 3.2 m^2
Conference Table	Surface Area = 6.4 m^2

Required Areas (± 10% or less)		
Total Bookcase Front Area =	**1.8 m^2**	**19 ft^2**
Total Lateral File Storage Front Area =	**1.8 m^2**	**19 ft^2**
Total Cabinet Storage Front Area =	**2.5 m^2**	**27 ft^2**
Total Office Table Worksurface Area =	**3.2 m^2**	**34 ft^2**
Total Conference Table Worksurface Area =	**6.4 m^2**	**69 ft^2**

Appendix 2
Informative

Appendix 2 - Informative

The information contained in this Appendix is intended to assist in the interpretation and application of the normative requirements in the body of the test method. The structure of this Appendix is similar to that of the body of the test methods. For instance, paragraph A2-1.1 in this appendix would correspond to paragraph 1.1 in the body.

BACKGROUND INFORMATION

A2-1.0. Scope

A2-1.0.10 Products taken from inventory or from within buildings can also be tested using this methodology, but are not considered representative of newly manufactured products.

COLLECTION, PACKAGING, SHIPMENT, & DOCUMENTATION OF PRODUCT SAMPLES

A2-2.1 Personnel

A2-2.1.1 Improper sample collection may impact the integrity of the sample and invalidate analysis, data and use of data.

A2-2.1 Sample Preservation

A2-2.3.2 Latex gloves minimize the risk of sample contamination by perfumes, soaps, or other contaminants on the hands of sample collection personnel.

A2-2.7 Sample Collection Procedures

A2-2.7.4 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 Certification.

LABORATORY SAMPLE PREPARATION AND ANALYSES

A2-3.1 Furniture Testing

A2-3.1.1.1 Furniture construction materials are often tested for comparative purposes, according to a shorter time period (e.g. 24-hour) evaluation protocol.

A2-3.1.1.2 Furniture components may either be tested as part of a larger scale comparative study (24 hr single point test), or for full characterization (168 hour or longer emissions profile studies).

A2-3.1.1.3 Complete, finished furniture products are typically tested for full 168 hour or longer evaluation periods, directly out of the original packaging.

A2-3.10 Environmental Chamber Performance Requirements

A2-3.10.3 *Duration:* The chamber test duration may be extended beyond 336 hours to capture ongoing emissions patterns, emitting VOCs, and their levels. Alternatively, chamber tests of shorter duration, such as 24 hours, may be used for profile or audit testing or other standard requirements.

A2-3.10.11 Air Sampling

A2-3.10.11.1 Alternate air sampling and analysis times are allowed, as dictated by a test program or specification requirements. Air collection with shorter or extended sampling periods may be warranted for profile or audit testing or specialized program/data requirements.

A2-3.10.12 Sampling Media

A2-3.10.12.1 Breakthrough minimization may 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.

Appendix 3
Informative

FURNITURE PRIVATE OFFICE

An updated private office more reflective of building stock is used for executive casegood office furniture and free standing furniture only. This “Furniture” Private Office has dimensions of 4.57 m x 3.66 m x 2.74 m (15’ x 12’ x 9’), which results in a room volume of 45.9 m^3 (1,620 ft^3). The room has one 0.914 m x 2.13 m (3’ x 7’) door and two 1.22 m x 2.13 m (4’ x 7’) windows. The office is designed for single occupancy. The ventilation rate is 0.59 ACH.

Room Length	4.57 m (15 ft)
Room Width	3.66 m (12 ft)
Room Height	2.74 m (9 ft)
Room Volume	45.9 m^3 (1,620 ft^3)
Ventilation Rate	0.59 hr^{-1}

The size of the “Furniture” Private Office is based on data from the following sources: US General Services Administration (GSA) Office Space Use Review (1997); GSA Space Usage Update (2002); Efficiency Standards for Office Space - Office of Government Commerce, UK (2007); Canada Northwest Territories Office Space Standards and Guidelines (2003); National Institute of Building Sciences (NIBS) Whole Building Design Guide (2009); Transportation Security Administration (TSA) Management Directive No. 200.12 (2005); Government of Manitoba Office Space Planning Guidelines (2009); Commonwealth of Virginia Space Planning Policy and Procedures (2006); State of Wisconsin Space Location, Allocation, Layout and Measurement Standard Policies (2006); U.S. Courts Design Guide (2007); and Federal Deposit Insurance Corporation (FDIC) Field Office Cost, Space Utilization, Design, and Usage (2001). The ventilation rate of 0.59 ACH is based on ASHRAE Standard 62.1-2007 “Ventilation for Acceptable Indoor Air Quality” using the specified parameters of 5 cfm per person and 0.06 cfm/ft^2 for office spaces in office buildings.

Appendix 3 - Attachment 1

Summary of Research

Office	No.	Area (ft)	Ht (ft)	Vol (ft^3)	Vol (m^3)	Reference
Staff-One Person Office		70	9	630	18	GSA Office Space Use Review (1997)
Telecom Company 2 - Support Staff		75	9	675	19	GSA Space Usage Update (2002)
C-Level Employee		75	9	675	19	GSA Office Space Use Review (1997)
Example Building - Enclosed Office III		81	9	726	21	Efficiency Standards for Office Space - Office of Government Commerce, UK (2007)
Telecom Company 1 - Director Low		90	9	810	23	GSA Space Usage Update (2002)
Supervisor		95	9	855	24	GSA Office Space Use Review (1997)
Professional		96	9	864	24	GSA Office Space Use Review (1997)
Professional/Administrative		100	9	900	25	GSA Office Space Use Review (1997)
Supervisor		100	9	900	25	GSA Office Space Use Review (1997)
Enclosed Type C		100	9	900	25	Canada Northwest Territories Office Space Standards and Guidelines (2003)
Professional		108	9	972	28	GSA Office Space Use Review (1997)
Supervisor		115	9	1035	29	GSA Office Space Use Review (1997)
Enclosed Small Offices (26)	26	120	9	1080	31	NIBS Whole Building Design Guide (2009)
Primary Office Space Standard for Staff		120	9	1080	31	GSA Office Space Use Review (1997)
Pay Grades 15 and up		120	9	1080	31	GSA Office Space Use Review (1997)
Supervisor		120	9	1080	31	GSA Office Space Use Review (1997)
Supervisor		120	9	1080	31	GSA Office Space Use Review (1997)
Technical/Professional		120	9	1080	31	GSA Office Space Use Review (1997)
Management		120	9	1080	31	GSA Office Space Use Review (1997)
Human Relations		120	9	1080	31	GSA Office Space Use Review (1997)
All Pay Band Ks, Administrative Officer, Human Resources Specialist, Legal Counsel, Special Agent		120	9	1080	31	TSA Management Directive No. 200.12 (2005)
Private Office (PO) 1 (10 ft x 12 ft)		120	9	1080	31	Government of Manitoba Office Space Planning Guidelines (2009)

Asst. Director and Confidential Staff		120	9	1080	31	Commonwealth of Virginia Space Planning Policy and Procedures (2006)
Professional General Requiring Immediate Confidentiality		120	9	1080	31	State of Wisconsin Space Location, Allocation, Layout and Measurement Standard Policies (2006)
Software Engineering Firm - Managerial, Supervisory, Technical		120	9	1597	45	GSA Space Usage Update (2002)
Software Engineering Firm - Director		130	9	1593	45	GSA Space Usage Update (2002)
Consulting Company - Support Staff		132	9	1188	34	GSA Space Usage Update (2002)
Example Building - Enclosed Office II		133	9	1199	34	Efficiency Standards for Office Space - Office of Government Commerce, UK (2007)
Hypothetical Office Layout 3		139	9	1249	35	Efficiency Standards for Office Space - Office of Government Commerce, UK (2007)
Senior Manager		140	9	1260	36	GSA Office Space Use Review (1997)
Manager		140	9	1260	36	GSA Office Space Use Review (1997)
Manager		140	9	1260	36	GSA Office Space Use Review (1997)
Direct Report to VP or Higher		140	9	1260	36	GSA Office Space Use Review (1997)
DC World Bank Building - Office 1		140	9	1260	36	Field Surveys
Software Engineering Firm - Executive		140	9	1679	48	GSA Space Usage Update (2002)
Staff-One Person Office		143	9	1287	36	GSA Office Space Use Review (1997)
Standard 1 (Walls to Ceiling Offices)		144	9	1296	37	GSA Office Space Use Review (1997)
LEED CI-Gold Executive Office		144	9	1296	37	Field Surveys
PO 2 (12 ft x 12 ft)		144	9	1296	37	Government of Manitoba Office Space Planning Guidelines (2009)
Managers & Supervising Professionals		144	9	1296	37	State of Wisconsin Space Location, Allocation, Layout and Measurement Standard Policies (2006)
LEED CI-Gold Human Resources Office		149	9	1341	38	Field Surveys
Telecom Company 1 - Executive Low		150	9	1350	38	GSA Space Usage Update (2002)
Telecom Company 1 - Director High		150	9	1350	38	GSA Space Usage Update (2002)
Telecom Company 2 - Managerial, Supervisory, Technical		150	9	1350	38	GSA Space Usage Update (2002)
Enclosed Large Offices (52)	52	150	9	1350	38	NIBS Whole Building Design Guide (2009)
Clerk of Court Visiting Office		150	9	1350	38	U.S. Courts Design Guide (2007)
Professional Administrative and Line Positions		150	9	1350	38	U.S. Courts Design Guide (2007)

Attorney		150	9	1350	38	U.S. Courts Design Guide (2007)
Clerk of Visiting Court Office		150	9	1350	38	U.S. Courts Design Guide (2007)
Professional Administration and Line Positions		150	9	1350	38	U.S. Courts Design Guide (2007)
Courtroom Deputy		150	9	1350	38	U.S. Courts Design Guide (2007)
Pro se Law Clerk		150	9	1350	38	U.S. Courts Design Guide (2007)
Professional Administrative and Professional Line Positions		150	9	1350	38	U.S. Courts Design Guide (2007)
PSA and PO Officers		150	9	1350	38	U.S. Courts Design Guide (2007)
Professional Staff		150	9	1350	38	U.S. Courts Design Guide (2007)
Attorney		150	9	1350	38	U.S. Courts Design Guide (2007)
Staff Attorneys		150	9	1350	38	U.S. Courts Design Guide (2007)
Office 3 (Smallest - Cubicles below this office size)		150	9	1350	38	GSA Office Space Use Review (1997)
Manager		150	9	1350	38	GSA Office Space Use Review (1997)
Standard 2		150	9	1350	38	GSA Office Space Use Review (1997)
Senior Manager		150	9	1350	38	GSA Office Space Use Review (1997)
Deputy FSD, Assistant FSD, Senior Lead Counsel		150	9	1350	38	TSA Management Directive No. 200.12 (2005)
Office Example 2		150	9	1350	38	FDIC Field Office Cost, Space Utilization, Design, and Usage (2001)
D or C-Level Employee		150	9	1350	38	GSA Office Space Use Review (1997)
Agency or Department Director		150	9	1350	38	Commonwealth of Virginia Space Planning Policy and Procedures (2006)
Enclosed Type B		150	9	1350	38	Canada Northwest Territories Office Space Standards and Guidelines (2003)
Section Manager		150	9	1350	38	GSA Office Space Use Review (1997)
Managers		156	9	1404	40	GSA Office Space Use Review (1997)
Direct Report to VP or Higher		160	9	1440	41	GSA Office Space Use Review (1997)
Managers		160	9	1440	41	State of Wisconsin Space Location, Allocation, Layout and Measurement Standard Policies (2006)
Assistant Commissioner		168	9	1512	43	GSA Office Space Use Review (1997)
Executive Secretary/Reception Area		170	9	1530	43	U.S. Courts Design Guide (2007)
LEED CI-Gold Managers Office		173	9	1557	44	Field Surveys

Consulting Company - Managerial, Supervisory, Technical		175	9	1575	45	GSA Space Usage Update (2002)
Telecom Company 2 - Director		175	9	1575	45	GSA Space Usage Update (2002)
Chief Deputy Clerk		180	9	1620	46	U.S. Courts Design Guide (2007)
Manager		180	9	1620	46	U.S. Courts Design Guide (2007)
Chief Deputy Clerk		180	9	1620	46	U.S. Courts Design Guide (2007)
Deputy Clerk in Charge		180	9	1620	46	U.S. Courts Design Guide (2007)
First-Line Supervisors		180	9	1620	46	U.S. Courts Design Guide (2007)
Manager		180	9	1620	46	U.S. Courts Design Guide (2007)
Deputy Chief Probation Officer		180	9	1620	46	U.S. Courts Design Guide (2007)
Manager		180	9	1620	46	U.S. Courts Design Guide (2007)
Professional First-Line Supervisor		180	9	1620	46	U.S. Courts Design Guide (2007)
Deputy		180	9	1620	46	U.S. Courts Design Guide (2007)
Assistant Circuit Executive		180	9	1620	46	U.S. Courts Design Guide (2007)
Senior Supervising Staff Attorney		180	9	1620	46	U.S. Courts Design Guide (2007)
Other Supervising Staff Attorney		180	9	1620	46	U.S. Courts Design Guide (2007)
Conference Pre-Argument Attorney		180	9	1620	46	U.S. Courts Design Guide (2007)
Vice President		180	9	1620	46	GSA Office Space Use Review (1997)
Manager		180	9	1620	46	GSA Office Space Use Review (1997)
LEED-NC Silver Government Building		180	9	1620	46	Field Surveys
Example Building - Enclosed Office I		186	9	1670	47	Efficiency Standards for Office Space - Office of Government Commerce, UK (2007)
Level 2 Dir, Program Manager, Production Manager		190	9	1710	48	GSA Office Space Use Review (1997)
Senior Management/Directors		190	9	1710	48	GSA Office Space Use Review (1997)
PO 3 (12 ft x 16 ft)		192	9	1728	49	Government of Manitoba Office Space Planning Guidelines (2009)
Administrator		192	9	1728	49	State of Wisconsin Space Location, Allocation, Layout and Measurement Standard Policies (2006)
Agency or Department Director		196	9	1764	50	Commonwealth of Virginia Space Planning Policy and Procedures (2006)
Hypothetical Office Layout 2		197	9	1772	50	Efficiency Standards for Office Space - Office of Government Commerce, UK (2007)

Field Security Director (FSD)		200	9	1800	51	TSA Management Directive No. 200.12 (2005)
LEED CI-Gold Executive Office		202	9	1818	51	Field Surveys
LEED CI-Gold Executive Office		205	9	1845	52	Field Surveys
Executive Office		206	9	1854	52	GSA Office Space Use Review (1997)
LEED CI-Gold Executive Office		208	9	1872	53	Field Surveys
Executive		216	9	1944	55	State of Wisconsin Space Location, Allocation, Layout and Measurement Standard Policies (2006)
Agency Division Directors		216	9	1944	55	GSA Office Space Use Review (1997)
Bureau Chief		220	9	1980	56	GSA Office Space Use Review (1997)
Deputy Commissioner		224	9	2016	57	GSA Office Space Use Review (1997)
Consulting Company - Director		225	9	2025	57	GSA Space Usage Update (2002)
Telecom Company 2 - Executive		225	9	2025	57	GSA Space Usage Update (2002)
Enclosed Executive Offices (2)	2	225	9	2025	57	NIBS Whole Building Design Guide (2009)
Office 2 (Moderate)		225	9	2025	57	GSA Office Space Use Review (1997)
Subsidiary VP, Division VP, Program VP, Level 1 Dir, GM		225	9	2025	57	GSA Office Space Use Review (1997)
Department Head		225	9	2025	57	GSA Office Space Use Review (1997)
Office Example 1		225	9	2025	57	FDIC Field Office Cost, Space Utilization, Design, and Usage (2001)
E or D-Level Employee		225	9	2025	57	GSA Office Space Use Review (1997)
Vice President		230	9	2070	59	GSA Office Space Use Review (1997)
Clerk Office		240	9	2160	61	U.S. Courts Design Guide (2007)
Clerk		240	9	2160	61	U.S. Courts Design Guide (2007)
Chief Probation Officer		240	9	2160	61	U.S. Courts Design Guide (2007)
Circuit Executive/District Court Executive		240	9	2160	61	U.S. Courts Design Guide (2007)
Clerk		240	9	2160	61	U.S. Courts Design Guide (2007)
Senior Staff Attorney		240	9	2160	61	U.S. Courts Design Guide (2007)
Senior Pre-Argument Conference Attorney		240	9	2160	61	U.S. Courts Design Guide (2007)
Enclosed Type A		240	9	2160	61	Canada Northwest Territories Office Space Standards and Guidelines (2003)
Vice President		250	9	2250	64	GSA Office Space Use Review (1997)

Hypothetical Office Layout 1		255	9	2295	65	Efficiency Standards for Office Space - Office of Government Commerce, UK (2007)
Subsidiary VP, Division VP, Program VP, Level 1 Dir, GM		256	9	2304	65	GSA Office Space Use Review (1997)
Primary Office Space Standard for Department/Agency Head		256	9	2304	65	GSA Office Space Use Review (1997)
Division Director		270	9	2430	69	GSA Office Space Use Review (1997)
Department Head		270	9	2430	69	GSA Office Space Use Review (1997)
Vice President		270	9	2430	69	GSA Office Space Use Review (1997)
Director		280	9	2520	71	GSA Office Space Use Review (1997)
Executive Management		290	9	2610	74	GSA Office Space Use Review (1997)
Telecom Company 1 - Executive High		300	9	2700	76	GSA Space Usage Update (2002)
Office 1 (Largest)		300	9	2700	76	GSA Office Space Use Review (1997)
Standard 1		300	9	2700	76	GSA Office Space Use Review (1997)
Div. President, Corporate VP, Senior VP, Group VP		300	9	2700	76	GSA Office Space Use Review (1997)
Executives in a Private Office		300	9	2700	76	GSA Office Space Use Review (1997)
DC World Bank Building - Office 2		300	9	2700	76	Field Surveys
E-Level Employee		300	9	2700	76	GSA Office Space Use Review (1997)
Div. President, Corporate VP, Senior VP, Group VP		320	9	2880	82	GSA Office Space Use Review (1997)
Agency Head		320	9	2880	82	GSA Office Space Use Review (1997)
Commissioner		320	9	2880	82	GSA Office Space Use Review (1997)
Consulting Company - Executive		325	9	2925	83	GSA Space Usage Update (2002)
Executive		350	9	3150	89	GSA Office Space Use Review (1997)
Agency Head		360	9	3240	92	GSA Office Space Use Review (1997)
Executive		370	9	3330	94	GSA Office Space Use Review (1997)
State Commissioners		400	9	3600	102	GSA Office Space Use Review (1997)
Agency Head		400	9	3600	102	GSA Office Space Use Review (1997)
Executive Office		411	9	3699	105	GSA Office Space Use Review (1997)
Statistical Measure	N	Area	Ceiling	Volume	Volume	

		(ft^2)	Ht (ft)	(ft^3)	(m^3)	
Average of All Data Inputs	151	189	9	1706	48	
Median of All Data Inputs	151	180	9	1620	46	
Air Change Rate Calculation:						
Floor Area (ft^2)	180					
Suggested Dimension (L[ft] x W[ft])	**15 x 12**					
Suggested Ceiling Height (ft)	**9**					
Volume (ft^3)	1620					
Volume (m^3)	46					
ASHRAE Standard 62.1-2007 Input for Floor Area (cfm/ft2)	0.06					
ASHRAE Standard 62.1-2007 Input for Person (cfm/person)	5					
Person(s) per Office	1					
Total cfm	15.8					
Total cfh	948					
Total ACH	**0.59**					

Appendix 4
Informative

FURNITURE AUTHENTIC CALIBRATION LISTS

Based on a review of primary chemicals emitting from office furniture as well as those chemicals which fall on key criteria target lists as required by GEI and CA 01350, GEI has developed guidance on specific chemical calibration requirements. These target lists are based upon reviewing emissions data for 373 different office furniture products including workstations, case goods and seating. Measured emissions data obtained over a three year period (2007-2010) were reviewed for the presence of chemicals of concern including those required by the GREENGUARD programs and those in the California Specification 01350 emissions testing protocol (v1.1). These included any VOCs found on the following lists and are considered chemicals of concern:

- CA/EPA OEHHA Chronic Reference Exposure Levels (CRELs);
- CA/EPA carcinogens and reproductive toxins (Proposition 65); and
- CA/EPA Toxic Air Contaminants (TACs) as required by the CA 1350 specification; and
- ACGIH Threshold Limit Values (TLVs) as required by the GEI.

Additional chemicals were reviewed for their presence including the top ten most frequently emitting VOCs and odorants. The following lists of VOCs provide guidance in expectation of specific VOC presence for analysis and calibrations purposes.

Table A lists those VOCs that have been measured and found to be the top 10 of highest frequency among all products; observed CRELs; and those Proposition 65, TAC, TLV and odorant chemicals that have been observed in greater than 10% of all measured products. Table B lists those VOCs that are CRELs but have not been found in measurable levels; those Proposition 65, TAC, TLV and odorant chemicals that are present in less than 10% of all measured products; and other non listed VOCs that have been observed with a frequency between 15 and 20 percent.

Table A should be considered a primary list for authentic calibration and Table B includes those VOCs that have a lower likelihood of presence in the emissions. However, any VOCs of concern present in the emissions, as found in the CA 1350 specification (v1.1), should be calibrated with authentic standards.

TABLE A

VOCs FROM OFFICE FURNITURE INCLUDING ALL MEASURED CRELs; THE TOP TEN HIGHEST EMITTING VOCs; AND ODORANTS, CARCINOGENS (AS LISTED IN CA PROPOSITION 65), TOXIC VOCs (AS LISTED BY CA AIR TOXICS) AND ACGIH TLVs IF MEASURED IN GREATER THAN 10% OF ALL PRODUCTS

Chemicals	CAS#	CREL	CA Prop 65	CA Toxics	ACGIH TLV	Odorants	Top 10†
Ethylbenzene	100-41-4	X	X	X	X		
Styrene	100-42-5	X		X	X		
Acetic acid, 2-ethylhexyl ester	103-09-3					X	
1-Hexanol, 2-ethyl	104-76-7					X	35.4
ε-Caprolactam (2H-Azepin-2-one, hexahydro)	105-60-2			X	X		
p-Xylene	106-42-3	X					
Benzene, 1,4-dichloro	106-46-7		X	X	X		
Ethylene Glycol	107-21-1	X		X	X		
1-Methoxy-2-propanol	107-98-2	X			X		
Vinyl Acetate	108-05-4	X		X	X		
m-Xylene	108-38-8	X					
Toluene (Methylbenzene)	108-88-3	X	X	X	X		
Benzene, chloro	108-90-7	X		X	X		
Cyclohexanone	108-94-1				X	X	
Phenol	108-95-2	X		X	X	X	
2-Heptanone	110-43-0				X	X	
n-Hexane	110-54-3	X		X	X		
2-Ethoxyethanol	110-80-5	X	X	X	X		
Ethanol, 2-ethoxy-, acetate (2-Ethoxyethyl acetate)	111-15-9	X	X	X	X		
Ethanol, 2-butoxy	111-76-2			X	X		39.9
Undecane	1120-21-4					X	29.8
Decanal	112-31-2					X	
Ethanol, 2-(2-butoxyethoxy)	112-34-5					X	
Dodecane	112-40-3					X	37.5
2-Pentanone, 4-hydroxy-4-methyl-	123-42-2				X	X	
Acetate, butyl	123-86-4				X	X	28.7
1,4-Dioxane	123-91-1	X	X	X	X		
Nonyl aldehyde (Nonanal)	124-19-6					X	
Tetrachloroethylene	127-18-4	X	X	X	X		
Pinene, β(6,6-Dimethyl-2-methylene-bicyclo[3.1.1]heptane)	127-91-3				X	X	
2,6-Di-tert-butyl-4-	128-37-0				X		

Chemicals	CAS#	CREL	CA Prop 65	CA Toxics	ACGIH TLV	Odorants	Top 10†
methylphenol (BHT)							
Xylenes (m-, o- and/or p-)	1330-20-7	X		X	X		
Limonene (Dipentene; 1-Methyl-4-(1-methylethyl)cyclohexene)	138-86-3					X	33.0
Hexanoic acid	142-62-1					X	
Hexanoic acid, 2-ethyl	149-57-5		X		X		
2-Octenal, (E)	2548-87-0					X	
Trimethylbenzene (All Isomers)	25551-13-7				X		
Tetramethylbutanedinitrile	3333-52-6				X		
Dipropylene glycol monomethyl ether	34590-94-8				X		
Longifolene	475-20-7						26.5
4-Phenylcyclohexene	4994-16-5					X	
Formaldehyde	50-00-0	X			X		
Cyclopentasiloxane, decamethyl	541-02-6						32.2
Tridecane	629-50-5					X	
Isopropanol	67-63-0	X		X	X		
N,N-Dimethyl Formamide	68-12-2	X		X	X		
1-Butanol (N-Butyl alcohol)	71-36-3			X	X		27.6
1-Pentanol (N-Pentyl alcohol)	71-41-0					X	
Benzene	71-43-2	X	X	X	X		
Acetaldehyde	75-07-0	X			X		
1-Propanol, 2-methyl (Isobutyl alcohol)	78-83-1				X	X	
2-Butanone (Methyl ethyl ketone, MEK)	78-93-3			X	X	X	
Trichloroethylene	79-01-6	X	X	X	X		
Pinene, α (2,6,6-Trimethyl-bicyclo[3.1.1]hept-2-ene)	80-56-8				X		44.8
1-Methyl-2-Pyrrolidinone	872-50-4	X	X				
Naphthalene	91-20-3	X	X	X	X		
Benzothiazole	95-16-9					X	
o-Xylene	95-47-6	X					
Propane, 1,2,3-trichloro	96-18-4		X		X		
Benzene, 1-methyl-4-(1-methylethyl) (p-Cymene; 4-Isopropyltoluene)	99-87-6					X	

†Percentage of all products found to emit this VOC.

TABLE B

VOCs FROM OFFICE FURNITURE INCLUDING CRELs (NOT MEASURED); ODORANTS, CARCINOGENS (AS LISTED IN CA PROPOSITION 65), TOXIC VOCs (AS LISTED BY CA AIR TOXICS), AND ACGIH TLVs IF MEASURED BUT IN LESS THAN 10% OF ALL PRODUCTS

Chemicals	CAS#	CREL	CA Prop 65	CA Toxics	ACGIH TLV	Odorants	Primary†
Cyclohexene, 4-vinyl (4-Ethenylcyclohexene)	100-40-3		X		X		
2-Propenoic acid, 2-ethylhexyl ester (Octyl acrylate)	103-11-7					X	
Phenol, 4-methyl	106-44-5			X	X	X	
Oxirane, ethyl	106-88-7			X			
Epichlorohydrin	106-89-8	X	X	X	X		
Propane, 1-bromo-	106-94-5		X		X		
Ethane, 1,2-dichloro	107-06-2		X	X	X		
Hexasiloxane, tetradecamethyl	107-52-8						> 15%
2-Pentanone, 4-methyl (Methyl isobutyl ketone, MIBK)	108-10-1			X	X	X	
Phenol, 3-methyl	108-39-4			X	X	X	
1-Methoxy-2-propyl acetate	108-65-6						> 15%
2-Methoxyethanol	109-86-4	X					
Acetic acid, 2-methylpropyl ester (Isobutyl acetate)	110-19-0				X	X	
Ethylene monomethyl acetate	110-49-6	X					
Cyclohexane	110-82-7			X	X		
Ethane,1,1'oxybis[2-chloro- (s-Dichloroethyl ether)	111-44-4		X	X	X		
Heptanal (Heptaldehyde)	111-71-7					X	
Nonane	111-84-2				X	X	
1-Dodecanol	112-53-8					X	
Benzene, 1,2,4-trichloro-	120-82-1			X	X		
Triethylamine (N,N-	121-44-8			X	X		

Chemicals	CAS#	CREL	CA Prop 65	CA Toxics	ACGIH TLV	Odorants	Primary†
Diethylethanamine)							
Octanal	124-13-0					X	
1,3-Butadiene, 2-chloro	126-99-8		X	X	X		
2-Propanol, 1-(2-methoxypropoxy)-	13429-07-7						> 15%
Estragole (4-Allylanisole)	140-67-0		X				
Butyl acrylate (2-Propenoic Acid, butyl ester)	141-32-2			X	X		
Acetate, ethyl	141-78-6				X	X	
Heptane	142-82-5				X	X	
Phosphoric acid, trimethyl ester	512-56-1		X				
Benzene, 1,2,3,5-tetramethyl	527-53-7					X	
Pentane, 2,2,4-trimethyl (Isooctane)	540-84-1			X	X		
2-Propanol, 1-[1-methyl-2-(2-propenyloxy)ethoxy]	55956-25-7						> 15%
1,2-Propanediol (Propylene glycol)	57-55-6						> 15%
Toluene Diisocyanate	584-84-9			X	X		
2-Hexanone	591-78-6		X		X		
D-Limonene	5989-27-5					X	
Aniline	62-53-3		X	X	X		
Tetradecane	629-59-4						> 15%
Pentadecane	629-62-9						> 15%
Chloroform	67-66-3	X	X	X	X		
Ethane, hexachloro	67-72-1		X	X	X		
1,1,1-Trichloroethane	71-55-6	X					
Methylene Chloride	75-09-2	X					
Carbon Disulfide	75-15-0	X					
Propane, 2-bromo-	75-26-3		X				
2,2,4-Trimethyl-1,3-pentanediol monoisobutyrate	77-68-9						> 15%
2-Cyclohexen-1-one, 3,5,5-trimethyl-	78-59-1			X	X		
Propane, 1,2-dichloro	78-87-5		X	X	X		
2-Butanol (s-Butyl alcohol)	78-92-2			X	X		

Chemicals	CAS#	CREL	CA Prop 65	CA Toxics	ACGIH TLV	Odorants	Primary†
Propanoic acid	79-09-4				X	X	
2-Propenoic acid	79-10-7			X	X		
Propane, 2-nitro	79-46-9		X	X	X		
Methyl methacrylate (2-Propenoic acid, 2-methyl-, methyl ester)	80-62-6			X	X		
o-Hydroxybiphenyl ([1,1-Biphenyl]-2-ol)	90-43-7		X	X			
Benzene, 1,2-dimethoxy-4-(2-propenyl)	93-15-2		X				
Benzenamine, 2-methyl	95-53-4		X	X	X		
Benzene, 1,2,4,5-tetramethyl	95-93-2					X	
2-Propanol, 1,3-dichloro-	96-23-1						> 15%
Furfural (2-Furaldehyde)	98-01-1				X	X	
Benzene, 1-methylethyl (Cumene)	98-82-8			X	X		
Acetophenone (Ethanone, 1-phenyl)	98-86-2			X	X	X	

† Primary includes VOCs beyond Top 10 than are observed in > 15% of all products.