GREENGUARD Environmental Institute
2211 Newmarket Parkway, Suite 110
Marietta, Georgia 30067
1.800.427.9681
www.greenguard.org

STANDARD METHOD FOR MEASURING AND EVALUATING CHEMICAL EMISSIONS FROM CLEANERS AND CLEANING MAINTENANCE SYSTEMS USING DYNAMIC ENVIRONMENTAL CHAMBERS

Foreword

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

The following standard test method incorporates the best-learned practices for testing and evaluating cleaning products and cleaning systems generally used for routine cleaning including general purpose cleaners, glass cleaners, toilet cleaners, floor cleaners, hard surface cleaners, institutional cleaning systems, aerosol products and carpet cleaners. Elements of the method include sample handling and shipment, sample preparation, product loadings and descriptions, environmental chamber exposure, analytical measurements, exposure modeling and allowable levels for the GREENGUARD Certification Program. Analytes include total volatile organic compounds (TVOC), individual VOCs, formaldehyde and other aldehydes, and phthalates. All individual VOCs emitting from products are measured as allowed by the Method, and each measured VOC is required to meet defined allowable levels.

The GREENGUARD For Children & Schools Standard that became publicly available in 2005, incorporated additional criteria to provide a higher margin of safety for young children and sensitive populations. This standard reduces allowable chemical levels. It also requires that emissions meet the ½ CREL criteria of certain target chemicals as listed in State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174) and adopted by the California High Performance School (CHPS) Program. The GREENGUARD Standard for Cleaning Products and Systems is the first that requires a review of measured chemical emissions across a broader range of risk based exposure levels, further strengthening the criteria by requiring product emissions be less than defined risk-based air concentration levels for both acute (short-term) and chronic (long-term) exposures.

This standard test method, which incorporates the most current science of emissions testing, including global ISO requirements for environmental chamber and VOC testing, can be used for other emissions test programs requiring the measurement of chemical 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. This test method is applicable to the measurement and evaluation of the inhalation criteria of Green Seal standard GS-37.

This standard method is developed and maintained by the GREENGUARD Environmental Institute (GEI). The master document at GEI's headquarters in Atlanta Georgia is the official

document. This document is revised as new science, test protocols and allowable levels become available, and will be reviewed on an annual basis. Significant revisions will be reviewed through a consensus process of users and interested parties.

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

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

TABLE OF CONTENTS

SECTION 1
BACKGROUND INFORMATION

1.0 Scope

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

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

1.0.1 The methodology provides a standard means of reproducibly and accurately testing cleaning products and systems under a realistic, yet highly controlled, atmosphere.

1.0.2 The methodology with standardized measurement and analyses provides consistent testing of products.

1.0.3 This protocol applies to any cleaning product or system belonging to a product category generally used within an enclosed indoor environment. This includes, for example, general cleaners, glass cleaners, toilet cleaners, floor cleaners, hard surface cleaners, institutional cleaning systems, aerosol products and carpet cleaners used in public and commercial office buildings, schools, medical buildings, residences and other building types. The protocol applies to products that can be tested alone or as part of a system.

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

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

1.0.6 While this practice may list specific chemicals and associated maximum allowable concentrations, as required by criteria indoor air guidelines and specifications, it does not assess the human risk with use of the materials, which are promulgated OSHA requirements or equivalents, as an installer.

1.0.7 This practice does not purport to address safety concerns, if any, associated with the use of this practice. It is the responsibility of the user of this protocol to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.1 Objectives and Use

1.1.1 Objectives

1.1.1.1 Measure VOCs, including aldehydes, and other potential pollutants from cleaning products and systems.

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

1.1.1.3 Obtain emission data for use by the GREENGUARD Certification Program, California CHPS Program, State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174), GREENSEAL, Blue Angel and other government and private product specification programs.

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

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

1.1.1.6 Identify irritants, odorants, and hazardous VOCs emitting from cleaning products and systems and their emission parameters to assist in risk evaluations.

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

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

1.1.2 Use

1.1.2.1 Small (0.05 – 1 m^3) chamber evaluations are used to determine source emission rates and emissions factors from dilute cleaning products.

1.1.2.2 Intermediate (approximately 1 – 6 m^3 volume) chamber evaluations are used to determine source emission rates and emission factors from concentrated cleaning products.

1.1.2.3 Large (> 25 m^3) chambers are used for the evaluation of cleaning systems and aerosol cleaners.

1.1.2.4 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.

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

1.2 References and Documents

ACGIH, Guide to Occupational Exposure Values*. Cincinnati, OH, 2007.*

Agency for Toxic Substances and Disease Registry. ATSDR - Minimal Risk Levels for Hazardous Substances (MRLs). Atlanta: Agency for Toxic Substances and Disease Registry, 2007.

American Conference of Governmental Industrial Hygienists. "Guide to Occupational Exposure Values - 2007." Cincinnati, OH: ACGIH, 2007.

ASHRAE Standard 55-2004. Thermal Environmental Conditions for Human Occupancy. ASHRAE, Atlanta, GA, 2004.

ASHRAE Standard 62.1. Ventilation for Acceptable Indoor Air Quality, ASHRAE, Atlanta, GA, 2007.

ASTM D 5116. Standard Guide for Small Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials / Products. *American Society for Testing and Materials, West Conshohocken, PA, 2006.*

ASTM D 6670. Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials / Products. *American Society for Testing and Materials, West Conshohocken, PA, 2001.*

ASTM D 5197. Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology). *American Society for Testing and Materials, West Conshohocken, PA, 2003.*

ASTM D 6196. Practice for the Selection of Sorbents and Pumped Sampling / Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air. *American Society for Testing and Materials, West Conshohocken, PA, 2003.*

ASTM D 6345. Standard Guide for Selection of Methods for Active, Integrative Sampling of Volatile Organic Compounds in Air. *American Society for Testing and Materials, West Conshohocken, PA, 2001.*

ASTM E 741. Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution. *American Society for Testing and Materials, West Conshohocken, PA, 2001.*

Bertoni, G., F. Bruner, A. Liberti, and C. Perrino. Some Critical Parameters in Collection, Recovery, and Gas Chromatographic Analysis of Organic Pollutants in Ambient Air Using Light Adsorbents*. J. Chromatogr., v.203, pp.263-270, 1981.*

Bruner, F., G. Bertoni, and G. Crescentini, Critical Evaluation of Sampling and Gas Chromatographic Analysis of Halocarbons and Other Organic Air Pollutants*. J. Chromatogr. v.167, pp.399-407, 1978.*

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

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

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

Cal/DHS, Standard Practice for the Testing of Volatile Organic Emissions for Various Sources Using Small Scale Environmental Chambers, (CA/DHS/EHLB/R-174) The current version is accessible at http://www.dhs.ca.gov/ps/deodc/ehlb/iaq/VOCS/Practice.htm

California Environmental Protection Agency. Proposition 65 Safe Harbor Levels: No Significant Risk Levels for Carcinogens and Maximum Allowable Dose Levels for Chemicals Causing Reproductive Toxicity (Status Report). Sacramento: California Environmental Protection Agency, October 2007.

European Committee for Standardization. 2002. PrEN 13419-1. Building Products, Determination of the Emissions of Volatile Organic Compounds. Part 1: Emissions Test Chamber Method

European Committee for Standardization. 2002. PrEN 13419-3. Building Products, Determination of the Emissions of Volatile Organic Compounds. Part 3: Procedure for Sampling, Storage of Samples and Preparation of Test Specimens

GREENGUARD Product Certification Program Laboratory Qualifications and Proficiency Requirements, 2005, http://www.greenguard.org

ISO 16000-3:2001. Indoor air - Part 3: Determination of formaldehyde and other carbonyl compounds – Active sampling method

ISO 16000-6:2006. Indoor air – Part 6 Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID

ISO 16000-9:2006. Determination of the emission of volatile organic compounds from building products and furnishing – Emission test chamber method

ISO 16017-1:2000. Indoor, ambient and workplace air -- Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography -- Part 1: Pumped sampling

ISO Guide 43-1:1997. Proficiency testing by interlaboratory comparisons – Part 1: Development and operation of proficiency testing schemes.

ISO Guide 43-2:1997. Proficiency testing by interlaboratory comparisons – Part 2: Selection and use of proficiency testing schemes by laboratory accreditation bodies.

Mangani, F., A. Mastrogiacomo, and O. Marras, Evaluation of the Working Conditions of Light Adsorbents and Their Use as Sampling Material for the GC Analysis of Organic Air Pollutants in Work Areas*. Chromatographia, v.15, pp.712-716, 1982.*

OSHA Method #104:1994. For the Detection of Airborne Phthalates (Dimethyl Phthalate (DMP), Diethyl Phthalate (DEP), Dibutyl Phthalate (DBP), Di-2-Ethylhexyl Phthalate (DEHP), and Di-n-Octyl Phthalate (DNOP)).

Reference Specifications for Energy and Resource Efficiency, Section 01350 Special Environmental Requirements. The current version of this Specification is accessible at http://www.eley.com/specs/index.htm and http://www.chps.net/manual/documents/Sec_01350.doc

Research Triangle Institute. Environmental Technology Verification (ETV) Test Protocol: Large Chamber Test Protocol for Measuring Emissions of VOCs and Aldehydes. *Research Triangle Park, NC, 1999.*

Research Triangle Institute. Environmental Technology Verification (ETV) Report: Emissions of VOCs and Aldehydes From Commercial Furniture, RTP, NC 1999.

Sparks, Leslie, Indoor Air Exposure Model, Version 2.0. Air and Energy Engineering Research Laboratory, USEPA, RTP, NC, April, 1991.

U.S Environmental Protection Agency. Report 600/8-89/-074. Research Triangle Park, NC, 1989.

U.S. Environmental Protection Agency. Integrated Risk Information System (IRIS). Springfield, VA: National Technical Information Service, 2007.

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

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

Winberry, W. T., et al. Compendium of Methods for the Determination of Air Pollutants in Indoor Air. Office of Research and Development, USEPA, RTP, NC, April 1990.

1.3 Terminology

Acronyms and Abbreviations

ACGIH - American Conference of Governmental Industrial Hygienists
ACH – Air changes per hour
ARB – Air Resources Board, Cal/EPA
AREL - Acute Reference Exposure Level
ASTM – American Society for Testing and Materials
AQS – Air Quality Sciences, Inc.
ATSDR - Agency for Toxic Substances and Disease Registry
BQL – Below quantifiable limit
BIFMA – The Business and Institutional Furniture Manufacturer's Association
Cal/DHS – California Department of Health Services
Cal/EPA – California Environmental Protection Agency
CIWMB – California Integrated Waste Management Board, Cal/EPA
COC – Chain of Custody
CREL - Chronic Reference Exposure Level
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
IRIS - Integrated Risk Information System
ISO – International Standards Organization
IUR - Inhalation Unit Risk
IVOC – Individual volatile compounds
LOQ – Limit of quantitation, lower
MDF – Medium density fiberboard
MFC – Mass flow controller
MRL - Minimal Risk Level
MSDS – Material safety data sheet
OEHHA – Office of Environmental Health Hazard Assessment, Cal/EPA
OSB – Oriented strand board
Prop65 – California Proposition 65
QL – Quantifiable limit
REL – Reference exposure level
RfC - Reference Concentration
RH – Relative humidity in percent
STEL/C - short-term exposure limit or ceiling
TAC – Toxic Air Contaminant
TD/GC/MS – Thermal desorption GC/MS
TIC – Total ion-current chromatogram
TLV - Threshold Limit Value
TVOC – Total volatile organic compounds
TWA - Time-weighted average
VOC – Volatile organic compound

1.4 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.

Acute REL – Non-cancer acute reference exposure level developed by Cal/EPA OEHHA.

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 – Non-cancer chronic reference exposure level developed by Cal/EPA OEHHA.

Cleaning Product – Any liquid, solid or vapor used to remove inert or biological soils or residues from surfaces and materials.

Cleaning System – Any products, application materials, and defined equipment specified for a particular cleaning use with application rates, usage instructions or protocol.

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 $1m^3$ 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 be 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.

Product Subcategory – Group of products within a product category having similar chemistry, construction, weight, formulation and manufacturing process and which may have a similar VOC emissions profile (including specific chemicals and decay profile over time).

Product Loading – The ratio of the amount of material to be placed in the chamber to the volume of the chamber. Typically based on the area (m^2/m^3 of chamber volume), or mass (g/m^3) or unit (1 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 Protocol – A defined cleaning process with specified materials, chemicals, application instructions and equipment for implementation in an environmental chamber.

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

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

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

Temperature (T) - Degree of hotness or coldness expressed in degrees Celsius.
Ventilation Rate – Same as air change rate
Volatile Organic Compound (VOC) - Those nonpolar and moderately polar organic chemicals with boiling points between 60°C and 290°C that are amenable to monitoring, based on sorbent collection /thermal desorption/GC/MS analysis. The volatility range of chemicals amenable to the method will depend on the sorbent cartridges and thermal desorption chromatographic system used by the laboratory.
Zero Time - Time establishing the beginning of an emission test or when product is placed in a chamber and door is sealed.

1.5 Symbols

Symbol	Description	Units
A	Projected surface area	m^2
C	Chamber concentration	$\mu g/m^3$
$C_{P,t}$	Predicted exposure concentration at time t	$\mu g/m^3$
EF	Emission factor	$\mu g/m^2 \cdot hr$ or $\mu g/g \cdot hr$ or $\mu g/unit \cdot hr$ or $\mu g/event$
EF_o	Initial emission factor	$\mu g/m^2 \cdot hr$ or $\mu g/g \cdot hr$ or $\mu g/unit \cdot hr$ or $\mu g/event$
EF_t	Measured emission factor at time t	$\mu g/m^2 \cdot hr$ or $\mu g/g \cdot hr$ or $\mu g/unit \cdot hr$ or $\mu g/event$
ER	Emission rate	$\mu g/hr$
k	Rate constant	hr^{-1}
L	Product loading factor	m^2/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^2/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
vfB	Building ventilated volume fraction	Unitless

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

2.0 Sample Collection

Purpose

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

2.1 Personnel

2.1.1 Personnel responsible for sample collection must perform the task carefully and conscientiously and according to specific instructions, if supplied. Improper sample collection may impact the integrity of the sample and invalidate analysis, data and use of data.

2.1.2 Individuals engaged in sample collection and handling must be qualified by training and experience and possess an understanding of the relevant practices and techniques or, at a minimum, be under the direct supervision of such an individual.

2.2 Representative Sample

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

2.3 Sample Preservation

2.3.1 Special care shall be taken to prevent contamination of the product sample from any external source, prior to, during and subsequent to the sample collection procedure.

2.3.2 Powder free latex gloves are recommended during collection and packaging of the sample. Latex gloves minimize the risk of sample contamination by perfumes, soaps, or other contaminants on the hands of sample collection personnel.

2.3.3 Product samples may be packaged in two ways: 1) using the manufacturers standard product packaging materials, including sealed containers (as provided to distributors and/or customers); or 2) using contaminant-free, airtight, specialized Mylar or polyethylene lined foil barrier bags provided by the laboratory (specialized sample bags). In each case, care shall be taken to ensure that the sample package is tightly sealed to minimize contamination from external sources or off gassing during shipment and storage. If the manufacturer's standard product packaging does not meet sealing requirements, then other specialized packaging must be used.

2.3.4 The product will remain in its packaging as received, or transferred to a specialized bag (see Section 2.3.3), foil bag or otherwise sealed to preserve the integrity of the sample, until immediately prior to loading into the environmental chamber. Until it is unpacked it will be stored in an environmentally controlled indoor environment free of contamination with environmental control of 20º – 25ºC and relative humidity no greater than 60% RH.

2.4 Location of Sampling

2.4.1 Generally, samples are to be collected directly from the manufacturing or packaging line. The most appropriate location is dependent on the product and packaging process employed by the manufacturer. Sample collection personnel shall document the sample collection location and any relevant observations. This information shall be included on the chain of custody (COC) form.

2.5 Sample Age

2.5.1 Samples shall be packaged no more than 1 hour following collection off the manufacturing line or immediately following completion of the manufacturer's product packaging process. However, the sample shall not be packaged until it has reached room temperature. If additional time is required for the product to reach room temperature beyond the one hour, note this on the chain of custody.

2.5.2 Samples shall be shipped from the manufacturing facility within 24 hours of collection and packaging.

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.

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

Dry/Wet Products

Manufacturing Date	Date product comes off of final manufacture line
Sample Collection	Same as Manufacturing Date
Shipment to Laboratory	Within 24 hours 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 Sample Collection Procedures

2.6.1 Containerized and Wet Products - Containerized and wet products can be supplied in original, standard 1-quart or 1-gallon consumer containers. Alternatively, wet and dry cleaner samples can be collected in clean, unused paint cans (1-pint or 1-quart size). Special care is required to assure that these samples are representative of the larger batches from which they are collected. Containers shall be filled so there is minimal unfilled headspace above or below the adhesive. The collection procedure shall be documented. Following packaging, the GREENGUARD COC must be fully completed. The white and yellow copies of the completed three-part form (Section 2.9) shall be attached to the outside of the sample package. The pink copy of the COC is retained as a record for the manufacturer. Samples of containerized products sent to a laboratory shall also be accompanied by a Material Safety Data Sheet (MSDS) and a specification sheet that describe the products, list the major chemical ingredients, identify the intended uses and describe the application methods. Disposal recommendations should also be provided.

2.7 Packaging and Shipment of Samples

2.7.1 Samples are shipped to the testing laboratory in sealed Mylar or polyethylene lined foil "barrier" bags (specialized bags) provided by the testing laboratory, in the manufacturer's standard packaging, or in otherwise sealed containers. The type of packaging used must ensure that the sample is tightly sealed to minimize contamination from external sources or offgassing during shipment and storage (also see Section 2.3)

2.7.2 Samples must be packaged to avoid cross contamination. Different types of products should be packaged individually for shipping.

2.7.3 Samples are to be shipped to the testing laboratory within 24 hours of collection and packaging except for multi-component or large samples (such as furniture). In these cases, the sample must be shipped within two days of completion of product consolidation and/or packaging. Products shall arrive at the testing laboratory within 7 days of shipment, although overnight shipment is recommended for small products.

2.8 Chain of Custody Documentation

2.8.1 The manufacturer is responsible for the completion of the GREENGUARD Product Documentation/Chain of Custody form. This form must be completed by the responsible manufacturer's employee/representative or by an independent third party pursuant to an agreement between the Licensee and the GEI. Each signatory shall retain a copy of this document.

2.8.2 The chain of custody form includes as a minimum the following information:

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

2.8.4 Contact Details – Contact Name, Title, Phone Number, Fax Number, Email Address

2.8.5 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

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

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

2.8.8 Laboratory Receiving Details – Received By, Received Date, Condition of Shipping Package, Condition of Sample, Assigned Laboratory Material Tracking Number

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

2.9 Receipt of Samples by Laboratory

2.9.1 Once the laboratory receives the product sample, the packages will be checked against the shipping invoice to ensure all packages and components have been received.

2.9.2 The laboratory will visually inspect the shipping containers upon arrival to ensure they are intact and do not appear to have been contaminated during shipping.

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

2.9.4 If containers are damaged or missing, the laboratory will notify the manufacturer as soon as feasible.

2.9.5 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.

2.9.6 Valid samples are assigned a unique identifier and entered into an electronic data management system for sample and data tracking purposes.

2.9.7 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.

2.10 Rejection of Samples by Laboratory

2.10.1 The testing laboratory has the right to reject a product sample for testing due to, but not limited to, any of the following reasons:

2.10.2 Shipping package is severely damaged upon arrival.

2.10.3 Product container (i.e., external bag, foil package, can, tube, etc) is damaged upon arrival so that integrity of the sample is compromised.

2.10.4 Chain of Custody form is missing or incomplete.

2.10.5 Product sample arrives with insufficient time to initiate testing within the required time frame.

2.10.6 When a product sample is rejected, the testing laboratory shall inform the manufacturer immediately and provide the reason for rejection.

2.10.7 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.

2.11 Storage of Samples by Laboratory Prior to and Following Testing

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

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

SECTION 3
LABORATORY SAMPLE PREPARATION AND ANALYSES

3.0 Test Specimen Preparation

3.0.1 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.

3.0.2 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.

3.0.3 Sample specimen replicates should be prepared for analysis as part of the laboratory quality program. The fraction of duplicates is established by the laboratory's quality assurance plan, and should be a minimum of one duplicate for every ten samples prepared of a product type.

3.0.4 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).

3.0.5 If special substrates and application 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.

3.0.6 If products are being tested for a particular specification with instructions, specific directions are followed for sample preparation.

3.0.7 All personnel entering the large chamber must put on lint-free, clean room shoe covers. Always wear unpowdered latex gloves when handling any products to be tested in an emissions chamber.

3.1 Preparation of Hard Surface Liquid Cleaner (includes General cleaners, Glass cleaners, Toilet cleaners, Floor cleaners, etc.) Test Specimens

3.1.1 Hard surface liquid cleaners are typically applied by spraying or pouring onto an inert hard surface, with a loading of 0.4-1 m^2/m^3. Unless a specific substrate is indicated, the cleaner is applied to a piece of clean non-emitting glass or stainless steel. The amount of cleaner applied is determined by the manufacturers instructions for use and application rate. For consistency, if no directions are provided apply 3g wet product per square foot, unless specified otherwise by the customer.

3.1.1.1 Apply the product to the inert substrate uniformly across the surface using designated application materials or application instructions.

3.1.1.2 Immediately weigh the assembly and calculate the weight of the cleaner by difference.

3.1.1.3 If applicable, wipe the surface to remove product, as in actual use scenario.

3.1.1.4 Re-weigh the assembly and calculate the final weight of the cleaner by difference.

3.1.1.5 Where applications of cleaner to be applied, report weight of test specimen prior to and after each application. The testing period begins immediately after the final application.

3.2 Preparation of Cleaning Systems

3.2.1 Cleaning systems are tested following the manufacturer's recommended cleaning procedures, including designated chemicals, application rates, application materials and equipment, amount of product applied, removal/wiping procedures, and time between applications.

3.2.2 Cleaning products are diluted inside the chamber just prior to the cleaning procedure, if applicable.

3.3 **Environmental Chamber Testing**

3.3.1 *Facilities*

3.3.1.1 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.

3.3.2 *Equipment*

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

3.3.3 *Chamber Sizes*:

3.3.3.1 Small (0.05 – 1 m^3) chamber evaluations are used to determine source emission rates and emissions factors from dilute cleaning products.

3.3.3.2 Intermediate (approximately 1 – 6 m^3 volume) chamber evaluations are used to determine source emission rates and emission factors from concentrated cleaning products.

3.3.3.3 Large (> 25 m^3) chambers are used for the evaluation of cleaning systems and aerosol cleaners.

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

3.4.1 *Principle:* The principle of the test is to determine the specific emission rates or emission factors of VOCs emitted from prepared specimens of cleaning products and/or systems. Testing 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".

3.4.2 *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 per hour (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 change per hour. The loading factor shall be optimized to produce a value that is close to the value for cleaning products and systems in both classroom and office building scenarios.

3.4.3 *Duration:* The chamber test shall last 14 hours, but may be extended to a longer period to capture on-going emissions patterns, emitting VOCs, and their levels. Chamber tests of shorter duration, such as 4 hours, may be used for profile testing or other standard requirements. Sealing of the chamber following insertion of the product specimen into the chamber establishes the zero time or start of the test.

3.4.4 *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%.

3.4.5 *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 must be confirmed (with ±10% accuracy) using procedures similar to those presented in ASTM Method E741 for tracer gas application. Alternatively, ASTM Method E741 may be used as the primary method for determining the air exchange rate. The frequency of ACH verification is prescribed by the Laboratory's quality assurance standards and should occur whenever flow changes are made to chamber air and at a minimum of twice per year, if conditions are not changed. Supply air contamination shall not exceed 10 µg m^{-3} and 2 µg m^{-3} for any individual VOC.

3.5 **Chamber and materials**:

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

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

3.5.3 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.

3.5.4 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.

3.5.5 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.

3.6 **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).

3.7 **Monitoring and data acquisition**: Instrumentation must be available to control and monitor the temperature and humidity with adequate accuracy, precision, and sensitivity to control these parameters and to document that the emission test is conducted within the control limits stated above. The measurements shall be made at the inlet air stream, inside the chamber or immediately at the chamber exhaust using electronic probes. The probes shall be calibrated periodically according the laboratory's quality assurance plan. At a minimum, these probes shall be calibrated on an annual basis against NIST traceable standards.

3.8 **Procedures**

3.8.1 *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.

3.8.2 *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.

3.8.3 *Specimen loading:* The time for basic sample preparation shall be minimized and shall never exceed 10 minutes. Once the product has been prepared for small chambers, it is to be loaded into the environmental chamber within five minutes. For extensive sample preparation where assemblies or multiple applications are used, the time between the preparation and loading in the chamber should be minimized. The process, along with times, should be documented. Load the product into the environmental chamber, approximately centered on the bottom surface. 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.

3.8.4 *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 or CO. The concentration is monitored over a period of time. The ending concentration shall be within 3% of the initial concentration. Additionally, the air leakage of specific chambers can be determined periodically after loading a

test specimen, if appropriate. This can be accomplished by measuring the flow rate at the chamber exhaust and comparing this to the supply airflow rate. The flow measurement device shall have low pressure drop. The exhaust flow rate shall be within 10% of the inlet flow rate by this method.

3.8.5 *Replicate tests*: A fraction of the tests shall be conducted in replicate using specimens prepared from the same product sample. The fraction of duplicates is determined by the laboratory's quality assurance plan and should be no less than 1 out of every 20 samples for those products appropriate for replicate measurement.

3.9 Air Sampling

3.9.1 *Sampling schedule:* For GREENGUARD Certification tests for cleaning systems, chamber air samples shall be collected for VOCs and aldehydes centered around the elapsed times of 4 and 14 hours after initiating the chamber test, or as otherwise dictated by the test program or specification requirements. For cleaning products, chamber air samples shall be collected for VOCs and aldehydes centered around the elapsed times of 4 and 14 hours after initiating the chamber test. Additional samples at other time points may be collected as otherwise dictated by the test program or specification requirements. Air collections with shorter or extended sampling periods may be warranted for quarterly testing or specialized program/data requirements. Phthalate samples for GREENGUARD Certification tests for cleaning systems and products are collected centered around the 14-hour point.

3.10 Sampling Media

3.10.1 VOC sampling media for individual VOCs and TVOC shall consist of thermally desorbed, solid-phase sorption tubes containing Tenax-TA. Refer to ASTM documents D 6196 and D 6345, and U.S. EPA Methods TO-1 and TO-17. The samplers shall be capable of quantitatively collecting VOCs with a broad range of functional groups and volatilities approximately within the volatility range of n-butane through n-octadecane, although TVOC is based on response from n-hexane through n-hexadecane (C_6 - C_{16}). Minimal losses of analytes (i.e., < 5%) due to breakthrough shall occur. This can be accomplished by the use of sampling tubes containing two or more sorbent materials in series, with the highest surface area material used as the backup to prevent the breakthrough of the most volatile compounds. Before use, samplers shall be conditioned by thermal desorption. Samplers taken from refrigerated storage shall be warmed to room temperature prior to use.

3.10.2 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.

3.10.3 Phthalate samples are collected by drawing known volumes of air through OVS-Tenax sampling tubes.

3.10.4 *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.

3.10.5 *Sampling procedures:* Air samples shall be collected directly from the chamber exhaust at the specified elapsed times. A short manifold with multiple ports and a

maximum length of 4 in is used at the exhaust to allow simultaneous collection of multiple samples. No other tubing is allowed between the chamber exhaust and the sampler inlet. The DNPH cartridge is placed downstream of the VOC sorption tubes to reduce the chance of VOC sample contamination with residual acetonitrile 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.

3.10.6 *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.

3.10.7 *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.

3.11.2.3 Phthalates: Sampling tube samples for phthalates shall be analyzed by GC using a mass spectrophotometer (MS).

3.11.3 *Methods for Individual VOCs*

3.11.3.1 The analytical methods for individual VOCs shall be based on ASTM D 6196, "Standard Practice for Selection of Sorbents, Sampling and Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air." Other relevant practices are EPA Methods TO17, "Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes" and TO-1, "Determination of Volatile Organic Compounds in Ambient Air Using Tenax Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS)" or equivalent methods. Standards and chamber samples shall be analyzed using identical conditions.

3.11.3.2 The analytical methods for formaldehyde, acetaldehyde and other low molecular weight aldehydes shall be based on ASTM Standard D 5197, "Standard Test Method for Formaldehyde and other Carbonyl Compounds in Air (Active

Sampler Methodology)" or an equivalent method. It is recognized that unsaturated low molecular weight aldehydes such as acrolein are not accurately determined by this method. Higher molecular weight aldehydes approximately beginning with butanal can be analyzed by the method for individual VOCs.

3.11.3.3 Analysis for the target list phthalates is based on OSHA Method 104 for phthalates. Samples are desorbed with toluene and analyzed by GC using a mass spectrometer (MS).

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.

3.11.5.4 The phthalate target list includes: diethylhexyl phthalate, butyl benzyl phthalate, di-n-octyl phthalate, dibutyl phthalate, diethyl phthalate, dimethyl phthalate.

3.11.6 *Analytical Calibrations*

3.11.6.1 Target VOCs of concern shall be quantified by GC/MS based on multi-point calibrations prepared using pure compounds. If possible, other positively identified VOCs shall be quantified by the same method. A minimum of four points shall be used. Target analytes shall be introduced onto sorbent tubes as gas or liquid standards and then analyzed using methods identical to those used for the analysis of chamber samples. Analyze calibration standards or perform full calibrations at least once every month or more frequently to ensure accuracy for the analyses.

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

3.11.6.3 Aldehydes analyzed by HPLC shall be quantified based on multi-point calibrations prepared from hydrazone derivatives of the pure compounds. Standards and samples shall be analyzed using identical methods. Analyze calibration standards or perform full calibrations at least once every month or more

frequently to ensure accuracy for the analyses.

3.11.7 *Quantifiable Limit (QL):* A lower QL often is quantitatively defined as the analyte mass that produces a response that is 10 times higher than the instrumental noise level or is 10 times the standard deviation for repeated analyses of a low level standard. A lower QL that is higher than this absolute value may be defined based on practical considerations.

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

3.11.7.2 The lower QL for VOCs appearing on list of chemicals of concern or allowable emission levels is 2 µg m^{-3}, or better.

3.11.7.3 The lower QL for non- listed VOCs is 2 µg m^{-3}, or better.

3.11.7.4 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 cleaning systems loading is consider as a unit of 1 per volume (m^3).

3.12.3 *Exposure Modeling*

3.12.3.1 The emission rates of individual VOCS, TVOC, formaldehyde, total aldehydes, and phthalates are used in a computer exposure model to determine potential air concentrations of the pollutants. The computer model uses the measured emission rates to determine the air concentrations that would consequently occur.

3.12.3.2 Determination of Predicted Exposure Concentrations

The emission rate data for the individual compounds identified during chamber testing is combined with expected use conditions to determine a predicted exposure concentration. The assumption is made that the space within which the cleaning product and/or system is applied is well-mixed.

The space within which the cleaners are applied is assumed to be 32 m^3, with an air exchange rate of 0.72 air changes per hour (ACH). Concentrations of the different compounds emitted by the cleaning product and/or system are calculated based on the measured 4-hour emission rates, for the determination of the short-tem exposure (acute) concentrations, and the measured 14-hour emission rates, for the determination of the long-tem (chronic) exposure concentrations. For each compound, the predicted exposure concentrations are calculated using the following equations:

$$C_{st} = E_4/(N \times V) \quad (1)$$

where:

- C_{st} = the short-term predicted exposure concentration (µg/m^3) of a given compound in the workspace;
- E_4 = the 4-hr emission rate (µg-unit/hr) of the compound of interest;
- N = the air exchange rate (hr^{-1}) in the space, assumed to be 0.72 ACH;
- V = the volume (m^3) of the space, assumed to be 32 m^3;

$$C_{lt} = E_{14}/(N \times V) \quad (2)$$

where:

- C_{lt} = the long-term predicted exposure concentration (µg/m^3) of a given compound in the workspace;
- E_{14} = the 14-hr emission rate (µg-unit/hr) of the compound of interest;
- N = the air exchange rate (hr^{-1}) in the workspace, assumed to be 0.72 ACH;
- V = the volume (m^3) of the workspace, assumed to be 32 m^3;

3.12.3.3 For GREENGUARD Annual Certification tests, the 4 and 14-hour time points are used to determine compliance. The constant emission factors (as determined at 4 and 14 hours) are used to determine compliance with the GREENGUARD Criteria by calculating an exposure concentration (Section 3.12.3.3). The building parameters including ventilation rate and material loading used in the calculations are detailed in Table 6.4.

3.12.3.4 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/m^3)
- EF_t = measured emission factor at time t (µg/m^2·hr) or (µg/unit·hr)
- A = product area exposed in room (m^2)
- V = room volume (m^3)
- N = room air change per hour (hr^{-1})

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

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

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

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

where:

EF_m = modeled emission factor (µg/m^2·hr) or (µg/unit·hr)
EF_0 = initial emission factor (µg/m^2·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/m^2·hr) or (µg/unit·hr)
EF_0 = initial emission factor (µg/m^2·hr) or (µg/unit·hr)
k = rate constant (hr^{-1})
t = time (hr).

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

3.12.3.6.1 The predicted exposure concentrations ($C_{P,t}$) (µg/m^3) 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/m^2·hr) or (µg/unit·hr)
A = product area exposed in room (m^2)
V = room volume (m^3)
N = room air change per hour (hr^{-1})

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

3.12.3.7.1 Office - Office ventilation rates are based on the ASHRAE 62.1-2007 ventilation standard for acceptable indoor air quality. The office ventilation rate is based on the ASHRAE parameters of 5 CFM per person and 0.06 CFM/ft² for office spaces in commercial buildings. These parameters are applied to the GREENGUARD office size (32 m³) for a single occupant, which results in a ventilation rate of 0.72 ACH. The air change rate to building volume ratio is

identical to State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174) requirements and will result in equivalent or more stringent estimated building concentrations.

3.12.3.7.2 Classroom - The classroom testing and modeling requirements of State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174) are required for use in the GREENGUARD Children and Schools Program. These parameters are applied to a classroom (40' x 24' x 8.5' or 231 m^3) with occupancy of 27 students and ventilation rate of 0.9 ACH. Classroom ventilation rates determined using the ASHRAE 62.1-2004 ventilation standard for acceptable indoor air quality are based on the ASHRAE parameters of 10 CFM per person and 0.12 CFM/ft^2 for classrooms in educational environments. These parameters applied to the 40' x 24' x 8.5' (or 231 m^3) classroom, with an occupancy of 27 students, result in a ventilation rate of 2.8 ACH. To account for older schools, times of inactive ventilation, and to harmonized with State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174), ACH of 0.9 ACH is applied. It is assumed if applicable, that only 90% of the room volume of 231 m^3 is ventilated at this rate due to occupancy and furnishings, and room content. The classroom ventilation rates and product areas are identical to those required by CHPS IEQ Credit 2.2 and specified by State of CA DHS's "Standard Practice for the Testing Of Volatile Organic Emissions Sources Using Small Scale Environmental Chambers" (CA/DHS/EHLB/R-174).

3.12.3.7.3 Bathroom – The office room volume and ventilation rate are also used for the bathroom model.

3.12.4 *Conversion to ppm*

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

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

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

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

3.12.5 The model measurements are made with the following assumptions: air within open office areas of the building is well-mixed at the breathing level zone of the occupied space; environmental conditions are maintained at 50% relative humidity and 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.

3.12.6 Table 6.5 is a summary table for application of this test method and criteria requirements as applicable to the Green Seal Standard GS-37 Section 4.13.2.

SECTION 4
TARGET CHEMICALS AND MAXIMUM ALLOWABLE CONCENTRATIONS

4.0 GREENGUARD Certification

Allowable Limits for GREENGUARD Product/Process Certification: Requirements met at 4 hours (acute) and 14 hours (chronic) with no preconditioning.

	Short-Term (Acute)	Long-Term (Chronic)
TVOC (mg/m^3) [1]	≤5.0	≤0.22
Formaldehyde (ppm) [2]	≤0.040	≤0.013
Carcinogens[3]	NA	Less Than the EPA IUR
Chronic Noncancer Toxins[4]	NA	Less Than the ATSDR MRL, ½ the CA CREL, and the EPA RfC
Acute Noncancer Toxins[5]	Less Than the ATSDR MRL and the CA AREL	NA
Developmental/Reproductive Toxins[6]	Less Than the ATSDR MRL and the CA AREL	NA
Other Individual VOCs[7]	Less Than 1/10 the ACGIH STEL/C TLV (or Less Than the TWA TLV if no STEL/C)	Less Than 1/100 the ACGIH TWA TLV
Total Phthalates (mg/m^3)[8]	NA	≤0.01

NA = Not Applicable

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

[2]Short-term level based on the ATSDR Acute Duration Minimal Risk Level (MRL). Long-term level based on ½ CA-OEHHA determined ALARA (As Low As Reasonably Achievable) value.

[3]Compared to the concentration corresponding to an E-5 risk level for the EPA Inhalation Unit Risk (IUR) (cancer potency factor). Excludes formaldehyde, which is covered by (2) above.

[4]Compared to the EPA Reference Concentration (RfC), CA Chronic Reference Exposure Level (CREL), and the ATSDR Intermediate or Chronic Duration MRL. Intermediate MRLs shall be used if a Chronic MRL is not available for that compound. Excludes Developmental and Reproductive endpoints (see Developmental/Reproductive Toxins).

[5]Compared to ATSDR Acute Duration MRL and CA Acute Reference Exposure Level (AREL). Excludes Developmental and Reproductive endpoints, which are covered by Developmental/Reproductive Toxins in (6) below.

[6]Compared to CA AREls and ATSDR MRLs for chemicals with Developmental or Reproductive endpoints.

[7]For the short-term exposure comparison, any VOC not otherwise listed must produce an air concentration level no greater than 1/10 the American Conference of Government Industrial Hygienists (ACGIH) Short-Term Exposure Level or Ceiling (STEL/C) Threshold Limit Value (TLV), or no greater than the Time-Weighted Average TLV if no STEL/C available. For the long-term exposure comparison, all VOC's must be less than 1/00 the ACGIH TWA TLV.

[8]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).

	Short-Term (Acute)	Long-Term (Chronic)
Step 1		
For All Emission Criteria	The emission rate (μg/unit-hr or μg/m^2-hr) measured at 4 elapsed exposure hours is combined with product use assumptions (product loading, ventilation rate, building volume) to determine a predicted exposure concentration (μg/m^3) as a result of product use.	The emission rate (μg/unit-hr or μg/m^2-hr) measured at 14 elapsed exposure hours is combined with product use assumptions (product loading, ventilation rate, building volume) to determine a predicted exposure concentration (μg/m^3) as a result of product use.
Step 2		
TVOC	The 4-hour predicted TVOC exposure concentration is compared directly to the GREENGUARD TVOC criterion.	The 14-hour predicted TVOC exposure concentration is used as a conservative proxy for chronic exposure and is compared directly to the GREENGUARD TVOC criterion.
Formaldehyde	The 4-hour predicted formaldehyde exposure concentration is compared directly to the GREENGUARD formaldehyde criterion.	The 14-hour formaldehyde predicted exposure concentration is used as a conservative proxy for chronic exposure and is compared directly to the GREENGUARD formaldehyde criterion.
Carcinogens (EPA IRIS - Inhalation Unit Risk)	Not applicable to acute exposures.	Individual VOC's detected in the emissions from the product are compared to a database of chemicals for which carcinogenic risks as a result of inhalation exposure have been evaluated by the US EPA. These compounds evaluated by the US EPA will have an established Inhalation Unit Risk (IUR). The IUR can be used to determine the risk level (excess cancers in a given population) posed by exposure to the chemical at a given concentration. Those compounds found to be emitting from the product that have been evaluated by the US EPA for inhalation carcinogenic risks are selected for further analysis. For these compounds, the 14-hour predicted exposure concentration is compared to the concentration corresponding to an E-5 risk level (1 excess cancer per population of 100,000 people) for the EPA IUR. The predicted exposure at 14 hours is used as a conservative proxy for chronic exposure.
Chronic Non-cancer Toxins	Not applicable to acute exposures.	Individual VOC's detected in the emissions from the product are compared to a database of chemicals for which Minimal Risk Levels (ATSDR Chronic MRL's), Reference Concentrations (EPA RfC's), and Chronic Reference Exposure Levels (California CREL's) have been established. Those compounds found to be emitting from the product and having an established Chronic MRL, RfC, and/or CREL are selected for further analysis. For those compounds, the 14-hour predicted exposure concentration for each chemical is compared to its corresponding Chronic MRL, RfC, and/or ½ CREL for determination of compliance with the GREENGUARD criteria. The predicted exposure at 14 hours is used as a conservative proxy for chronic exposure.

Acute Non-cancer Toxins	Individual VOC's detected in the emissions from the product are compared to a database of chemicals for which Minimal Risk Levels (ATSDR Acute MRL's) and Acute Reference Exposure Levels (California ARELs) have been established. Those compounds found to be emitting from the product and having an established MRL and/or AREL with endpoints other than Developmental/Reproductive are selected for further analysis. For those compounds, the 4-hour predicted exposure concentration for each chemical is compared to its corresponding Acute MRL and/or AREL for determination of compliance with the GREENGUARD criteria.	Not applicable to chronic exposures.
Developmental/ Reproductive Toxins (MRLs and ARELs)	Individual VOC's detected in the emissions from the product are compared to a database of chemicals for which Minimal Risk Levels (ATSDR MRLs) and Acute Reference Exposure Levels (California ARELs) have been established. Those compounds found to be emitting from the product and having an established MRL and/or AREL with Developmental/Reproductive endpoints are selected for further analysis. For those compounds, the 4-hour predicted exposure concentration for each chemical is compared to its corresponding MRL and/or AREL, with Developmental/Reproductive endpoints, for determination of compliance with the GREENGUARD criteria.	Not applicable to chronic exposures.
Other Individual VOCs	Individual VOCs detected in the emissions from the product for which an MRL, AREL, or MADL has not been established are compared to a database of chemicals for which Threshold Limit Values (TLVs) have been established. Those compounds found to be emitting from the product and not having an established MRL, AREL or MADL but having a TLV are selected for further analysis. For these compounds, the 4-hour predicted exposure concentration for each chemical is compared to $1/10^{th}$ of its corresponding Short Term Exposure Limit or Ceiling value (STEL/C) TLV or to the 8-Hour Time Weighted Average (TWA) TLV if no STEL/C exists.	Individual VOCs detected in the emissions from the product for which a NSRL, IUR, Chronic MRL, RfC, or CREL has not been established are compared to a database of chemicals for which Threshold Limit Values (TLVs) have been established. Those compounds found to be emitting from the product and not having an established NSRL, IUR, Chronic MRL, RfC or CREL but having a TLV are selected for further analysis. For these compounds, the 14-hour predicted exposure concentration for each chemical is compared to $1/100^{th}$ of its corresponding 8-Hour Time Weighted Average (TWA) TLV for determination of compliance with the GREENGUARD criteria.

4.1 GREENGUARD Children & Schools

Products meeting the emission criteria in Section 4.0 also meet the Emissions Criteria defined by GREENGUARD for Children & Schools[SM].

4.2 VOCs with Existing TLVs and CA RELs

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)	1/2 Chronic[b] REL (µg/m³)
4.2.1 WITH TLV and CREL			
1,1-Dichloroethylene (Vinylidene chloride)	75-35-4	200	35
1,2-Butylene oxide (1,2-Epoxybutane)	106-88-7	59†	10
1,2-Dibromoethane (Ethylene dibromide) 1,2-dibromo)	106-93-4		0.4
1,2-Dichloroethane (Ethylene dichloride)	107-06-2	400	200
1,3-Butadiene	106-99-0	44	10
1-Chloro,2,3-epoxy-propane (Epichlorohydrin)	106-89-8	19	1.5
2-Ethoxyethanol (Ethylene glycol monoethyl ether)	110-80-5	180	35
2-Ethoxyethyl acetate (Ethylene glycol monoethyl ether acetate)	111-15-9	270	150
Acetaldehyde	75-07-0	450*	9**
Acrylonitrile (Vinyl cyanide)	107-13-1	43	2.5
Benzene	71-43-2	16	30
Carbon disulfide	75-15-0	310	400
Chlorobenzene (Monochlorobenzene)	108-90-7	460	500
Cresol, All isomers	1319-77-3	220	300
Dichloromethane (Methylene chloride)	75-09-2	1740	200
Diethanolamine	111-42-2	20	1.5
Diethylene dioxide (1,4-Dioxane)	123-91-1	720	1500
Dimethylbenzene (Xylene o-,m-,p-isomer)	1330-20-7	4340	350
Dimethylformamide	68-12-2	300	40
Ethyl chloride (Chloroethane)	75-00-3	2640	15000
Ethylbenzene	100-41-4	4340	1000
Ethylene glycol	107-21-1	1000*	200
Formaldehyde	50-00-0	3.7*	16.5***
Glutaraldehyde	111-30-8	2*	0.04
Hexane (n-Hexane)	110-54-3	1760	3500
Isophorone (2-Cyclohexen-1-one, 3,5,5-trimethyl-)	78-59-1	280*	1000
Isopropanol (2-Propanol)	67-63-0	4920	3500
Maleic anhydride	108-31-6	4	0.35
Methyl alcohol (Methanol)	67-56-1	2600	2000
Methyl bromide (Methane, bromo)	74-83-9	39	2.5
Methyl Cellosolve® (2-Methoxyethanol)	109-86-4	160	30
Methyl Cellosolve® acetate (2-Methoxyethyl acetate; Ethylene glycol methyl ether acetate)	110-49-6	240	45
Methyl chloroform (1,1,1-Trichloroethane)	71-55-6	19100	500
Methyl-tert-butyl ether (MTBE; tert-Butyl methyl ether)	1634-04-4	1800	4000
m-Xylene (meta-Xylene)	108-38-3	4340	350
Naphthalene	91-20-3	520	4.5
o-Xylene (Xylene, ortho)	95-47-6	4340	350

p-Dichlorobenzene (1,4-Dichlorobenzene)	106-46-7	600	400
Phenol	108-95-2	190	100
Phthalic anhydride (1,3-Isobenzofurandione)	85-44-9	61	10
Propylene	115-07-1	8600	1500
Propylene glycol-1-methyl ether (1-Methoxy-2-propanol)	107-98-2	3690	3500
Propylene oxide (1,2-Epoxypropane)	75-56-9	48	15
p-Xylene (para-Xylene)	106-42-3	4340	350
Styrene, monomer (Phenylethylene; Vinyl benzene)	100-42-5	850	450
Tetrachloroethylene (Perchloroethylene)	127-18-4	1700	17.5
Tetrachloromethane (Carbon tetrachloride)	56-23-5	310	20
Toluene (Toluol)	108-88-3	1880	150
Trichloroethylene	79-01-6	2690	300
Trichloromethane (Chloroform)	67-66-3	490	150
Trichloronitromethane (Chloropicrin)	76-06-2	6.7	0.2
Triethylamine (N,N-Diethylethanamine)	121-44-8	41	100
Vinyl acetate (Acetic acid ethenyl ester)	108-05-4	350	100
4.2.2 CHEMICALS WITH TLV 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	
Adipic acid(Hexanedioic acid)	124-04-9	50	
Adiponitrile	111-69-3	88	
Aldrin	309-00-2	2.5	
Allyl alcohol (2-Propen-1-ol)	107-18-6	11.9	
Allyl chloride (1-Propene, 3-chloro)	107-05-1	30	
Allyl glycidyl ether (AGE; Oxirane, [(2-propenyloxy)methyl]-)	106-92-3	47	
Allyl propyl disulfide	2179-59-1	30	
∀-Chloroacetophenone (Phenacyl chloride)	532-27-4	3.2	
∀-Methylstyrene (iso-Propenylbenzene; (1-Methylethenyl)benzene)	98-83-9	2420	
∀-Pinene	80-56-8	1120	
Aniline	62-53-3	76	
Anisidine (o,p-isomers)	29191-52-4	5	
ANTU (∀-Naphthylthiourea)	86-88-4	3	
Benzotrichloride (Benzyl trichloride; Benzene, (trichloromethyl)-)	98-07-7	8*	
Benzoyl chloride	98-88-4	28*	
Benzyl acetate	140-11-4	610	
Benzyl chloride (Benzene, (Chloromethyl))	100-44-7	52	
bis(2-Dimethylaminoethyl) ether (DMAEE)	3033-62-3	3.3	
bis(Chloromethyl) ether	542-88-1	0.047	
Bromochloromethane (Chlorobromomethane)	74-97-5	10600	
Bromotrifluoromethane (Trifluorobromomethane)	75-63-8	60900	
Butanethiol (n-Butyl mercaptan)	109-79-5	18	
Camphor, synthetic	76-22-2	120	
Caprolactam	105-60-2	50	
Chlorinated diphenyl oxide	31242-93-0	5	
Chloroacetaldehyde	107-20-0	32*	
Chloroacetone (2-Propanone, 1-chloro)	78-95-5	38*	
Chloroacetyl chloride	79-04-9	2.3	
Chlorodifluoromethane (FC-22)	75-45-6	35400	
Chlorodiphenyl (42 % chlorine)	53469-21-9	10	
Chlorodiphenyl (54% chlorine)	11097-69-1	5	
Chloropentafluoroethane	76-15-3	63200	
Crotonaldehyde (2-Butenal)	4170-30-3	8.6*	
Crufomate	299-86-5	50	
Cumene (Benzene, 1-methylethyl-)	98-82-8	2460	
Cyclohexane	110-82-7	3440	
Cyclohexanol	108-93-0	2060	
Cyclohexanone	108-94-1	500	
Cyclohexene	110-83-8	10100	
Cyclohexylamine	108-91-8	410	
Cyclopentadiene	542-92-7	2030	
Cyclopentane	287-92-3	17200	
)-3-Carene	13466-78-9	1120	

Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone)	123-42-2	2380	
Dichloroacetic acid	79-43-6	26.4	
Dichloroacetylene	7572-29-4	3.9*	
Dichlorodifluoromethane (FC-12)	75-71-8	49500	
Dichlorodiphenyltrichloroethane (DDT)	50-29-3	10	
Dichloroethyl ether (bis[2 Chloroethyl] ether)	111-44-4	290	
Dichlorofluoromethane (FC-21)	75-43-4	420	
Dicyclopentadiene	77-73-6	270	
Diethyl ether (Ethyl ether)	60-29-7	12100	
Diethyl ketone	96-22-0	7050	
Diethyl phthalate	84-66-2	50	
Diethylamine	109-89-7	150	
Diethylene triamine	111-40-0	42	
Difluorodibromomethane	75-61-6	8580	
Diglycidyl ether (DGE)	2238-07-5	5.3	
Dihydroxybenzene (Hydroquinone)	123-31-9	20	
Diisopropylamine	108-18-9	210	
Dimethoxymethane (Methylal)	109-87-5	31100	
Dimethyl disulfide	624-92-0	19.3	
Dimethylaniline (N,N-Dimethylaniline)	121-69-7	250	
Dimethylethoxysilane	14857-34-2	21	
Dinitolmide	148-01-6	50	
Dinitrobenzene	100-25-4	10	
Dinitrotoluene	25321-14-6	2	
Diphenylamine	122-39-4	100	
Dipropyl ketone (4-Heptanone)	123-19-3	2330	
Dipropylene glycol methyl ether [bis-(2-Methoxypropyl) ether; DPGME]	34590-94-8	6060	
Divinyl benzene	1321-74-0	530	
Dodecyl mercaptan (1-Dodecanethiol)	112-55-0	8	
Enflurane	13838-16-9	5660	
EPN (O-Ethyl-O-[4nitrophenyl]phenylthiophosphonate)	2104-64-5	0	
Ethanethiol (Ethyl mercaptan)	75-08-1	13	
Ethyl acetate	141-78-6	14400	
Ethyl amyl ketone (3-Heptanone, 5-methyl-)	541-85-5	1310	
Ethyl bromide (Bromoethane)	74-96-4	220	
Ethyl butyl ketone (3-Heptanone)	106-35-4	2340	
Ethyl cyanoacrylate (Ethyl 2-cyanoacrylate)	7085-85-0	10	
Ethyl formate (Formic acid, ethyl ester)	109-94-4	3030	
Ethyl tert-butyl ether (ETBE)	637-92-3	210	
Ethylene chlorohydrin (2-Chloroethanol)	107-07-3	33*	
Ethylene glycol dinitrate	628-96-6	3.1	
Ethylenimine	151-56-4	8.8	
Ethylidene norbornene	16219-75-3	250*	
Formamide (Methanamide)	75-12-7	180	
Formic acid (Methanoic acid)	64-18-6	94	
Furfural (2-Furaldehyde)	98-01-1	79	
Furfuryl alcohol (2-Furanmethanol)	98-00-0	400	
Heptane (n-Heptane)	142-82-5	16400	
Hexachlorobenzene (HCB)	118-74-1	0.02	
Hexachlorobutadiene	87-68-3	2.1	

Hexachlorocyclopentadiene	77-47-4	1.1	
Hexachloroethane	67-72-1	97	
Hexachloronaphthalene	1335-87-1	2	
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	
Mesityl oxide	141-79-7	600	
Methacrylic acid (2-Propenoic acid, 2-methyl)	79-41-4	700	
Methyl 2-Cyanoacrylate (Mecrylate)	137-05-3	10	
Methyl acetylene-propadiene mixture	MAPP	16400	
Methyl amyl alcohol (Methyl isobutyl carbinol ; 4-Methyl-2-pentanol)	108-11-2	1040	
Methyl ethyl ketone peroxide	1338-23-4	15*	
Methyl formate (Formic acid, methyl ester)	107-31-3	2460	
Methyl isoamyl ketone (2-Hexanone, 5-methyl)	110-12-3	2340	
Methyl isobutyl ketone (Hexone)	108-10-1	2050	
Methyl isopropyl ketone (2-Butanone, 3-methyl)	563-80-4	7050	
Methyl methacrylate (Methacrylic acid, methyl ester)	80-62-6	2050	
Methyl n-amyl ketone (2-Heptanone)	110-43-0	2330	
Methyl n-butyl ketone (2-Hexanone)	591-78-6	200	
Methyl propyl ketone (2-Pentanone)	107-87-9	7050	
Methyl silicate	681-84-5	60	
Methyl vinyl ketone (3-Buten-2-one)	78-94-4	6*	
Methylacrylonitrile (2-Propenenitrile, 2-methyl-)	126-98-7	27	
Methylamine	74-89-5	64	
Methylcyclohexane	108-87-2	16100	
Methylcyclohexanol	25639-42-3	2340	
Methylhydrazine	60-34-4	0.19	
Methylisocyanate	624-83-9	0.47	
Monochloroacetic acid	79-11-8	19.4	
Morpholine	110-91-8	710	
m-Phenylenediamine	108-45-2	1	
m-Toluidine	108-44-1	88	
m-Xylene ∀,∀'-diamine	1477-55-0	1*	
N,N-Dimethylacetamide	127-19-5	360	
n-Amyl acetate (1-Pentyl acetate; Acetic acid, pentyl	628-63-7	2260	

ester)			
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	
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	
p-Toluidine (p-Aminotoluene)	106-49-0	88	
Pyridine	110-86-1	31	
Sec-Butanol (sec-Butyl alcohol)	78-92-2	3000	
Sec-Butyl acetate (Acetic acid, 1-methylpropyl ester)	105-46-4	9500	
Sec-Hexyl acetate	108-84-9	2950	
Stoddard solvent	8052-41-3	5250	
Tert-Amyl methyl ester (TAME)	994-05-8	800	
Tert-Butanol (tert-Butyl alcohol)	75-65-0	3030	
Tert-Butyl acetate	540-88-5	9500	
Tert-Pentane	463-82-1	17700	
Tetrachloronaphthalene	1335-88-2	20	
Tetrafluoroethylene	116-14-3	82	
Tetrahydrofuran	109-99-9	0	
Tetramethyl succinonitrile	3333-52-6	28	
Tetranitromethane	509-14-8	0.4	
Thioglycolic acid	68-11-1	38	
Toxaphene (Chlorinated camphene)	8001-35-2	5	
Trichloronaphthalene	1321-65-9	50	
Triethanolamine	102-71-6	50	
Trimethyl benzene	25551-13-7	1230	
Trimethyl benzene, All isomers	108-67-8	1230	
Trimethyl benzene, All isomers	526-73-8	1230	
Trimethyl benzene, All isomers	95-63-6	1230	
Triphenyl amine	603-34-9	50	
Vinyl bromide (Ethene, bromo-)	593-60-2	22	
Vinyl chloride (Chloroethylene)	75-01-4	26	
Vinyl fluoride	75-02-5	19	
Vinyl toluene (Methyl styrene, All isomers)	25013-15-4	2420	
Xylidine, mixed isomers	1300-73-8	25	
Vinyl cyclohexene dioxide (7-Oxabicyclo[4.1.0]heptane, 3-oxiranyl)	106-87-6	5.7	
1,1,1,2-Tetrachloro-2,2-difluoroethane (FC-112a)	76-11-9	41700	
1,1,2-Trichloroethane	79-00-5	550	
1,1,2,2-Tetrachloro-1,2-difluoroethane (FC-112)	76-12-0	41700	
1,1,2,2-Tetrachloroethane	79-34-5	69	
Acetylene tetrabromide (1,1,2,2-Tetrabromoethane)	79-27-6	140	
Dichlorotetrafluoroethane (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	76-14-2	69900	
1,1,2-Trichloro-1,2,2-trifluoroethane (FC-113)	76-13-1	76700	
1,2,3-Trichloropropane	96-18-4	600	
1,2,4-Trichlorobenzene	120-82-1	370*	
3-Amino-1,2,4-triazole (Amitrole; 3-Amino-s-triazole)	61-82-5	2	
1,3,5-Triglycidyl-s-triazinetrione	2451-62-9	0.5	
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)	93-76-5	100	
2,4,6-Trinitrophenylmethylnitramine (Tetryl)	479-45-8	15	
Picric acid (2,4,6-Trinitrophenol)	88-89-1	1	
Tetryl (2,4,6-Trinitrophenylmethylnitramine)	479-45-8	15	
2-Chloro-1,3-butadiene (∃-Chloroprene)	126-99-8	360	
Quinone (p-Benzoquinone; 2,5-cyclohexadiene-1,4-dione)	106-51-4	4.4	
1,1-Dichloro-1-nitroethane	594-72-9	120	

1,1-Difluoroethylene (Vinylidene fluoride)	75-38-7	13100	
1,1-Dimethylhydrazine	57-14-7	0.25	
Biphenyl (Diphenyl; 1,1'-Biphenyl (9CI))	92-52-4	13	
p-tert-Butyltoluene (Toluene, 4-t-butyl (Benzene,1-(1,1-dimethylethyl)-4-methyl))	98-51-1	61	
tert-Amyl acetate (1,1-Dimethylpropyl acetate)	625-16-1	2660	
1,2-Diaminoethane (Ethylenediamine)	107-15-3	250	
1,2-Dichloropropane (Propylene dichloride)	78-87-5	3470	
Dimethylphthalate (1,2-Benzenedicarboxylic acid, dimethyl ester)	131-11-3	50	
o-Dichlorobenzene (1,2-Dichlorobenzene)	95-50-1	1500	
Pyrocatechol (Catechol ;1,2-Benzenediol)	120-80-9	230	
1,3-Dichloropropene	542-75-6	45	
1,3-Dioxalane	646-06-0	610	
m-Phthalodinitrile (1,3-Benzenedicarbonitrile)	626-17-5	50	
Toluene-2,6-diisocyanate (Benzene, 1,3-diisocyanato-2-methyl)	91-08-7	0.36	
1,4-Dichloro-2-butene	764-41-0	0.25	
1,6-Hexanediamine (Hexamethylenediamine)	124-09-4	23	
2,2-Dichloropropionic acid	75-99-0	50	
2,2-Dimethylbutane (Hexane)	75-83-2	17600	
2,3-Dimethylbenzene (Hexane)	79-29-8	17600	
2,3-Epoxy-1-propanol (Glycidol)	556-52-5	61	
2,4-Dichlorophenoxyacetic acid (2,4-D)	94-75-7	100	
2,6-Dimethyl-4-heptanone (Diisobutyl ketone)	108-83-8	1450	
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, 2004 Threshold Limit Values for Chemical Substances and Physical Agents, Cincinnati, OH

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

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

† - AIHA 2005 Workplace Environmental Exposure Level (WEEL)

** - Full REL value allowed per CA DHS.

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

SECTION 5
REQUIRED ELEMENTS OF THE LABORATORY TEST REPORT

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

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

5.0.2 *Manufacturer, product and sample identification*:

5.0.2.1 Manufacturer

5.0.2.2 Product name, product number, product category and subcategory (if applicable)

5.0.2.3 Manufacturer's ID number and other identification numbers (if applicable)

5.0.2.4 Manufacturing date, collection date, shipment date and date of arrival at laboratory (on chain of custody)

5.0.2.5 Laboratory sample ID or tracking number.

5.0.3 *Testing conditions:* Chamber volume, air change rate, temperature, relative humidity, exposed area of test specimen (or other relevant test specimen measurement parameter), chamber loading factor, test specimen preparation details, conditioning period start date and duration (if applicable), and test period start date and end date.

5.0.4 *Chamber methodology:* Referenced methods/practices followed to operate chambers; description of the chamber used, how air flows through the chamber, supply air contaminant levels (either in report or readily available upon request).

5.0.5 *Data analysis procedures:* Analytical methods used to determine measured chamber concentrations and to derive emission factors from measured chamber concentrations; methodology and parameters used to calculate room concentrations from the emission factors including the assumed product area, room volume, and ventilation rate and ventilated volume fraction.

5.0.6 *Test results:* For GREENGUARD Certification tests, for all time points list chamber concentration emission factors of the TVOC, individual VOCs, formaldehyde, and other individual aldehydes quantified.

5.0.7 *Provide the following information:*

5.0.7.1 CAS numbers for individual VOCs.

5.0.7.2 Identify those VOCs with chronic RELs (http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html) and VOCs on the other lists of toxic substances including:
CA Proposition 65 http://www.oehha.ca.gov/prop65/prop65_list/newlist.html;
ATSDR Acute Duration Minimal Risk Levels (MRL);
EPA Inhalation Unit Risks (IUR) (cancer potency factor);
Compared to the EPA Reference Concentrations (RfC);
CA Acute Reference Exposure Levels (AREL);
American Conference of Government Industrial Hygienists (ACGIH) Threshold Limit Values (TLV);
CA Toxic Air Contaminants (TACs) http://www.arb.ca.gov/toxics/taclist.htm;
Class I and II carcinogens.

5.0.8 Provide estimated concentrations for modeled building scenarios for TVOC, formaldehyde, and target list chemicals at the 4 and 14 hour time points.

5.0.9 Indicate non-listed VOCs which were quantified using surrogate compound standards instead of authentic standards.

5.0.10 Certification of the Report with date including authorized laboratory.
5.0.11 Report any additional facts, which may have influenced the test results. These may include, but are not limited to, the following:
5.0.11.1 Dates of most recent internal and external calibrations, methods and compounds used
5.0.11.2 Dates of most recent proficiency evaluation(s) and corrective actions taken, if any
5.0.11.3 Any deviations of laboratory parameters from specified values
5.0.11.4 Any other relevant observations.

5.0.12 Attach a copy of the completed and signed chain-of-custody (COC) form with the laboratory report.

Section 6
Tables

Table 6.1 Sample collection and testing chronology for products

Event	Schedule
Cleaners and Cleaning Products	
Manufacturing date	Date product comes off of final manufacture line
Sample collection	Same as *Manufacturing date*
Shipment to laboratory	Within 24 hours of sample collection
Arrival at laboratory	Not to exceed 7 days from shipment date
Commence laboratory testing	Not to exceed 10 days after arrival and product acceptance at laboratory

Table 6.2 Chamber conditions for 14 hr test period

3.12.3 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 6.3 All chronic inhalation Reference Exposure Levels (RELs) adopted by Cal/EPA OEHHA as of August 2006.

Substance (CAS #)	*Listed in CAPCOA - 1993*	*Chronic Inhalation REL (µg/m³)*	*Hazard Index Target(s)*	*Human Data*
Acetaldehyde* (75-07-0)	□	9	Respiratory system	
Acrolein (107-02-8)	□	0.06	Respiratory system; eyes	
Acrylonitrile (107-13-1)	□	5	Respiratory system	
Ammonia (7664-41-7)	□	200	Respiratory system	□
Arsenic (7440-38-2) & arsenic compounds	□	0.03	Development; Cardiovascular system; Nervous system	
Benzene (71-43-2)	□	60	Hematopoietic system; development; nervous system	□

Substance (CAS #)	*Listed in CAPCOA - 1993*	*Chronic Inhalation REL (µg/m³)*	*Hazard Index Target(s)*	*Human Data*
Beryllium (7440-41-7) and beryllium compounds	□	0.007	Respiratory system; immune system	□
Butadiene (106-99-0)		20	Reproductive system	
Cadmium (7440-43-9) & cadmium compounds	□	0.02	Kidney; respiratory system	□
Carbon tetrachloride (56-23-5)	□	40	Alimentary system; development; nervous system	
Carbon disulfide (75-15-0)		800	Nervous system; reproductive system	□
Chlorinated dioxins (1746-01-6) & dibenzofurans (5120-73-19)	□	0.00004	Alimentary system (liver); reproductive system; development; endocrine system; respiratory system; hematopoietic system	
Chlorine (7782-50-5)	□	0.2	Respiratory system	
Chlorine dioxide (10049-04-4)		0.6	Respiratory system	
Chlorobenzene (108-90-7)	□	1000	Alimentary system; kidney; reproductive system	
Chloroform (67-66-3)	□	300	Alimentary system; kidney; development	
Chloropicrin (76-06-2)	□	0.4	Respiratory system	
Chromium hexavalent: soluble except chromic trioxide	□	0.2	Respiratory system	
Chromic trioxide (as chromic acid mist)	□	0.002	Respiratory system	□
Cresol mixtures (1319-77-3)	□	600	Nervous system	
Dichlorobenzene (1,4-) (106-46-7)	□	800	Nervous system; respiratory system; alimentary system; kidney	
Dichloroethylene (1,1) (75-35-4)	□	70	Alimentary system	
Diesel Exhaust*		5	Respiratory system	
Diethanolamine (111-42-2)		3	Cardiovascular system; nervous system	
Dimethylformamide (N,N-) (68-12-2)		80	Alimentary system ; respiratory system	□
Dioxane (1,4-) (123-91-1)	□	3,000	Alimentary system; kidney; cardiovascular system	
Epichlorohydrin (106-89-8)	□	3	Respiratory system; eyes	
Epoxybutane (1,2-) (106-88-7)		20	Respiratory system; cardiovascular system	
Ethylbenzene (100-41-4)		2,000	Development; alimentary system (liver); kidney; endocrine system	
Ethyl chloride (75-00-3)	□	30,000	Development; alimentary system	
Ethylene dibromide (106-93-4)	□	0.8	Reproductive system	□

Substance (CAS #)	*Listed in CAPCOA - 1993*	*Chronic Inhalation REL (µg/m³)*	*Hazard Index Target(s)*	*Human Data*
Ethylene dichloride (107-06-2)		400	Alimentary system (liver)	
Ethylene glycol (107-21-1)		400	Respiratory system; kidney; development	
Ethylene glycol monoethyl ether (110-80-5)		70	Reproductive system; hematopoietic system	
Ethylene glycol monoethyl ether acetate (111-15-9)		300	Development	
Ethylene glycol monomethyl ether (109-86-4)		60	Reproductive system	
Ethylene glycol monomethyl ether acetate (110-49-6)		90	Reproductive system	
Ethylene oxide (75-21-8)		30	Nervous system	
Fluoride including Hydrogen Fluoride		13 F 14 HF	Bone and teeth; respiratory system	
Formaldehyde (50-00-0)		3	Respiratory system; eyes	
Glutaraldehyde (111-30-8)		0.08	Respiratory system	
Hexane (n-) (110-54-3)		7000	Nervous system	
Hydrazine (302-01-2)		0.2	Alimentary system; endocrine system	
Hydrogen chloride (7647-01-0)		9	Respiratory system	
Hydrogen cyanide (74-90-8)		9	Nervous system; endocrine system; cardiovascular system	
Hydrogen sulfide (7783-06-4)		10	Respiratory system	
Isophorone (78-59-1)		2000	Development; liver	
Isopropanol (67-63-0)		7,000	Kidney; development	
Maleic anhydride (108-31-6)		0.7	Respiratory system	
Manganese & manganese compounds		0.2	Nervous system	
Mercury & mercury compounds (inorganic)		0.09	Nervous system	
Methanol (67-56-1)		4,000	Development	
Methyl bromide (74-83-9)		5	Respiratory system; nervous system; development	
Methyl chloroform (71-55-6)		1,000	Nervous system	
Methyl isocyanate (624-83-9)		1	Respiratory system; reproductive system	
Methyl t-butyl ether (1634-04-4)		8,000	Kidney; eyes; alimentary system (liver)	

Substance (CAS #)	*Listed in CAPCOA - 1993*	*Chronic Inhalation REL (µg/m³)*	*Hazard Index Target(s)*	*Human Data*
Methylene chloride (75-09-2)	□	400	Cardiovascular system; nervous system	□
Methylene dianiline (4,4'-) (101-77-9)	□	20	Eyes; alimentary system (hepatotoxicity)	
Methylene Diphenyl Isocyanate (101-68-8)		0.7	Respiratory system	
Naphthalene (91-20-3)	□	9	Respiratory system	
Nickel & compounds (except nickel oxide)	□	0.05	Respiratory system; hematopoietic system	
Nickel oxide (1313-99-1)		0.1	Respiratory system; hematopoietic system	
Phenol (108-95-2)	□	200	Alimentary system; cardiovascular system; kidney; nervous system	
Phosphine (7803-51-2)	□	0.8	Respiratory system; alimentary system; nervous system; kidney; hematopoietic system	
Phosphoric acid (7664-38-2)		7	Respiratory system	
Phthalic anhydride (85-44-9)	□	20	Respiratory system	□
Propylene (115-07-1)		3,000	Respiratory system	
Propylene glycol monomethyl ether (107-98-2)		7,000	Alimentary system (liver)	
Propylene oxide (75-56-9)	□	30	Respiratory system	
Selenium and selenium compounds (other than hydrogen selenide)	□	20	Alimentary system; cardiovascular system; nervous system	□
Silica (crystalline, respirable)		3	Respiratory system	□
Styrene (100-42-5)	□	900	Nervous system	□
Sulfuric acid (7664-93-9)		1	Respiratory system	
Tetrachloroethylene* (perchloroethylene) (127-18-4)	□	35	Kidney; alimentary system (liver)	
Toluene (108-88-3)	□	300	Nervous system; respiratory system; development	
Toluene diisocyanates (2,4-&2,6-)	□	0.07	Respiratory system	□
Trichloroethylene (79-01-6)	□	600	Nervous system; eyes	□
Triethylamine (121-44-8)		200	Eyes	
Vinyl acetate (108-05-4)		200	Respiratory system	
Xylenes (m-, o-, p-)	□	700	Nervous system; respiratory system	□

Table 6.4 Parameters to be used for calculation of VOC concentrations

Parameter	Unit of Measure	Office Model	School Model	Bathroom Model
Room Length	ft	10	40	10
Room Width	ft	14	24	14
Room Height	ft	8	8.5	8
Room Volume	m^3	32	231	32
Air Change Rate (hr^{-1})	hr^{-1}	0.72	0.9	0.72
Area Loadings by Application				
Floor	m^2	13.1	89.2	13.1
Wall	m^2	28.1	94.6	28.1
Desk/Seating (children's)	Units	NA	27	NA
Shelving/Bookcases	m^2	20	7.81	NA
Millwork (Doors)	m^2	1.89	1.89	1.89
Windows	m^2	4.1	4.46	NA
Desk/Worksurface/Countertop Surface Area	m^2	3.2	12.3	0.93
Markerboards	m^2	3.0	9.9	NA
Casegood, freestanding large product	Unit	1	NA	NA
Office Seating	Unit	1	NA	NA
Mirrors	m^2	NA	NA	2.0
Bathroom Partitions	m^2	NA	NA	8.2
Toilets	Unit	NA	NA	2

NA = Not Available

Table 6.5 - Summary Table for the Required Inhalation Toxicity Criteria for GREENGUARD Cleaning Products and Systems for Application Towards Green Seal Standard GS-37 Section 4.13.2

Attribute	Acute (4 hour) Criteria	Chronic (14 hour) Criteria
TVOC (mg/m^3) [1]	≤5.0	≤0.22
Formaldehyde (ppm) [2]	≤0.040	≤0.013
Carcinogens[3]	NA	Less Than the EPA IUR
Chronic Noncancer Toxins[4]	NA	Less Than the ATSDR MRL, ½ the CA CREL, and the EPA RfC
Acute Noncancer Toxins[5]	Less Than the ATSDR MRL and the CA AREL	NA
Developmental/Reproductive Toxins[6]	Less Than the ATSDR MRL and the CA AREL	NA
Other Individual VOCs[7]	Less Than 1/10 the ACGIH STEL/C TLV (or Less Than the TWA TLV if no STEL/C)	Less Than 1/100 the ACGIH TWA TLV
Total Phthalates (mg/m^3)[8]	NA	≤0.01

2.0 Required parameters for compliance testing or modeling

Amount of Cleaner Evaluated	$3g/ft^2$, unless otherwise specified by the manufacturer

Parameter	Unit of Measure	Office Model	School Model	Bathroom Model
Room Length	ft	10	40	10
Room Width	ft	14	24	14
Room Height	ft	8	8.5	8
Room Volume	m^3	32	231	32
Air Change Rate (hr^{-1})	hr^{-1}	0.72	0.9	0.72
Area Loadings by Application				
Floor	m^2	13.1	89.2	13.1
Wall	m^2	28.1	94.6	28.1
Desk/Seating (children's)	Units	NA	27	NA
Shelving/Bookcases	m^2	20	7.81	NA
Millwork (Doors)	m^2	1.89	1.89	1.89
Windows	m^2	4.1	4.46	NA
Desk/Worksurface/Countertop Surface Area	m^2	3.2	12.3	0.93
Markerboards	m^2	3.0	9.9	NA
Casegood, freestanding large product	Unit	1	NA	NA
Office Seating	Unit	1	NA	NA
Mirrors	m^2	NA	NA	2.0
Bathroom Partitions	m^2	NA	NA	8.2
Toilets	Unit	NA	NA	2

NA = Not Applicable

Attachment
GREENGUARD's *Laboratory Qualifications and Proficiency Requirements*

GREENGUARD PRODUCT CERTIFICATION PROGRAM
LABORATORY QUALIFICATIONS AND PROFICIENCY REQUIREMENTS

1.0 LABORATORY PROFICIENCY

The primary purpose of the GREENGUARD Environmental Institute (GEI) Laboratory Program is to establish and maintain the highest possible standards of performance for laboratories testing products in support of the GREENGUARD Indoor Air Quality Certification Program™.

Laboratories taking part in the GREENGUARD Certification Program must comply with the quality management requirements as defined in this document, including outside audits by the GEI. In addition, it is expected that each laboratory will take part in a round robin testing program among all participating laboratories and proficiency testing for measured analytes. Laboratories that comply with the elements of this program must operate a quality system that meets the requirements of the elements of ISO 9001 relevant to the testing services, or ISO 17025. The program also requires a Quality Assurance Project Plan (QAAP) and strict compliance with GREENGUARD/ANSI quality and test methods.

2.0 GENERAL OVERVIEW

As an overview, the GREENGUARD Laboratory Qualification Process requires laboratories to meet the following minimum qualifications.

2.1 Chambers (small and large) constructed and tested based on ASTM Standards 5116 and 6670.

2.2 Enforcement of a stringent quality management system (ISO 9001 or ISO 17025). Approved testing laboratories must maintain a quality control (QC) program which encompasses all facets of the measurement program from sample receipt to final review and issuance of reports, where product control, testing, data handling, and reporting protocols and procedures are standardized and controlled.

Measures to be routinely implemented in a product's evaluation program include but are not limited to:

- Appropriate record keeping of sample identifications and tracking throughout the study
- Calibration of all instrumentation and equipment used in the collection and analysis of samples
- Validation and tracking of all chamber parameters including air purification, environmental controls, air change rate, chamber mixing, and sample recovery
- Analysis of spiked samples for accuracy determinations
- Duplicate analyses of all samples evaluated and analyzed
- Multi-point calibration and linear regression of all standardization

- Analysis of controls including chamber backgrounds, sampling media, and instrumental systems.

2.3 Independent, third party status.

2.4 Qualified personnel and scientific staff.

2.5 Completion of round robin and proficiency testing to confirm chamber and analytical capabilities.

2.6 External audit of the laboratory.

3.0 ENVIRONMENTAL TEST CHAMBER REQUIREMENTS

3.1 Small chamber construction and operation must follow the guidance of ASTM D 5116 "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions From Indoor Materials/Products".

3.2 Large chamber construction and operation must follow the ASTM D 6670 "Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products".

3.3 Size and Construction:

3.3.1 Small chambers are by definition less than 5 m^3 in volume.

3.3.1.1 Small chambers for material testing are required to have a volume between 0.05 and 0.10 m^3.

3.3.1.2 Office equipment requires chambers with a minimum volume of 1 m^3.

3.3.2 Large chambers are by definition greater than 5 m3 in volume.

3.3.2.1 Testing of chairs and other small office furniture requires chambers between 5 and 6 m^3.

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

3.3.3 All chambers must have controlled environmental operational parameters used for the purpose of providing accurate and reproducible emission measurements from sources of indoor air pollutants.

3.4 Material:

3.4.1 Environmental test chambers shall be constructed of inert, smooth surfaces such as stainless steel.

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

3.4.3 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.

3.4.4 The surfaces and seals of the chamber shall be sufficiently chemically inert such that formaldehyde at the level of 0.05 ppm and representative VOCs at the level of 10 $\mu g/m^3$ are not irreversibly retained on the interior surfaces.

3.4.4.1 Quality control testing must demonstrate recoveries between 80% to 120% for formaldehyde, toluene, and n-decane spiked at these levels. Recoveries of these compounds must show consistency. Other chemical recoveries may be required based on testing/certification standards.

3.5 Air Exchange Rate:

3.5.1 Air shall be supplied to the chamber using a single pass system. The air that flows through the chamber shall be maintained at a constant volume that provides 1.0 ± 0.05 ACH and will depend on the chamber size. If a chamber with an interior volume of 21 m^3 is used, then the airflow shall be 21 m^3/h. Likewise, if a chamber with an interior volume of 29 m^3 is used then the airflow shall be 29 m^3/h. Note: Operation of excessively large chambers to meet this requirement may dilute the emissions and not provide accurate results.

3.5.1.1 Instrumentation must be available to control and monitor the air exchange rate with adequate accuracy, precision, and sensitivity to control this parameter and to document that the emission test is conducted within the control limits stated above.

3.5.2 At a minimum, the air exchange rate shall be monitored immediately before the product is placed in the chamber (at the same time background contamination checks are made) by accurately measuring the air flow into the chamber. ACH (h^{-1}) is then calculated as air flow (m^3/h) divided by chamber volume (m^3). The accuracy of this air exchange rate must be confirmed (with ± 5% accuracy) using procedures similar to those presented in ASTM Method E741 for tracer gas application. Alternatively, ASTM Method E741 may be used as the primary method for determining the air exchange rate.

3.6 Mixing:

3.6.1 The air within the chamber shall be well mixed.

3.6.1.1 The mixing of air within the chamber shall be evaluated against a theoretical model, and considered well-mixed if the result is within 5% of the theoretical well-mixed model.

3.6.1.2 Mixing shall be evaluated in an empty chamber.

3.6.1.3 Mixing must be evaluated prior to the initiation of testing.

3.6.2 Mixing may be achieved with or without the use of fans.

3.6.2.1 Ideally, mixing will be achieved by the introduction of air into the chamber via engineered manifolds with a matching exhaust manifold. Internally or externally mounted fans must demonstrate that they do not contaminate the chamber air or irreversible adsorb/absorb VOCs.

3.6.3 Mixing Confirmation: The air within the chamber shall be well mixed and comply within 5% of the theoretical well-mixed model. Mixing shall be evaluated in an empty chamber. It shall be evaluated within 6 months prior to testing. Several procedures as described below may be used to evaluate chamber air mixing. If CO is used as the tracer gas, the laboratory should follow precautions to its use, as it is hazardous.

3.6.3.1 The methods referenced in ASTM standards D 5116 and D 6670 may be used for this evaluation, for small and large chambers, respectively.

3.6.3.2 An inert tracer gas (SF_6 or CO) is introduced into the chamber (preferably with the inlet air) at a known concentration and constant flow. The chamber air concentration of the tracer gas is then measured over time at the same location as the sampling ports. The experimental curve (concentration vs. time) is compared to the theoretical curve for the same variables, assuming complete mixing by estimating the relative standard deviation (RSD) of the mean of the deviation of the difference between the observed and theoretical air concentrations at selected time points. An estimate of the variance (S^2) is:

$$s^2 = 3\ \frac{(o - t)^2}{n - 1} \qquad \text{(B-1)}$$

where,

o = observed value
t = theoretical value
n = number of observations

The mean of the differences would be:

$$m = \frac{3\ (o - t)}{n} \qquad \text{(B-2)}$$

The RSD is then:

$$RSD = s / m. \qquad \text{(B-3)}$$

Using this approach, the chamber air is considered well mixed if the RSD is less than 5%.

3.6.3.3 An inert tracer gas (SF_6 or CO) is introduced into the chamber (preferably with the inlet air) at a constant known concentration and flow. The chamber air concentration of the tracer gas is then measured over time at the same location as the sampling ports. The chamber concentrations vs.time plot is compared to the theoretical curve for a completely mixed chamber:

$$C = C_o\ (I - e^{-Nt}) \qquad \text{(B-4)}$$

where,

C = chamber concentration,
C_o = inlet concentration
t = time
N = air exchange rate, N = Q/V, where
Q = flow rate through chamber
V = chamber volume

To evaluate mixing, the chamber volume (V) then is estimated by fitting the air concentration data for the trace gas to the theoretical curve. The chamber air is considered well mixed if the actual chamber volume and the chamber volume estimated from the tracer gas concentration agree within 5%.

3.6.6.4 An inert tracer gas (SF_6 or CO) is introduced into the chamber (preferably with the inlet air) over a short period of time (1 to 10 minutes). The chamber air concentration of the tracer gas is then measured over time in at least two and preferably three locations within the chamber. One location must be at the sampling ports; other locations should be toward the front one-third and/or rear one-third of the chamber. Chamber air exchange rates (air changes per hour) are calculated from tracer gas decay measurements as:

$$ACH = 1 / (t_o - t_i)\ \ln (C_i / C_o) \qquad \text{(B-5)}$$

where,

ACH = air changes per hour
t_o = final time (elapsed time in hours)
t_i = initial time
C_i = initial tracer gas concentration in ppm
C_o = final tracer gas concentration in ppm

3.7 Air Supply:

3.7.1 Oil-less piston type compressors shall be used to supply filtered air passed thru an air scrubbing system sufficient to meet required background air levels.

3.7.2 The purified air shall be supplied to the chambers via stainless steel lines.

3.7.3 Background levels of contaminants shall be monitored weekly.

3.7.3.1 Upper limits for background levels are 2 $\mu g/m^3$ for formaldehyde, 10 $\mu g/m^3$ for total VOCs, 2 $\mu g/m^3$ for any individual VOC, and 10 $\mu g/m^3$ for respirable (<10µm) particles.

3.8 Temperature and Humidity:

3.8.1 The inlet air supply to the chamber must be monitored continuously, and maintained at a constant temperature and humidity of 23 ± 1° C and 50 ± 5% RH.

3.8.1.1 Instrumentation must be available to control and monitor the temperature and humidity with adequate accuracy, precision, and sensitivity to control these parameters and to document that the emission test is conducted within the control limits stated above.

3.9 Air Tightness:

3.9.1 The chamber shall be operated at a slight positive pressure of less than 2 inches of water.

3.9.2 The chamber shall be airtight with an air-leakage rate of less than 0.03 ACH (sealed chamber at atmospheric pressure).

3.9.2.1 The tracer gas decay method referenced in ASTM E 741 “Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution” is used for this validation.

3.9.2.2 Air tightness must be evaluated prior to the initiation of testing.

3.10 Sampling Ports:

3.10.1 Sampling ports for collecting chamber air samples may integrate into the exhaust manifold exit or may be affixed to the chamber walls.

3.10.2 The sample ports should be designed to minimize the amount of tubing between the chamber and sampling media.

3.10.3 Sampling lines shall be made of nonabsorbent material, such as stainless steel.

3.10.4 Sampling ports and lines shall be located in a way that does not adversely affect the chamber airflow.

3.10.5 In large chambers, the sample lines shall be positioned to draw air at a height of 43 $\pm$ 6 inches, the midpoint of the breathing zone, as defined by ASHRAE Standard 55-2004.

4.0 QUALITY MANAGEMENT SYSTEM.

4.1 Quality Management

As part of the GREENGUARD Certification Program, the GEI has developed a Quality Management Program (QMP) for its verification partners. This document follows the ANSI/ASQC guidelines.

It is expected that all laboratories participating in the program meet the QA/QC requirements defined below and have an adequate quality system to manage the quality of work performed. Documentation and records management must be performed in accordance, and laboratories must also perform assessments and allow audits by GEI corresponding to those specified by the specific program.

4.2 Quality Assurance and Quality Control

For emission testing conducted as part of this GEI program, a GREENGUARD Test Plan and Quality Assurance Project Plan (QAPP) must be prepared. Elements of the plan must follow EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5. The QAPP will address all aspects of the measurement program from acquisition of test product to final review and data reporting. Approval by the GEI must be obtained. Important elements of the QAPP include:

4.2.1 Project Description

A brief description of the test program shall include objectives, identification of the objects to be tested, and how testing is to be conducted. All testing must be conducted following GREENGUARD/ANSI specific test methods. The test conditions should be described, including the test temperature, air exchange rate, and material loading; sample collection schedule, procedures, equipment, and materials; analytical system procedures and equipment.

4.2.2 Project Organization and Description

A project organizational chart shall be provided that designates a Program Leader, a sample custodian, analysis supervisor, and a QA Officer. The QA Officer should be independent of the technical effort of the program to avoid real or perceived conflicts of interest. The responsibility of all individuals should be defined.

4.2.3 Data Quality Indicator Goals/Acceptance Criteria

The QA/QC Plan shall include data quality indicators and acceptance criteria as required by the GREENGUARD Program. Data quality objectives may vary with the particular product and/or standard requirements. Data quality indicators shall be established for the following parameters prior to beginning the testing program:

4.2.3.1 Time and Environmental Conditions for Product Acquisition, Packaging, Shipping and Storage.

Limits for the elapsed time from sample packaging to testing under an acceptable range of specified environmental conditions. These will be defined by the specific product test method.

Table 1 - General Data Quality Indicator Goals for Environmental Chamber Test Measurements

Parameter	Goal	Precision	Accuracy	Completeness[a]
Temperature	23º C	± 1.0º C	± 0.5ºC[b]	> 90%
Relative Humidity	50%	±5.0% RH	± 5.0% RH[b]	> 90%
Air Flow Rate	1.0 ACH	±5.0%	± 5.0%[b]	> 90%
Test Specimen Area	Variable	± 1%	± 10%	> 90%
Chamber Air Concentration ▪ Aldehydes ▪ TVOC ▪ IVOC	 < 90 ng < 180 ng < 36 ng	± 20 RSD[c]	± 20% [d]	> 90%

[a] Completeness characterizes the percentage of the planned measurements that are actually conducted.

[b] Accuracy certifications should be supplied by the manufacturers of the sensors who calibrate them against NIST-traceable primary sources. Precision measurements are obtained within the laboratory by continuous recording of the parameters. Non-compliance requires immediate correction and/or replacement of sensors. Calibrated replacements shall be kept in the laboratory. Experience indicates that routine calibration and tracking of precision prevents non-compliance.

[c] RSD = Relative standard deviation for replicate chamber air samples based on 10% measurement rate.

[d] Based on third party proficiency performance on quarterly basis.

4.2.3.2 Test Chamber Conditions and Test Results.
Precision, accuracy and completeness limits shall be met for each of the parameters listed in Table 1. Additional performance parameters will be required based on the specific test method and analytes being measured. This will include, but not be limited to, analytical instrument and measurement performance criteria including calibration, detection limits, media blanks, range of detection, instrument blanks, and instrument response.

4.2.3.3 Record Keeping and Logs.

Various logging requirements shall be implemented for all test parameters, including chamber and analytical performance. Many of these are identified in ASTM D5116. Additionally, personnel conducting each procedure shall be so noted.

Records of the devices used, date and time of tests, and the test results shall be part of the QA/QC recording process. The completeness of records indicates the care and attention given the QC process. Logs that shall be maintained include:

- Sample tracking to record receipt, storage, and disposition of materials to be tested.

- GC standards preparation to document preparation of all standards.

- Calibration to contain environmental systems calibration data.

- Instrument maintenance to document repairs and maintenance on all equipment.

- Work orders to record all pertinent information for each test, including sample details, sample identification number sampling requested, and sampling times.

- GC runs to record run number and test identification number

- Sample tube preparation logs.

4.2.3.4 Sample Management and Custody.

Products are to be logged into automated data management system. Chamber air samples shall be tracked through the automated data management system via a sequential numbering and work order system. Chain of custody forms shall be used to document the receipt and disposal of all products tested. A sample custodian shall be designated.

4.2.4 Quality Control Procedures.

All procedures shall be evaluated for acceptable performance at the point the data are generated. This minimizes the need to repeat testing because of out of control situations. Project staff shall carry out Quality Control activities in a routine, consistent manner to provide necessary feedback in the operation of all measurement systems, including:
- Routine maintenance and calibration of systems

- Daily recording of GC calibration accuracy and precision.

- Collection and analysis of duplicate samples, analytical as well as material duplicates.

- QC checking of sorbent tubes.

- Periodic analysis of proficiency samples supplied by an independent

source.

- All records (including temperature, relative humidity, air change, and background levels) shall be maintained and available for review.

- Internal auditing of the quality management system is to be performed annually, at a minimum, to elevate compliance with established criteria. Internal audits shall be conducted in accordance with established procedures. All audits are to be documented in an audit report and made available for review.

4.2.5 Control Charts

QC charts will allow visual analysis of system performance and observation of anomalistic or unacceptable deviations. This may be done by use of the Shewart Chart (reference: Shewart, W.A., 1931, Economic Control of Quality of Manufactured Products, Bell Telephone Laboratories). (Cf. 'Manual on Presentation of Data and Control Chart Analysis', 6th ed., prepared by Committee E-11 on Quality and Statistics, ASTM, 1991.)

4.2.6 Internal Performance and System Audits

All major components of the test shall be audited yearly by the QA Officer or as required by ISO 9001 or 17025. These may include, but not be limited to, the preparation of samples, laboratory systems, analytical measurement systems, data entry and processing.

4.2.7 External Audits

The GREENGUARD Environmental Institute will audit the components of the program yearly.

4.2.8 Corrective Action.

The need for corrective action may be identified through reviews, internal QC checks, audits or observations made during routine sampling and analysis activities. All corrective actions will be documented and root cause determined. No further work may be performed until the problem has been satisfactorily resolved, and the QA Officer has acknowledged approval.

4.2.9 Quality Assurance Reporting

All data reported on this project shall be accompanied by the applicable QA/QC data, including the results of internal QC checks, audit results, and any necessary corrective actions. The QA Officer will maintain current records of all QA/QC activities.

4.2.10 Document Control

Policies should be stated and procedures maintained to control all documents as part of the quality system including test methods, internal standard operating procedures (SOPs), software, equipment manuals, product documentation forms, data algorithms, and report formats.

4.2.11 Control of Records

Retention policies should be stated and procedures maintained to control all quality and technical records. Policies to identify, collect, maintain, access, file, store and dispose of quality and technical records must be documented. Computer files are satisfactory, provided copies can be obtained as needed and data edits are documented.

4.2.12 Sample Retention and Disposal

Policies shall include manner and duration of sample retention and disposal and must comply with GREENGUARD/ANSI test method requirements.

5.0 STANDARD OPERATING PROCEDURES

The laboratory shall prepare laboratory specific SOPs for all aspects of the analytical procedures. The SOPs shall be specific and be readily available to those involved in the analysis and testing. A copy of the method shall be retained in the laboratory. The SOPs shall meet all specific requirements of the GREENGUARD/ANSI Test Methods including:

- Sample handling, storage, unusual preparation

- Test sample preparation

- Environmental chamber operation and control

- Assembly, calibration, and operation of the sampling system

- Preparation, handling, and storage of the sorbent collection media

- Air sample collections

- Description and operation of the instrumentation systems, including the sampling device, sample introduction system, separation chemistry, and data system

- All aspects of data recording and processing and reporting

-QA/QC procedures to ensure data quality objectives are met for specific test method and analytes being measured

-Corrective Actions.

6.0 PROFICIENCY TESTING

As indicated in section 4.2.4 all analytical laboratories must include in proficiency testing as part of their quality program and be found to be proficient. This establishes the bias and accuracy of test results. Regular participation in a proficiency-testing scheme provides independent verification of the analytical competence of a laboratory and shows a commitment to the maintenance and improvement of performance. It demonstrates to the public, customers, accreditation bodies, regulators, and to the GEI that analytical procedures are under control and gives analysts confidence that the service which they provide will withstand scrutiny and meet the overall GEI quality performance requirements.

The proficiency program operates by providing participating laboratories with sorbent samples containing known analytes at concentrations found in the emissions of products. Tenax tubes are conditioned by the respective labs as used for their sampling media. The tubes are then sent to GEI's contract laboratory where chemicals are loaded and then the tubes are returned to the respective laboratory for thermal desorption analysis and results are sent to GEI. The laboratory is then provided with a report showing how closely their results agree with the accepted value, and where necessary, can then take appropriate action to improve performance. Performance must be within 20% of the real value to be acceptable. New laboratories must show two back to back proficient rounds for acceptance on the quarterly proficiency program, including acceptable performance on the Euro Proficiency Testing program offered by Greenguard and Blue Angel, as globally recognized throughout Europe. The chemical spikes on the tubes will be in a concentration range of 0.1 - 1 µg/tube, which corresponds to a concentration range of 20 - 200 µg/m³. The analysis is to be conducted using gas chromatography with thermodesorption according to the guidance of ISO/DIS 16000 and appropriate GEI standards. Specific chemicals loaded on the tubes will be those representative of chemicals found in the emissions of indoor products. Some chemicals that may be included are demonstrated below:

Alcohols	2-butoxyethanol, 2-(2-butoxyethoxy)ethanol, 2-ethyl-1-hexanol, 2-phenoxyethanol, propylene glycol
Alkanes	Decane, dodecane, pentadecane
Aromatic hydrocarbons	styrene, toluene, trimethylbenzenes, o-xylene, 4-phenylcyclohexene
Esters	2-(2-butoxyethoxy)ethyl acetate, 2-butoxyethyl acetate, n-butyl acetate, texanol isobutyrate, texanol (2,2,4-trimethyl-1,3-pentandiol monoisobutyrate)
Ketones and Aldehydes	acetophenone, hexanal, octanal
Terpenes	3-carene, limonene, longifolene, α-pinene

Following demonstration of analytical proficiency, the laboratory will be expected to participate in an annual round robin testing of representative products being tested for the Greenguard Certification program. Acceptable performance within two standard deviations of the average across all laboratories is expected for specific target emissions of a product. Participation in this effort will follow the guidelines of the Euro Proficiency Testing Program.

7.0 SAFETY AND HEALTH

Laboratories are expected to follow applicable federal, state and local regulations regarding safety and health, for example, OSHA Standard 29 CFR 1910.1450, "Occupational Exposures to Hazardous Chemicals in Laboratories."