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STANDARD METHOD FOR MEASURING AND EVALUATING CHEMICAL AND PARTICLE EMISSIONS FROM ELECTRONIC EQUIPMENT USING DYNAMIC ENVIRONMENTAL CHAMBERS

Prepared for
The GREENGUARD Certification Program[SM]

By
Air Quality Sciences, Inc.

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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 Method incorporates the best-learned practices for testing and evaluating electronic equipment for GREENGUARD Certification, including computers, video monitors, televisions, DVD players, cable boxes, scanners, receivers, CD players, and speakers. 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, phthalates, ozone, and respirable particles ($PM_{2.5}$). 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. 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 Electronic Equipment requires a review of measured chemical emissions across a broader range of risk based exposure levels established by the US Environmental Protection Agency (EPA), the Agency for Toxic Substances and Disease Registry (ATSDR) of the Center for Disease Control (CDC), and the State of California Office of Environmental Health Hazard Assessment (OEHHA), This further strengthens 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 document will be updated as new test protocols and standards become available.

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SECTION 1
BACKGROUND INFORMATION

1.0 Scope

Electronic equipment 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, phthalate, ozone and respirable particle emission levels from electronic equipment using test conditions defined to simulate product use in realistic commercial office, educational, healthcare and/or residential settings. The levels of emissions are determined by observing the TVOC, IVOC, aldehyde, phthalate, ozone, and respirable particle ($PM_{2.5}$) concentrations in a dynamic environmental chamber under specified test conditions. The observed chamber concentration is then converted by a mathematical calculation to an emission rate, a product specific variable, and then modeled to obtain room concentration estimates.

The quantity of VOCs in the environmental chamber air is determined by gas chromatography/mass spectrometry (GC/MS). 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 measured using gas chromatography with mass spectrometry. Ozone is measured using a UV-absorbance based ozone analyzer. Respirable particles ($PM_{2.5}$) are monitored using a 90° light scattering measurement to continuously determine airborne particle concentrations over time. Specialized analysis of chamber air samples may be conducted for other specific target chemicals as specified for a specific product/project requirement.

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

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

1.0.3 This protocol applies to any electronic equipment belonging to a product category generally used within an enclosed indoor environment. This includes, for example, computers, video monitors, televisions, DVD players, cable boxes, scanners, receivers, CD players, and speakers 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 involved with use of the materials as an installer or manufacturer.

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 electronic equipment.

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 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 electronic equipment and their emission parameters to assist in risk evaluations.

1.1.1.7 Rank and evaluate products within a category or across categories with 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 electronic equipment components.

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

1.1.2.3 Large (> 25 m^3) chambers are used for the evaluation of electronic equipment systems.

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.

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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
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 organic compounds
LOQ – Limit of quantitation, lower
MFC – Mass flow controller
MRL - Minimal Risk Level
MSDS – Material safety data sheet
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
WEEL – Workplace Environmental Exposure Level

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 the 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.

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.

Electronic Equipment – A category of equipment without printing function capabilities, such as computers, video monitors and televisions.

Emission Rate (ER) – The rate of emission of a specific compound defined as the total μg/hr of a chemical emitted from a product.

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

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

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

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

Loading Factor or Loading Ratio (L) - The ratio of the area of exposed surface(s) of the test specimen to the chamber volume (m^2/m^3). This can also be expressed as the number of units per chamber volume (units/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.

Ozone - A molecule consisting of three oxygen atoms. Ground-level ozone is an air

pollutant with harmful effects on the respiratory systems of humans.

$PM_{2.5}$ – Particles less than 2.5 micrometers in diameter (respirable particles).

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 unit (1 unit/m^3). See Loading Factor.

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.

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 Phthalates - The sum of the target list phthalates, which includes diethylhexyl phthalate, butyl benzyl phthalate, di-n-octyl phthalate, dibutyl phthalate, diethyl phthalate, and dimethyl phthalate.

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	$\mu g/m^3$
ER	Emission rate	µg/hr
k	Rate constant	hr^{-1}
L	Product loading factor	$unit/m^3$ (# of devices/chamber volume)
N	Chamber air exchange rate	hr^{-1}
N_e	Modeled air changes per hour	hr^{-1}
SER	Product specific emission rate	µg/unit·hr
T	Time after start of test	hr or day
t	Time	hr
V	Volume	m^3

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

2.0 Sample Collection

Purpose

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

2.1 Representative Sample

2.1.1 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. The electronic equipment may be a prototype or taken from the current production line. The manufacturer is responsible for ensuring that the prototype is identical to the latter serial product.

2.2 Sample Preservation

2.2.1 Product samples shall be packaged using the manufacturers standard product packaging materials.

2.2.2 After a check to ensure that the delivered contents are correct and undamaged, the product will be stored in the original packaging in an environmentally controlled indoor environment free of contamination with environmental control of 20º – 25ºC and relative humidity no greater than 60% RH.

2.3 Chain of Custody Documentation

2.3.1 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.

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

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

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

2.3.5 Sample Details – Sample ID, Product Category, Product Subcategory (if applicable), Product Name, Manufacturers Identification Number, Date Manufactured

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

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

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

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

2.4 Receipt of Samples by Laboratory

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

2.4.1 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.

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

2.4.3 If containers are damaged or missing, the laboratory will notify the manufacturer as

soon as feasible.

2.4.4 If a package or container is significantly damaged or the other criteria are not met, the laboratory shall reject the sample as described in Section 2.5.

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

2.4.6 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.

2.5 Rejection of Samples by Laboratory

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

2.5.2 Shipping package is severely damaged upon arrival.

2.5.3 Product container is damaged upon arrival so that integrity of the sample is compromised.

2.5.4 Chain of Custody form is missing or incomplete.

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

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

2.5.7 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.

2.6 Storage of Samples by Laboratory Prior to and Following Testing

2.6.1 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. Testing should take place as soon as possible, but no later than ten days after receipt

2.6.2 After Testing: Following testing and report issuance, the product is stored until returned to the manufacturer. 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 Machine Set-up for Laptop Computers, Desktop Computers, and Monitors

3.0.1.1 Laptop computers and desktop computers will be set-up with a monitor and keyboard connected from outside the chamber. Monitors will be controlled from outside the chamber using a laptop computer.

3.0.1.2 Initial set-up for all machines

3.0.1.2.1 Go through instrument set-up and skip all possible steps

3.0.1.3 Change "screen saver" settings

3.0.1.3.1 Right Click on background and Select "Properties"

3.0.1.3.2 Click on "Screen Saver" tab

3.0.1.3.3 Set to "Mystify" and "1 minute"

3.0.1.3.4 Click "Power"

3.0.1.3.5 Set "Turn Off Monitor" to "Never" for both settings

3.0.1.3.6 Set "Turn Off Hard Disks" to "Never" for both settings

3.0.1.3.7 Set "Standby" to "Never" for both settings

3.0.1.3.8 Set "Hibernate" to "Never" for both settings

3.0.1.3.9 Click "Apply" then "OK"

3.0.1.4 Change to Dual Viewing (for Laptop computers only)

3.0.1.4.1 Right Click on background and select "Graphic Properties"

3.0.1.4.2 Adjust to dual settings; primary = monitor and secondary = laptop (product being tested inside chamber).

3.0.1.5 Verify Changes

3.0.1.5.1 Power down machine

3.0.1.5.2 Re-start machine (make sure external monitor is connected when evaluating computers)

3.0.1.5.3 Confirm that the image appears on the external monitor and the Mystify screen saver is activated after one minute.

3.0.2 Set-up for TVs, Cable Boxes, DVD Players, CD Players and Receivers

3.0.2.1 Plug in and turn on

3.0.2.2 Adjust setting such that unit will operate/play continuously for 8 hours.

3.0.3 Set-up for Other Electronic Equipment

3.0.3.1 Plug in and turn on

3.0.3.2 Adjust setting such that unit will operate continuously for 8 hours or as long as possible.

3.0.4 Test Specimen Burn In

3.0.4.1 Upon completion of test specimen preparation and prior to testing, power the device on to allow the test specimen to burn in for 1 hour.

3.1 **Environmental Chamber Testing**

3.1.1 *Facilities*

3.1.1.1 Chemical Emissions - A facility designed and operated to measure organic emissions and emission rates electronic equipment should contain environmental test 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.

3.1.2 *Equipment*

3.1.2.1 Environmental Test Chamber Requirements - The chamber and analytical requirements are fully defined in the referenced ECMA 328 document and the "GREENGUARD Product Certification Program Laboratory Qualifications and Proficiency Requirements", based on 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.

3.1.3 *Chamber Sizes*:

3.1.3.1 Small (0.05 – 1 m^3) chamber evaluations are used to determine source emission rates and emissions factors from electronic equipment components.

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

3.1.3.3 Large (> 25 m^3) chambers are used for the evaluation of electronic equipment systems.

3.2 **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) and in the referenced ECMA 328 document.

3.2.1 *Principle:* The principle of the test is to determine the specific emission rates of VOCs, phthalates and ozone emitted from electronic equipment. Testing is conducted in an environmental chamber at specified constant conditions of temperature, relative humidity, and ventilation rate. 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 and the VOC concentration an emission rate is calculated using the state-state form of the mass-balance model. The chamber test is conducted following the guidance of ECMA 328, 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".

3.2.2 *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.

3.2.3 *Duration:* The chamber test shall last 8 hours, but may be extended to a longer period to capture on-going emissions patterns, emitting VOCs, and their levels. Sealing of the chamber following insertion of the product specimen into the chamber establishes the zero time or start of the test.

3.2.4 *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%.

3.2.5 *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.

3.3 **Chamber and materials**:

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

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

3.3.3 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.

3.3.4 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/m^3 are not irreversibly retained on the interior surfaces.

3.3.5 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.

3.4 **Temperature and humidity control**: The temperature of the chamber shall be maintained at 23 ±2°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).

3.5 **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.

3.6 **Procedures**

3.6.1 *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.

3.6.2 *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.

3.6.3 *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.

3.7 **Air Sampling**

3.7.1 *Sampling schedule:* For GREENGUARD Certification tests for electronic equipment, chamber air samples shall be collected for VOCs and aldehydes centered around the elapsed times of 0.5, 1.5, 2.5, 4 and 8 hours after initiating the chamber test, or as otherwise dictated by the test program or specification requirements. 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 electronic equipment are collected centered around the 6 hour point. Ozone and respirable particles ($PM_{2.5}$) are continuously monitored.

3.8 **Sampling Media**

3.8.1 VOC sampling media for individual VOCs and TVOC shall consist of thermally desorbed, solid-phase sorption tubes containing Tenax-TA. Refer to ASTM documents D6196 and D 6345, and U.S. EPA Methods TO-1 and TO-17. The samplers shall be capable of quantitatively collecting VOCs with a broad range of functional groups and volatilities approximately within the volatility range of n-butane through n-octadecane, although TVOC is based on response from n-hexane through n-hexadecane (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.

3.8.2 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.

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

3.8.4 *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.

3.8.5 *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 acetontrile that may be present in the DNPH cartridge. The total sampling flow rate at any time shall not exceed 75% of the inlet flow rate. The start and stop times and the sampling flow rates shall be recorded. A unique identification number is assigned to each air sample.

3.8.6 *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.

3.8.7 *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.

3.9 Chemical and Particle Analyses

3.9.1 *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.

3.9.2 *Analytical Instruments*

3.9.2.1 VOCs and TVOC: Sorbent tube samples for individual VOCs and TVOC shall be analyzed by thermal desorption GC/MS (TD-GC/MS). The thermal desorber desorption and inlet parameters shall be optimized to obtain quantitative recovery of 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.

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

3.9.2.3 Phthalates: Sampling tube samples for phthalates shall be analyzed by GC using a flame ionization detector (FID).

3.9.2.4 Ozone: A UV-absorbance based ozone analyzer or equivalent is used for ozone measurements.

3.9.2.5 $PM_{2.5}$: Respirable particles are measured using a laser photometer aerosol monitor set-up for the collection of particles less than 2.5 microns.

3.9.3 *Methods for Individual VOCs (Analytical Methods)*

3.9.3.1 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.

3.9.3.2 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.

3.9.3.3 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).

3.9.4 *TVOC Method*

3.9.4.1 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.

3.9.5 *Identification of Individual VOCs*

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

3.9.5.2 If no high quality match is obtained, the unknown spectrum is compared to spectra contained in the latest version of the NIST/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.

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

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

3.9.6 *Analytical Calibrations*

3.9.6.1 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.

3.9.6.2 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.

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

3.9.7 *Ozone Method*

3.9.7.1 Ozone measurements are made using an analyzer which operates based on the strong UV absorbance of ozone at 254 nm. A ratio of the sample absorbance to that of air with ozone catalytically removed is used to determine the concentration in the sample. The instrument is pre-calibrated prior to use, and satisfies requirements for USEPA ambient ozone monitoring.

3.9.8 *Respirable Particles ($PM_{2.5}$) Method*

3.9.8.1 Particle concentrations are measured using an aerosol monitor set-up for the collection of particles less than 2.5 microns ($PM_{2.5}$).

3.9.9 *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.

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

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

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

3.9.9.4 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.

3.9.9.5 The quantifiable level for phthalates is 10 µg based on a standard 240 L air collection volume.

3.9.9.6 The quantifiable level for ozone is 10 µg m^{-3}.

3.9.9.7 The quantifiable level for respirable particles is 10 µg m^{-3}.

3.10 **Calculations**

3.10.1 *Emission Factor Calculations*:

3.10.2 Conversion from chamber concentration (C) (µg/m³) to emission factor (EF) (µg/m²·hr)

3.10.2.1 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/unit·hr)
C = chamber concentration (µg/m³) (less any background concentration of chamber)
N = chamber air exchange rate (hr^{-1})
L = product loading (unit/m³)

3.10.2.2 For electronic equipment, loading is considered as a unit of 1 per volume (m³).

3.10.2.3 Average and Maximum Emission Rates

3.10.2.3.1 The average emission rate is the time weighted average of the emission factors determined at the sampling timepoints, nominally 0.5, 1.5, 2.5, 4 and 8 hours. The average emission rate is determined based on detection of the chemical at all available time points when the maximum emission rate exceeds the quantifiable level. The average emission factor is thus calculated using the following equation:

$$E_{avg} = \{[(E_{0.5} + E_{1.5} + E_{2.5})/3]*3 + [(E_4 + E_8)/2]*5\}/8$$

3.10.2.3.2 The maximum emission rate is the highest maximum emission factor determined at the sampling timepoints, nominally 0.5, 1.5, 2.5, 4 and 8 hours. The maximum emission rate is independently determined for each compound identified.

3.10.3 *Exposure Modeling*

3.10.3.1 The emission rates of individual VOCS, TVOC, formaldehyde, total aldehydes, phthalates, ozone and respirable particles 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.

3.10.3.2 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 electronic equipment is used is well-mixed.

The space within which the electronic equipment used 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 electronic equipment are calculated based on the average emission rate observed and the maximum emission rate observed over the nominal 8-hour testing period. The average concentration determined assumes 8-hours of equipment operation during an 8-hour working day. The maximum concentration assumes a single exposure at the maximum level each day. The predicted average or maximum exposure concentration is calculated for each compound using the following equations:

$$C_{avg} = E_{avg}/(N \times V)$$

where:

C_{avg} = the average predicted daily concentration (µg/m³) of a given compound in the workspace;
E_{avg} = the average emission rate (µg-unit/hr), over the 8 hour testing period, of the compound of interest;
N = the air exchange rate (hr^{-1}) in the workspace, assumed to be 0.72 ACH;
V = the volume (m³) of the workspace, assumed to be 32 m^3;

$$C_{max} = E_{max}/(N \times V)$$

where:

C_{max} = the maximum predicted concentration (µg/m³) of a given compound in the workspace;
E_{max} = the maximum observed 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 (m³) of the workspace, assumed to be 32 m^3;

3.10.3.3 For GREENGUARD and GREENGUARD Children & Schools Annual Certification tests, the average and maximum emission factors are used to determine compliance with the GREENGUARD Criteria (Section 4) by calculating exposure concentrations (Section 3.10.3.2). The office model as detailed in Section 3.10.3.3.1 is always used as it is the most conservative use scenario due to extended daily exposure durations (8 hours for office vs. 2 hours for classroom), weekly exposure frequency (5 days vs. 3 days), and daily air change rate variables (0.72 ACH v.s 2.8 ACH). The building parameters including ventilation rate and material loading used in the calculations are detailed in Table 6.4.

3.10.3.3.1 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.

3.10.3.3.2 Classroom - Classroom ventilation rates are based on the ASHRAE 62.1-2007 ventilation standard for acceptable indoor air quality. The classroom ventilation rate is based on the ASHRAE parameters of 10 CFM per person and 0.12 CFM/ft² for classrooms in educational environments. These parameters are applied to a classroom (40' x 24' x 8.5' or 231 m³) with occupancy of 27 students, which results in a ventilation rate of 2.8 ACH.

3.10.4 *Conversion to ppm*

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

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

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

SECTION 4
TARGET CHEMICALS AND MAXIMUM ALLOWABLE CONCENTRATIONS

4.0 GREENGUARD Certification

Allowable Limits for GREENGUARD Product Certification: Requirements for maximum (acute) and average (chronic) exposures 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] (Occupational Exposure Levels)	Less Than 1/10 the STEL/C corresponding to the ACGIH TLV and AIHA WEEL (or Less Than the TWA if no STEL/C)	Less Than 1/100 the TWA corresponding to the ACGIH TLV and AIHA WEEL
Total Phthalates (mg/m^3)[8]	NA	≤0.01
Ozone (ppm)	NA	≤0.05
Respirable Particles ($PM_{2.5}$) (mg/m^3)[9]	NA	≤0.035

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 the concentration corresponding to an E-5 risk level for the EPA Inhalation Unit Risk (IUR). 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 Short-Term Exposure Level or Ceiling (STEL/C) listed as an American Conference of Government Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) or American Industrial Hygiene Association (AIHA) Workplace Environmental Exposure Limit (WEEL), or no greater than the Time-Weighted Average TLV or WEEL if no STEL/C available. For the long-term exposure comparison, all VOC's must be less than 1/00 the TWA listed as an ACGIH TLV or AIHA WEEL.

[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).

[9]Respirable particles are based on the National Air Quality Ambient Standard 24-hour average, promulgated January, 2007. Results based on an 8-hour average.

	Short-Term (Acute)*	Long-Term (Chronic)*
Step 1		
For All Emission Criteria	The maximum emission rate ($\mu g/m^2$-hr) measured during an 8-hour testing period is combined with product use assumptions (product loading, ventilation rate, building volume) to determine a predicted exposure concentration ($\mu g/m^3$) as a result of product use.	The average (8-hour time-weighted) emission rate ($\mu g/m^2$-hr) is combined with product use assumptions (product loading, ventilation rate, building volume) to determine a predicted exposure concentration ($\mu g/m^3$) as a result of product use.
Step 2		
TVOC	The maximum predicted TVOC exposure concentration is compared directly to the GREENGUARD TVOC criterion.	The average predicted TVOC exposure concentration is used as a conservative proxy for chronic exposure and is compared directly to the GREENGUARD TVOC criterion.
Formaldehyde	The maximum predicted formaldehyde exposure concentration is compared directly to the GREENGUARD formaldehyde criterion.	The average 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 average 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 average predicted exposure 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 average 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 average predicted exposure 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 maximum 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 maximum 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 (Occupational Exposure Levels)	Individual VOCs detected in the emissions from the product for which an MRL, AREL, or MADL has not been established are compared to databases of chemicals for which Threshold Limit Values (TLVs) or Workplace Environmental Exposure Limits (WEELs) 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 and/or WEEL are selected for further analysis. For these compounds, the maximum predicted exposure concentration for each chemical is compared to 1/10th of its corresponding Short Term Exposure Limit or Ceiling value (STEL/C) TLV or WEEL or to the Weighted Average (TWA) TLV or WEEL 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 databases of chemicals for which Threshold Limit Values (TLVs) or Workplace Environmental Exposure Limits (WEELs) 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 and/or WEEL are selected for further analysis. For these compounds, the average predicted exposure concentration for each chemical is compared to 1/100th of its corresponding Time Weighted Average (TWA) TLV or WEEL for determination of compliance with the GREENGUARD criteria.

* Standard application of the data for the GREENGUARD program uses directly the average predicted exposure concentration as a conservative proxy for chronic exposure and the maximum predicted concentration as a conservative proxy for acute exposure. Upon request by the manufacturer, a full risk assessment may be undertaken to determine chronic and acute exposure concentrations.

4.1 GREENGUARD Children & Schools

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

4.2 VOCs with Existing TLVs and CA CRELs

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		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*	70
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
1,4-Dioxane	123-91-1	720	1500
Xylene (o-,m-,p-isomers)	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
2-Methoxyethanol	109-86-4	160	30
2-Methoxyethyl acetate (Ethylene glycol methyl ether acetate)	110-49-6	240	45
Methyl chloroform (1,1,1-Trichloroethane)	71-55-6	19100	500
Methyl-tert-butyl ether (MTBE; tert-Butyl methyl ether)	1634-04-4	1800	4000
Naphthalene	91-20-3	520	4.5
p-Dichlorobenzene (1,4-Dichlorobenzene)	106-46-7	600	400
Phenol	108-95-2	190	100
Phthalic anhydride (1,3-Isobenzofurandione)	85-44-9	61	10

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)	1/2 Chronic[b] REL (µg/m³)
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
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	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)	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	

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)	1/2 Chronic[b] REL (µg/m³)
Acrylic acid (2-Propenoic acid)	79-10-7	59	
Acrylic acid, ethyl ester (Ethyl acrylate)	140-88-5	200	
Acrylic acid, methyl ester (Methyl acrylate; 2-Propenoic acid, methyl ester)	96-33-3	70	
Acrylic acid, n-butyl ester (n-Butyl acrylate; 2-Propenoic Acid, butyl ester)	141-32-2	110	
Adipic acie (Hexanedioic acid)	124-04-9	50	
Adiponitrile	111-69-3	88	
Aldrin	309-00-2	2.5	
Allyl alcohol (2-Propen-1-ol)	107-18-6	11.9	
Allyl chloride (1-Propene, 3-chloro)	107-05-1	30	
Allyl glycidyl ether (AGE; Oxirane, [(2-propenyloxy)methyl]-)	106-92-3	47	
Allyl propyl disulfide	2179-59-1	30	
α-Chloroacetophenone (Phenacyl chloride)	532-27-4	3.2	
α-Methylstyrene (iso-Propenylbenzene; (1-Methylethenyl)benzene)	98-83-9	2420	
α-Pinene	80-56-8	1120	
Aniline	62-53-3	76	
Anisidine (o,p-isomers)	29191-52-4	5	
ANTU (α-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	

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)	1/2 Chronic[b] REL (µg/m³)
Cyclohexylamine	108-91-8	410	
Cyclopentadiene	542-92-7	2030	
Cyclopentane	287-92-3	17200	
S-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	

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)	1/2 Chronic[b] REL (µg/m³)
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	

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)	1/2 Chronic[b] REL (µg/m³)
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-α,α'-diamine	1477-55-0	1*	
N,N-Dimethylacetamide	127-19-5	360	
n-Amyl acetate (1-Pentyl acetate; Acetic acid, pentyl ester)	628-63-7	2260	
n-Butanol (N-Butyl alcohol)	71-36-3	610	
n-Butyl acetate	123-86-4	7130	
n-Butyl glycidyl ether (BGE)	2426-08-6	1330	
n-Butyl lactate (Propanoic acid, 2-hydroxy-, butyl ester)	138-22-7	300	
n-Butylamine	109-73-9	150*	
N-Ethylmorpholine	100-74-3	240	
Nicotine (Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)-)	54-11-5	5	
N-Isopropylaniline	768-52-5	110	
Nitrapyrin (2-Chloro-6-(trichloromethyl) pyridine	1929-82-4	100	
Nitrobenzene	98-95-3	50	
Nitroethane	79-24-3	3070	
Nitromethane	75-52-5	500	
Nitrotoluene, m-isomer (3-Nitrotoluene)	99-08-1	110	
Nitrotoluene, o-isomer (2-Nitrotoluene)	88-72-2	110	
Nitrotoluene, p-isomer (4-Nitrotoluene)	99-99-0	110	
N-Methyl aniline (Monomethyl aniline)	100-61-8	22	
Nonane	111-84-2	10500	
n-Propyl acetate	109-60-4	8350	
n-Propyl alcohol (n-Propanol)	71-23-8	4920	
n-Propyl nitrate (Nitric acid, propyl ester)	627-13-4	1070	
n-Valeraldehyde	110-62-3	1760	
N-Vinyl-2-Pyrrolidinone (1-Vinyl-2-pyrrolidinone)	88-12-0	2.3	
o-Anisidine (Benzenamine, 2-methoxy-)	90-04-0	5	
o-Chlorobenzylidene malononitrile	2698-41-1	3.9*	
o-Chlorostyrene	2039-87-4	2830	
o-Chlorotoluene (Toluene, 2-chloro)	95-49-8	2590	
Octachloronaphthalene	2234-13-1	1	
Octane, All isomers	111-65-9	14010	
Octane, All isomers	540-84-1	14010	
o-Methylcyclohexanone	583-60-8	2290	
o-Nitrobenzene (Dinitrobenzene)	528-29-0	10	
o-Phenylenediamine	95-54-5	1	
o-sec-Butylphenol	89-72-5	310	
o-Toluidine	98-53-4	88	

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)	1/2 Chronic[b] REL (µg/m³)
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	

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)	1/2 Chronic[b] REL (µg/m³)
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 (β-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	

CHEMICAL	CAS NUMBER	1/100 TLV[a] (µg/m³)	1/2 Chronic[b] REL (µg/m³)
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, 2009 Threshold Limit Values for Chemical Substances and Physical Agents, Cincinnati, OH

[b] - http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html - Chronic Reference Exposure Levels (CRELs) adopted by the State of California Office of Environmental Health Hazard Assessment (OEHHA), December 2008

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

** 1/2 OEHHA staff recommended indoor air limit for formaldehyde

SECTION 5
REQUIRED ELEMENTS OF THE LABORATORY TEST REPORT

5.0 Required Elements of the Laboratory Test Report

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 room volume, product loading, and ventilation rate.

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);
EPA Reference Concentrations (RfC);
CA Acute Reference Exposure Levels (AREL);
ACGIH Threshold Limit Values (TLV);
AIHA Workplace Environmental Exposure Levels (WEEL);

5.0.8 Provide estimated average and maximum concentrations for modeled building scenarios for TVOC, formaldehyde, and target list chemicals. Provide estimated average concentrations for phthalates, ozone and respirable particles ($PM_{2.5}$).

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
Electronic Equipment	
Manufacturing date	Date product comes off of final manufacture line
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 48 hr test period

3.10.3 Parameter	Symbol	Units	Value
Chamber volume	V	m^3	0.05 – 31
Loading factor	L	unit/ m^3	0.03 – 1.0
Air change rate	a	hr^{-1}	1.00 ± 0.05
Temperature	T	ºC	23 ± 2
Relative humidity	RH	%	50 ± 5

Table 6.3 All chronic inhalation Reference Exposure Levels (RELs) adopted by Cal/EPA OEHHA as of December 2008.

Substance (CAS #)	*Listed in CAPCOA - 1993*	*Chronic Inhalation REL (µg/m³)*	*Hazard Index Target(s)*	*Human Data*
Acetaldehyde (75-07-0)	√	70	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	√
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	

Substance (CAS #)	*Listed in CAPCOA - 1993*	*Chronic Inhalation REL (µg/m³)*	*Hazard Index Target(s)*	*Human Data*
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	√
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	

Substance (CAS #)	*Listed in CAPCOA - 1993*	*Chronic Inhalation REL (µg/m³)*	*Hazard Index Target(s)*	*Human Data*
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)	√	9	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)	
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	

Substance (CAS #)	*Listed in CAPCOA - 1993*	*Chronic Inhalation REL (µg/m³)*	*Hazard Index Target(s)*	*Human Data*
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	GG Office Model
Room Length	10 ft
Room Width	14 ft
Room Height	8 ft
Room Volume	32 m^3
Air exchange Rate	0.72 hr^{-1}
# of units	1