



UL 2822

GREENGUARD Certification Program Method For Measuring And Evaluating Chemical Emissions From Cleaners And Cleaning Maintenance Systems Using Dynamic Environmental Chambers

GREENGUARD Certification Program Method For Measuring And Evaluating Chemical Emissions From Cleaners And Cleaning Maintenance Systems Using Dynamic Environmental Chambers, UL 2822

First Edition, Dated March 29, 2013

Summary of Topics

This revision to 2822 is issued for editorial updates.

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**GREENGUARD Certification Program Method For Measuring And
Evaluating Chemical Emissions From Cleaners And Cleaning Maintenance
Systems Using Dynamic Environmental Chambers**

First Edition

March 29, 2013

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Comments or proposals for revisions on any part of the Document may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <http://csds.ul.com..>

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PREFACE

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. UL Environment provides Greenguard Certification to 1) bring together performance based, field validated documents 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 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. 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 Certification Gold incorporates additional criteria to provide a higher margin of safety for young children and sensitive populations. This document reduces allowable chemical levels. It also requires that emissions meet the 1/2 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 Certification Program for Chemical Emissions for Cleaners and Cleaning Maintenance 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 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 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 method is maintained by UL Environment. The master document at UL Environment 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.

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GENERAL

1 Scope

1.1 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 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, or aldehyde 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. Specialized analysis of chamber air samples may be conducted for other specific target chemicals as required for a specific product/project requirement.

1.2 This method may be used for certification solely by UL and its affiliated entities in the UL GREENGUARD certification program. Accordingly, only UL or its affiliated entities can determine and declare whether a product is in compliance with the requirements in this method. Any purported determination or declaration of testing, conformance, compliance or certification to this method by any other party is null and void and cannot be used to meet the requirements of this method.

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

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

1.5 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.

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

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

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

1.9 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.

1.10 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.

2 Objectives and Use

2.1 Objectives

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

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

2.1.3 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.

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

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

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

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

2.1.8 Provide compound specific emission parameters for use in indoor exposure models

2.2 Use

2.2.1 Small ($0.05 - 1 \text{ m}^3$) chamber evaluations are used to determine source emission rates and emissions factors from dilute cleaning products.

2.2.2 Intermediate (approximately $1 - 6 \text{ m}^3$ volume) chamber evaluations are used to determine source emission rates and emission factors from concentrated cleaning products.

2.2.3 Large ($> 25 \text{ m}^3$) chambers are used for the evaluation of cleaning systems and aerosol cleaners.

2.2.4 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.

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

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

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4 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

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-Dinitrophenylhydrazine

EF – Emission factor

EPA – U.S. Environmental Protection Agency

GC/MS – Gas chromatography/mass spectrometry

HAP – Hazardous Air Pollutant

HPLC – High performance liquid chromatography

IAQ – Indoor Air Quality

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

SDS – 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

5 Definitions

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

5.2 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.

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

5.4 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).

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

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

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

5.8 Background Concentrations – VOC and aldehyde concentrations in emission test chamber in the absence of a product test specimen.

5.9 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.

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

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

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

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

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

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

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

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

5.18 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.

5.19 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.

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

5.21 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).

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

5.23 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.

5.24 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.

5.25 Product Category – General group of similar products intended for a particular application and performance.

5.26 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).

5.27 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).

5.28 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.

5.29 Representative Product Sample – A product sample, which is representative of the product manufactured and produced under typical operating conditions.

5.30 Sampling Interval – Time over which a single air sample is collected.

5.31 Sampling Period – Established time for collection of an air sample from the emission test chamber.

5.32 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.

5.33 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.

5.34 Test Protocol – A defined cleaning process with specified materials, chemicals, application instructions and equipment for implementation in an environmental chamber.

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

5.36 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.

5.37 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.

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

5.39 Ventilation Rate – Same as air change rate.

5.40 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.

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

6 Symbols

Symbol	Description	Units
A	Projected surface area	m ²
C	Chamber concentration	µg/m ³
C _{P,t}	Predicted exposure concentration at time t	µg/m ³
EF	Emission factor	µg/m ² ·hr or µg/g·hr or µg/unit·hr or µg/event
EF ₀	Initial emission factor	µg/m ² ·hr or µg/g·hr or µg/unit·hr or µg/event
EF _t	Measured emission factor at time t	µg/m ² ·hr or µg/g·hr or µg/unit·hr or µg/event
ER	Emission rate	µg/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	µg/m ² ·hr
T	Time after start of test	hr or day
t	Time	hr
V	Volume	m ³
v _{fB}	Building ventilated volume fraction	Unitless

PRODUCT SAMPLE COLLECTION, PACKAGING, SHIPMENT, AND DOCUMENTATION

7 Purpose

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

8 Personnel

8.1 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.

8.2 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.

9 Representative Sample

9.1 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.

10 Sample Preservation

10.1 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.

10.2 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.

10.3 Product samples may be packaged in two ways:

- a) Using the manufacturers standard product packaging materials, including sealed containers (as provided to distributors and/or customers); or
- b) 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.

10.4 The product will remain in its packaging as received, or transferred to a specialized bag (see Section 10.3), foil bag or otherwise sealed to preserve the integrity of the sample, until immediately prior to loading into the environmental chamber. Until it is unpacked it will be stored in an environmentally controlled indoor environment free of contamination with environmental control of 20° – 25°C and relative humidity no greater than 60% RH.

11 Location of Sampling

11.1 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.

12 Sample Age

12.1 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.

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

12.3 Samples shall arrive at the testing laboratory within 7 days of shipment, although overnight shipment is recommended for small products.

12.4 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.

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

Dry/Wet Products

Manufacturing Date	Date Product comes off of final manufacturing line
Sample Collection	Same as Manufacture 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

13 Sample Collection Procedures

13.1 Containerized and Wet Products

13.1.1 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 COC must be fully completed. The CoC (Section 16) shall be attached to the outside of the sample package. A 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 Safety Data Sheet (SDS) 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.

14 Packaging and Shipment of Samples

14.1 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 10).

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

14.3 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.

15 Chain of Custody Documentation

15.1 The manufacturer is responsible for the completion of the 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 UL Environment. Each signatory shall retain a copy of this document.

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

a) Manufacturer/Company Details

- 1) Name,
- 2) Street Address,
- 3) City, State/Province,
- 4) Country,
- 5) Zip/Postal Code

b) Contact Details

- 1) Contact Name,
- 2) Title,
- 3) Phone Number,
- 4) Fax Number,
- 5) Email Address

c) Sample Details

- 1) Sample ID,