



UL 2821

UL GREENGUARD Certification Program Method for Measuring and Evaluating Chemical Emissions From Building Materials, Finishes and Furnishings

August 24, 2022

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**GREENGUARD Certification Program Method for Measuring and Evaluating
Chemical Emissions From Building Materials, Finishes and Furnishings**

Second Edition

August 24, 2022

Summary of Topics

This new second edition GREENGUARD Certification Program Method for Measuring and Evaluating Chemical Emissions From Building Materials, Finishes and Furnishings, UL 2821 dated August 24, 2022, has been issued to include the calibration list for individual chemicals and their sources, and remove outdated references to outside criteria.

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PREFACE

Testing procedures for the GREENGUARD Certification program were initially developed and applied to cover a breadth of product types and building applications. The science of measuring product emissions developed from research conducted by the Environmental Protection Agency, Department of Energy, the Department of Housing and Urban Development, the Consumer Product Safety Commissions, California Department of Public Health, the State of Washington Department of General Administration, and additional national and international researchers. The GREENGUARD Certification Program seeks to 1) bring together performance based, field validated requirements and test methods to define and measure low emitting products and materials for the indoor environment; 2) provide a third party, non-industry and publicly available certification process for manufactured products; and 3) establish a public directory of certified products for architects, designers, specifiers, purchasers, and consumers.

The following test method (Method) incorporates the best-learned practices for testing and evaluating products for third party certification and specification programs such as GREENGUARD Certification, the California Department of Public Health Standard Method V1.2, "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.2 (CDPH Standard Test Method V1.2)", ANSI/BIFMA M7.1 and ANSI/BIFMA X7.1, the German Blue Angel Programs, the Green Guide for Health Care, the National Association of Home Builders (NAHB) Green Standards, MBDC's Cradle to Cradle, Collaborative for High Performance School Program (CHPS), LEED, Green Globes, and other private and government programs.

The Method is applicable to office furniture, paints and coatings, adhesives and sealants, wallboard and insulation, flooring, ceilings, window furnishings, and other dry and wet materials. Elements of the method include sample handling and shipment, sample preparation, product loadings and descriptions, environmental chamber methodology, analytical measurements, exposure modeling and allowable levels. Analytes include total volatile organic compounds (TVOC), individual VOCs, formaldehyde, total aldehydes, and specialized pollutants as defined by specific programs. All individual VOCs or pollutants emitting from products are measured as prescribed by the Method, and each measured analyte is required to meet defined allowable levels as specified by the certification or specification programs.

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

The GREENGUARD Gold Certification incorporates criteria to provide a higher margin of safety. This certification lowers allowable chemical levels and requires that emissions meet the 1/2 CREL criteria of specified target chemicals as listed in the CDPH Standard Test Method V1.2, as recognized and referenced by the national Collaborative for High Performance Schools (CHPS) programs and USGBC LEED programs. This test method ensures that product testing and calculations of estimated building concentrations meet or exceed the requirements of the CDPH Standard Method V1.2 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers Version 1.2" with applicable emissions criteria as defined by the specific standard. Approval of GREENGUARD Gold (as the former Children & Schools Program) and this test method was received as an acceptable alternate for the CHPS EQ P6.0 and EQ C6.1 Low-Emitting Materials Credits.

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GENERAL

1 Scope

1.1 This methodology provides a standard means of reproducibly and accurately testing building materials and products under a realistic, yet highly controlled, atmosphere.

1.2 This method may be used for certification solely by UL and its affiliated entities in the 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 measures total volatile organic compounds (TVOC), individual volatile organic compounds (IVOCs), formaldehyde, and the other aldehyde emission levels from materials using test conditions defined to simulate product use in realistic commercial office, educational, healthcare and/or residential settings.

1.4 The level of total or individual volatile organic chemical emissions is determined by observing the TVOC, IVOC, or aldehyde concentration in a dynamic environmental chamber under specified test conditions.

1.5 The observed chamber concentration is then converted by a mathematical calculation to an emission rate, a product specific variable, and then modeled to obtain room concentration estimates.

1.6 The quantity of VOCs in the environmental chamber air is determined by gas chromatography/mass spectrometry. The methodology is generally applicable to volatile organic compounds with boiling points from 60 °C to 290 °C emitting from individual products.

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

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

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

1.10 This protocol applies to any material belonging to a product category generally used within an enclosed indoor environment. This includes, for example, paints, other architectural coatings, sealants, adhesives, wall coverings, floor coverings, wood paneling, ceilings, furniture and furniture components used in public and commercial office buildings, schools, medical buildings, residences and other building types. The protocol applies to products that are to be tested whole or by a representative component or material in an environmental chamber.

1.11 This methodology is applicable for newly manufactured products before they are used in construction or furnishing.

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

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

1.14 While this practice lists specific chemicals and associated maximum allowable concentrations, as required by criteria indoor air procedures and specifications, it does not assess the human risk involved with use of the materials either as an installer and/or as an end user.

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

2 Objectives and Use

2.1 Objectives

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

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

2.1.3 Obtain emission data for use by Third Party Certification Programs such as the GREENGUARD Certification Program, the California CHPS Program, the State of CA DPH's CDPH/EHLB/Standard Method V1.2 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.2", ANSI/BIFMA X7.1, the German Blue Angel Programs, the Green Guide for Health Care, the National Association of Home Builders (NAHB), MBDC's Cradle to Cradle Certification, LEED credits, Green Globes, and other government and private product specification programs.

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 building materials, finishes and indoor furnishings and their emission parameters to assist in risk evaluations.

2.1.7 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 small products and small components of 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 larger components and smaller pieces of office furniture (chairs, file cabinets, etc.).

2.2.3 Large ($> 25 \text{ m}^3$) chambers are used for the evaluation of large products, including assembled workstations.

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.

3 References and Documents

ASTM D5116, Standard Guide for Small Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials / Products. ASTM International, West Conshohocken, PA.

ASTM D6670, Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials / Products. ASTM International, West Conshohocken, PA.

ASTM D5197, Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology). ASTM International, West Conshohocken, PA.

ASTM D6196, Practice for the Selection of Sorbents and Pumped Sampling / Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air. ASTM International, West Conshohocken, PA.

ASTM D6345, Standard Guide for Selection of Methods for Active, Integrative Sampling of Volatile Organic Compounds in Air. ASTM International, West Conshohocken, PA.

ASTM D7339, Standard Test Method for Determination of Volatile Organic Compounds Emitted from Carpet using a Specific Sorbent Tube and Thermal Desorption / Gas Chromatography. ASTM International, West Conshohocken, PA.

ASTM E741, Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution. ASTM International, West Conshohocken, PA.

USEPA Report 600/8-89/-074. Research Triangle Park, NC.

State of Washington Indoor Air Quality Specifications, Department of General Administration, Furniture Specification.

ANSI/BIFMA M7.1, Standard Test Method for Determining VOC Emissions From Office Furniture Systems, Components and Seating.

ANSI/BIFMA X7.1, Standard for Formaldehyde and TVOC Emissions of Low-emitting Office Furniture Systems and Seating.

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

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

ACGIH, Threshold Limit Values for Chemical Substances and Biological Exposure Indices. Cincinnati, OH (updated annually).

Title 40 CFR § 600.315-08 – Classes of Comparable Automobiles

Rudolf J Engelmann, William R Pendergrass, J. Randy White, Mark E Hall, The effectiveness of stationary automobiles as shelters in accidental releases of toxic materials, Atmospheric Environment. Part A. General Topics, Volume 26, Issue 17, 1992, Pages 3119-3125.

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

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

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

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

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

Cal/EPA, ARB list of Toxic Air Contaminants (TACs).

Cal/EPA OEHHA Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65).

Cal/EPA OEHHA list of chemicals with noncancer chronic Reference Exposure Levels (RELs).

CDPH/EHLB/Standard Method V1.2 "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions From Indoor Sources Using Environmental Chambers Version 1.2".

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

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

ISO 16000-9, "Indoor air – Part 9: Determination of the emission of volatile organic compounds from building products and furnishing – Emission test chamber method."

ISO 16000-11, "Indoor air – Part 11: Determination of the emission of volatile organic compounds from building products and furnishing – Sampling, storage of samples and preparation of test specimens."

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

U.S. EPA Method TO-1, Method for the Determination of Volatile Organic Compounds in Ambient Air Using Tenax Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS). Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b).

U.S. EPA Method TO-17, Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b).

4 Acronyms and Abbreviations

ACH – Air changes per hour

ARB – Air Resources Board, Cal/EPA

ASTM – ASTM International

BQL – Below quantifiable limit

BIFMA – The Business and Institutional Furniture Manufacturer's Association

CDPH – California Department of Public Health

Cal/EPA – California Environmental Protection Agency

CIWMB – California Integrated Waste Management Board, Cal/EPA

CHPS – Collaborative for High Performing Schools

COC – Chain of Custody

DL – Detection limit

DNPH – 2,4 – 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

ISO – International Organization for Standardization

IVOC – Individual Volatile Organic Compounds

LOQ – Limit of quantitation, lower

MDF – Medium density fiberboard

MFC – Mass flow controller

MSDS – See SDS – Safety data sheet

OEHHA – Office of Environmental Health Hazard Assessment, Cal/EPA

OSB – Oriented strand board

Prop 65 – California Proposition 65

QL – Quantifiable limit

REL – Reference exposure level

RH – Relative humidity in percent

SDS – Safety data sheet

TAC – Toxic Air Contaminant

TD/GC/MS – Thermal desorption GC/MS

TIC – Total ion-current chromatogram

TVOC – Total volatile organic compounds

VCT – Vinyl composition tile

VOC – Volatile organic compound

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 dry 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 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).

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

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

5.6 Aldehydes – The sum of all measured normal aldehydes from formaldehyde through nonanal, plus benzaldehyde, individually calibrated to a compound specific standard. Heptanal through nonanal are measured via TD/GC/MS analysis and the remaining aldehydes are measured using HPLC/UV analysis.

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

5.8 Chain of Custody (COC) – 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.