PRODUCT EVALUATION METHODOLOGIES

ENVIRONMENTAL CHAMBER

The product was tested in a UL Environment (ULE) environmental chamber and chemical emissions were analytically measured. The chamber operation and control measures used in this study comply with the specified GREENGUARD Standard and Test Method indicated in the test report. The chamber used is manufactured from stainless steel and/or aluminum to minimize contaminant adsorption. Air flow through the chamber enters and exits through an aerodynamically designed, stainless steel, air distribution manifold. Supply air to the chamber is stripped of formaldehyde, VOCs, and other contaminants, so that any contaminant backgrounds present in the empty chamber fall below strict levels. ULE chambers are process controlled and are equipped with a continuous data acquisition system for verification of the operating conditions of air flow, temperature, and humidity.

ANALYTICAL MEASUREMENTS

Note: all analytical measurements are not performed on every product. Please refer to the specific report for tests conducted and analysis performed

<u>Target List Aldehydes by HPLC/UV</u>

Emissions of specific aldehydes, including formaldehyde, were measured following the GREENGUARD Standard using high performance liquid chromatography (HPLC). Solid sorbent cartridges with 2,4-dinitrophenylhydrazine (DNPH) were used to collect formaldehyde and other low-molecular weight carbonyl compounds in chamber air. The DNPH reagent in the cartridge reacted with collected carbonyl compounds to form the stable hydrazone derivatives retained by the cartridge.

The hydrazone derivatives were eluted from a cartridge with HPLC-grade acetonitrile. An aliquot of the sample was analyzed for low-molecular weight aldehyde hydrazone derivatives using reverse-phase high-performance liquid chromatography (HPLC) with UV detection. The absorbances of the derivatives were measured at 360 nm. The mass responses of the resulting peaks were determined using multi-point calibration curves prepared from standard solutions of the hydrazone derivatives. Measurements are reported to a quantifiable level of 0.1 µg based on a standard air volume collection of 45 L.

<u>Volatile Organic Compounds by TD/GC/MS</u>

VOC measurements were made using gas chromatography with mass spectrometric detection (GC/MS). Chamber air was collected onto a solid sorbent which was then thermally desorbed into the GC/MS. The sorbent collection technique, separation, and detection analysis methodology has been adapted from techniques outlined in the GREENGUARD Standard. The technique is generally applicable to C_6 - C_{16} organic chemicals with boiling points ranging from 35ºC to 250ºC. Measurements are reported to a quantifiable level of 0.04 µg based on a standard air volume collection of 18 L.

Individual VOCs were separated and detected by GC/MS. The TVOC measurements were made by adding all individual VOC responses obtained by the mass spectrometer and calibrating the total mass relative to toluene. Individual VOCs were identified using ULE's specialized indoor air mass spectral database and quantitated using multipoint calibration standards, if available. Other compounds were identified with less certainty using a general mass spectral library available from the National Institute of Standards and Technology (NIST) or equivalent. Calibration is typically based on toluene equivalent unless an authentic standard is available. This library contains mass spectral characteristics of more than 75,000 compounds as made available from NIST, the USEPA and the National Institutes of Health (NIH). A match is first sought in the ULE database, which includes data for the gas chromatographic retention time of the compound in addition to the mass spectrum. This additional information, along with the use of spectra generated on ULE equipment, makes confidence in identifications made from the ULE database higher than in identifications made using only the NIST/USEPA/NIH mass spectral library.

Particle Emission Measurements (Air Handling Duct Products Only)

The particle emissions were tested in a duct assembly, which simulates the flow conditions in a typical supply air duct. An air supply system capable of supplying up to 2,000 cfm of HEPA filtered air was used to provide air to the duct material. Prior to testing, a 12 foot duct assembly constructed from the duct material to be tested was attached to the HEPA filtered air supply and an average air velocity of 1,100 ft/min was maintained in the duct. The supply air background was measured upstream from the test material to monitor background particulate levels.

Prior to sampling the particle emissions, the duct assembly was allowed to condition under test conditions (23ºC and 1,100 ft/min air flow) for 24 hours. Particle concentrations were measured over a 60 minute period in the duct airstream, 10 feet downstream from the connection point of the duct assembly to the HEPA air supply.

Continuous particle monitoring was performed using an aerosol monitor. This monitor uses a 90° light scattering measurement to continuously determine airborne particle concentrations over time. The analytical range of this instrument is 0.010 to 100 mg/m^3, with the measurement of particles ranging from 0.1 to 10 µm in diameter.

AIR CONCENTRATION DETERMINATIONS

Office Furniture and Classroom Furniture

Emission rates of formaldehyde, total aldehydes, and TVOC were used in a computer model to predict air concentrations of the pollutants. Air concentration predictions are based on standard product definitions according to BIFMA M7.1.

Compliance with the GREENGUARD Indoor Air Quality Criteria is at the 168 hour measured emission factor. The predicted exposure concentrations are calculated from the measured emission factors as identified in the standards performed. For air concentrations predicted beyond 168 hours, the emission factor is modeled according to BIFMA M7.1.

The model measurements were made with the following assumptions: air within spaces 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.

Building Products Tested in Accordance to CDPH/EHLB/Standard Method

Emission rates of formaldehyde, total aldehydes, and TVOC were used in a computer model to determine potential air concentrations of the pollutants. The computer model used the measured emission rate changes over the 168 hour time period to determine the change in air concentrations that would accordingly occur.

The emission factor can be modeled according to a first-order decay or a power law decay. Regression analysis was used to determine the model that best fits the data. The use of least squares fitting, a mathematical procedure for finding the best-fitting curve to a given set of points by minimizing the sum of the squares of the offsets of the points from the curve, dictates the appropriate model for the given product.

The model measurements were made with the following assumptions: air within spaces 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.

Indoor air quality criteria compliance with the GREENGUARD Standard is at the 168 hour measured emission factor. The predicted exposure concentrations are calculated from the measured emission factors as identified in the specified GREENGUARD Standard.

For UL Environment's technical references and resources click here or https://industries.ul.com/wp-content/uploads/sites/2/2018/02/Technical-references-and-resources.pdf