



PRODUCT EVALUATION METHODOLOGIES

ENVIRONMENTAL CHAMBER

The product was tested in a UL Environment (ULE) environmental chamber and chemical emissions were analytically measured. Chamber operation and control measures used in studies meet the requirements of ISO 16000-9, ASTM D 5116, and/or ASTM D 6670. The chamber used is manufactured from stainless steel and/or aluminum to minimize contaminant adsorption. 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

Target List Aldehydes by HPLC/UV

Emissions of selected aldehydes, including formaldehyde, were measured following ISO 16000-3, ASTM D5197 and USEPA Method TO-11A, measurement by HPLC, or high performance liquid chromatography. 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.

Volatile Organic Compounds by TD/GC/MS

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 presented by the USEPA and other researchers. The technique follows ISO 16000-6, USEPA Compendium Method TO-17, and ASTM D 6196; and is generally applicable to C₆ - C₁₆ organic chemicals with boiling points ranging from 35°C to 250°C. 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). 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.

ADDITIONAL ANALYSES

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

Carbon Dioxide (CO₂) and Carbon Monoxide (CO)

CO₂ and CO were measured continuously with a CO₂ and CO monitor. The monitor has an effective quantitation range of 1 - 5,000 ppm for CO₂ (resolution of 1 ppm) and 1 - 500 ppm for CO (resolution of 0.1 ppm)

Particulate Matter (PM_{2.5} and PM₁₀)

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 monitor simultaneously measures particles of 2.5 micrometers and smaller in size (PM_{2.5}) and 10 micrometers and smaller in size (PM₁₀). The analytical range of this instrument is 0.005 to 150 mg/m³.

Ozone

Ozone levels were measured continuously with a monitor using a dual path UV analyzer that 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 calibrated annually, and satisfies requirements for USEPA ambient ozone monitoring, including an analytical range of 0.010 to 1.000 mg/m³.

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