

Chemical Emissions From Polyurethane Spray Foam (SPF)

Polyurethane foam insulation (SPF) is a 2-component spray foam is an alternative to traditional building insulation such as fiberglass.



Figure 1. Photograph of polyurethane spray foam (SPF) with high chemical emissions applied to underside of a roof.

SPF has the advantage of also being an effective air barrier. Two components, A (isocyanates) and B (polyol resin and additives, including fire retardants), are mixed together and sprayed from an application gun onto surfaces such as the underside of roof decks and cavity side of exterior walls. We collected samples of installed SPF from 5 homes where the occupants reported odors and irritation months following the SPF application. The SPF samples included three open cell and two closed cell foams manufactured by three different manufacturers. We measured the chemical emission rates of volatile organic compounds (VOCs) according to ASTM D7706-17 using a micro-scale stainless test chamber operated at 35 °C with a 50 cc/min of ultra high purity air.

The following 7 chemicals had emission rates exceeding 25 $\mu\text{g}/\text{m}^2\text{-h}$.

Acetic acid

Allyl chloride: (25 – 1,070 $\mu\text{g}/\text{m}^2\text{-h}$)

Bis(2-(dimethylamino)ethyl)ether (BDMAEE): (500 - 550 $\mu\text{g}/\text{m}^2\text{-h}$)

1,4-Dioxane: (40 $\mu\text{g}/\text{m}^2\text{-h}$)

Hexamethylcyclotrisiloxane: (30 $\mu\text{g}/\text{m}^2\text{-h}$)

n-Hexane: (50 $\mu\text{g}/\text{m}^2\text{-h}$)

Tris(1-chloro-2-propyl)phosphate (TCPP): (450 $\mu\text{g}/\text{m}^2\text{-h}$)

Only TCPP, a common fire retardant additive to SPF, was disclosed on one of the manufacturers Safety Data Sheets (SDS), and is the only chemical with no established exposure guideline. The modeled indoor air concentrations in an attic with SPF installed to the underside of the roof deck exceeded recommended exposure guidelines for two of the six chemical with exposure guidelines; BDMAEE with an exceedance of 169 and allyl chloride with an exceedance of 36. BDMAEE is believed to be the undisclosed proprietary amine catalyst in one of the SPF samples, and allyl chloride is either an undisclosed chemical contained in the foam ingredients or are a reaction product released by the foam, possibly a hydrolyses reaction of water vapor with TCPP.

Not all SPF installations result in unacceptable VOC emissions. SPF chemical emissions can vary widely from those samples that manufacturer prepares and submits for CDPH compliance testing depending upon the on-site the mixing of the A and B components and the environmental conditions during the application of the foam. In addition, the CDPH compliance testing only certifies products for emissions of 35 chemicals, with tests conducted at room temperature. SPF VOC emissions include VOCs not included in the CDPH list of 35 and the emissions from installed SPF are substantially higher when the substrate onto which the SPF is applied is hot, such as the underside of a roof deck in the Summer when temperatures can reach 140 °F. Further, an installation of SPF insulation that has high chemical emissions often cannot be mitigated by a reasonable amount of outdoor air ventilation and these chemical emissions can persist for decades. The only sure mitigation that works is complete removal of SPF, which is difficult because of the strong adhesive bonds the SPF forms with the substrate, and removal of the substrate, which if a material is porous, such as plywood or OSB, may have absorbed significant amounts of SPF chemicals.