Problems with spray foam

The Fourth Pig creates energy efficient low carbon buildings made with healthy materials that are good for people and the planet. With this mandate we believe the downsides of spray foam far outweigh the upsides.

The information below is intended to give a sense of the issues of concern and while it is in no way comprehensive,[1] it covers environmental issues, health issues, fire issues and performance issues.

Environmental issues

There are a few environmental issues related to spray foam (air quality and health issues discussed below) but one of the issues is the embodied carbon of spray foam. The urgency to address the carbon in construction materials from the manufacturing, transportation, use and end of life is urgent. As a 2019 report from the World Green Building Council[2] the need to reduce embodied carbon is urgent. Embodied carbon, the report says, is 11% of all carbon emissions and “Carbon emissions released before the building or infrastructure begins to be used, sometimes called upfront carbon, will be responsible for half of the entire carbon footprint of new construction between now and 2050, threatening to consume a large part of our remaining carbon budget.”[3]

Circular Ecology’s inventory of Carbon and Energy (also known as the ICE database) reports that the embodied energy of poly foam is 102 MJ/KG (milajoules per kilogram) compared to 16.8 MJ/KG for rockwool, 20.9MJ/KG for recycled wool, 28MJ/KG for fibreglass and .94 to 3.3 for cellulose. In other words the embodied energy is almost four times that of fibreglass and up to 100 times that of cellulose.

In addition, unlike many other insulation materials when you use spray foam on a material it limits the ability to re-use the material. For example, when spray foaming a wood stud cavity, you are encapsulating what is essentially stored carbon with a petrochemical product, largely ensuring that its long-term life is in a landfill.

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[1] For more information see “Foam Fails” series by 475 building supply. https://foursevenfive.ca/foam-fails/ This series provided invaluable research for this document.

[2] “Bringing embodied carbon upfront:Coordinated action for the building and construction sector to tackle embodied carbon” World Building Council, September 2019 https://www.worldgbc.org/embodied-carbon

[3] Ibid

There are emerging foam products that have low global warming potential due to their use of hydrofluoroolefins (HFOs) blowing agents as alternatives to the use of hydrofluorocarbons (HFCs). However, this may result in another environmental concern - namely ozone depletion. As the Healthy Building Network reported,

> "While HFOs do not directly deplete the ozone layer or significantly contribute to global warming, many HFOs use carbon tetrachloride (CCl4) as a chemical feedstock. . . Production of carbon tetrachloride is likely to increase as industry replaces HFC blowing agents (and refrigerants), most of which aren't produced with carbon tetrachloride, with HFOs that do use CCl4 as a feedstock. With increased production and use of carbon tetrachloride, increased emissions are expected – and that's bad news for the earth's recovering ozone layer."[4]

For more on Carbon Tetrachloride see Stratsosphere-Troposhere Processes and their Role in Climate (SPARC)'s report "Mystery of Carbon Tetrachloride"[5].

Health issues

The use of spray foam carries health care risks in application, post application and in deconstruction. A 2019 report from the Healthy Building Network recommends against its use: "Avoid foam insulation, whether board or spray applied, whenever possible. Foam insulations commonly contain highly toxic flame retardants, and spray foam contains asthma-causing isocyanates."[6]

As the Living Future organization points out on their red list of materials to avoid[7] "virtually all foam insulations, contain HRFs [Halogenated Flame Retardants]" and explain:

> HRFs are a broad class of flame retardants containing chlorine or bromine that have aroused concern due to their exponential accumulation in human beings in recent years. HFRs are persistent bioaccumulative toxins, meaning that they accumulate in organisms and the broader environment, often reaching alarmingly high concentrations as they travel up the food chain. In addition, certain halogenated products have shown evidence of harm to humans and other animal species.

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[4] "Beware the Hidden Ozone Depleter: Upstream Impacts of Blowing Agents", Healthy Building Network Rebecca Stamm | August 2018 | Newsletter
https://healthybuilding.net/blog/247-beware-the-hidden-ozone-depleter-upstream-impacts-of-blowing-agents

[5] SPARC (2016), SPARC Report on the Mystery of Carbon Tetrachloride. Q. Liang, P.A. Newman, S. Reimann (Eds.), SPARC Report No. 7, WCRP-13/2016
https://www.wcrp-climate.org/WCRP-publications/2016/SPARC_Report7_2016.pdf

[6] *Guidance for Specifying Healthier Insulation and Air-Sealing Materials* Health Building Network, 2019
https://s3.amazonaws.com/hbnweb.dev/uploads/files/vKbS_NRDC-3094%20Specifying%20Healthier%20Materials%20report_05.pdf

[7] https://living-future.org/declare/declare-about/red-list/

> According to the Washington State Department of Ecology, for example, the toxicity endpoints of concern for Penta-PBDE include adverse effects on neurological development, reproduction, thyroid hormone disruption and possible liver toxicity.[8]

The U.S. Centre for Disease Control raised the issue of the need for research on spray foam and health risks a few years ago. In 2014 CBC Marketplace did a story on the "Nightmare" and health effects from improperly installed spray foam. In the CBC piece, expert Bernard Bloom notes "you're playing Russian Roulette" with your property when you decide to use spray foam. The CBC marketplace blog on the same issue[9] stated " While there are federal Canadian standards for spray foam, this directive is not policed or enforced. Some insulation companies do not make this rule clear in their contracts or brochures. According to the EPA, 'homeowners who are exposed to isocyanates and other spray foam chemicals in vapors, aerosols, and dust during or after the installation process 'run the risk of developing asthma, sensitization, lung damage, other respiratory and breathing problems, and skin and eye irritation.'""

A 2021 study[10] in the journal "Environmental Science and Technology" raises concerns about the use of polymeric flame retardant (PolyFR) in foam products and the release of harmful chemicals to humans and the enviroment in the manufacture, installation and disposal of foam products such as insulation. Additional information about this research can be found at the Green Science Policy Institute.

In terms of worker safety a recent (2018) study[11] shows that *despite spray foam application workers wearing industry standard protection*, exposure to tris 1-chloro2-propyl phosphate (TCIPP), "a suspected endocrine disruptor" were very high.

What about removing spray foam, perhaps for a future renovation project? The authors of the study reported that "The TCIPP content in the aerosol generated during foam removal/trimming with a powered brush was the highest we measured. This process generates visible clouds of airborne dust that could potentially remain in the indoor environment for long periods. The magnitude of exposures for workers performing these foam removal tasks and of homeowners is not known.[A. Bellow et al. P 63] "

Note that Wood fibre board and cellulose are also fire retarding without the use of HRFs.

Finally, when spray foam burns it also releases significant chemicals and gases harmful to human health.

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[8] Ibid

[9] "Is Spray Foam Insulation Safe?" *CBC Marketplace blog*. Oct 25, 2013
http://www.cbc.ca/marketplace/blog/is-spray-foam-safe

[10] High Production, Low Information: We Need To Know More About Polymeric Flame Retardants
Laura Minet, Arlene Blum, Seth R. Fernández, Kathryn M. Rodgers, Veena Singla, Anna Soehl, and Miriam L. Diamond
Environmental Science & Technology Article ASAP
DOI: 10.1021/acs.est.0c08126

[11] Bello, Anila & Carignan, Courtney & Xue, Yalong & M Stapleton, Heather & Bello, Dhimiter. (2018). "Exposure to organophosphate flame retardants in spray polyurethane foam applicators: Role of dermal exposure". *Environment international*. 113. 55-65. 10.1016/j.envint.2018.01.020.

Fire Hazard

Spray foam is a petroleum based product and as such it is a fire accelerant (even with the fire retardant put in spray foam). As Doug Stewart from Federated Insurance wrote "Over the years, this type of insulation has become known as 'solid gasoline' in the insurance industry."[12]

In "Reason Foam Fails #2: Unacceptable Fire Hazard" the author observes that "foam can be particularly hazardous during construction or renovation, as it is often exposed" and cites an 1989 OSHA report [13] that says "Rigid polyurethane and polyisocyanurate foams will, when ignited, burn rapidly and produce intense heat, dense smoke and gases which are irritating, flammable and/or toxic. As with other organic [carbon based petrochemical] materials the most significant gas is usually carbon monoxide. Thermal decomposition products from polyurethane foam, consist mainly of carbon monoxide, benzene, toluene, oxides of nitrogen, hydrogen cyanide, acetaldehyde, acetone, propene, carbon dioxide, alkenes and water vapor."

Notably there is good evidence[14] that the use of foam cladding played a crucial role in the Grenfell Tower fire that killed 72 people in 2017 including that "Smoke toxicity [is] 15 times greater for polyisocyanurate insulation than mineral wool." [15]

Performance

There are a few performance related issues to spray foam: 1) long term reduction in performance, 2) shrinking and cracking, 3) vapor control.

Foam's performance degrades over time in what is measured as "Long Term Thermal Resistance (LTTR) testing." However, "long-term" is defined at 15 years and what happens over decades is not well documented.[16] However in 2015 the U.S Army Corps of Engineers experimented with an "accelerated aging" simulation test and found an almost 28% degradation of R value of spray foam:

> Some of the aerogel blankets and closed cell polyurethane samples degraded by as much as 15% and 27.5%, respectively. . . . It appears that the reduction in R-values for closed cell

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[12] "Safely speaking" by Doug Stewart. Reprinted in "Building Integrated Solar PV Symposium" by Canadian German Chamber of Industry and Commerce.
http://kanada.ahk.de/fileadmin/ahk_kanada/03.Events/2013_Events/2013-04_BIPV_Symposium/Presentations/3_Sevag_Pogharian_-_Canada_BIPV_best_practices.pdf

[13] OSHA Hazard Information Bulletins
"Fire Hazard of Polyurethane and Other Organic Foam Insulation Aboard Ships and in Construction"
https://www.osha.gov/dts/hib/hib_data/hib19890510.html

[14] McKenna et al, "Fire behaviour of modern façade materials – Understanding the Grenfell Tower fire" *Journal of Hazardous Materials* Volume 368, 15 April 2019, Pages 115-123 https://doi.org/10.1016/j.jhazmat.2018.12.077

[15] Ibid

[16] Reasons Foam Fails #3 - Degrading Insulation Values.

> polyurethanes and aerogel blankets follows an exponential decay law. The significant decrease in R-value for the closed cell spray polyurethane foam is apparently due to exchange of higher and lower thermal conductivity gases in and out of the material, i.e., diffusion of air into the foams and blowing agent out of the foams.[17]

Spray foam, once cured, is rigid, though it will shrink (and it can expand and it can crack). "The curing process after spray foam is applied inherently entails shrinkage and hardening. Not only can such shrinkage result in pulling back from stud bays and other connections – which often leads to gaps in the insulation layer – it can lead to cracking within the foam structure itself. Because foam's performance is hypersensitive to slight manufacturing variations, it is best controlled by factory application. But too often spray foam is applied on the job site under poorly controlled conditions."[18]

Finally there is the issue of vapor control. Again 475 has good data on this where in wall assembly tests they conducted the wall with 2" of XPS foam board insulation resulted in unsafe levels of relative humidity for mold noting that "The vapor wants to go out and the sheathing and foam are damming it, raising the humidity and moisture levels - decreasing resilience."[19]'

Conclusion

There are almost always alternatives to the use of foam, including bio-based products such as wood fibre products or cellulose. These bio-based product alternatives are healthier to install, to be around, to repair, to remove and to re-use. These alternatives have high performance values and low embodied carbon while being fire resistant without the use of Halogenated Flame Retardants. They can make buildings energy efficient and healthy for people and the planet.

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[17] L. D. Stephenson, et al. 2015 "Prediction of Long Term Degradation of Insulating Materials" Pg. 49. Army Corps of Engineers. https://apps.dtic.mil/dtic/tr/fulltext/u2/a618149.pdf

[18] In "Foam Fails Reason #6: Inflexible and Prone to Cracking" See also Foam Fails Reason #5: Excessive shrinkage.

[19] Foam Fails Reason #4 Counter Productive Vapour Retarder