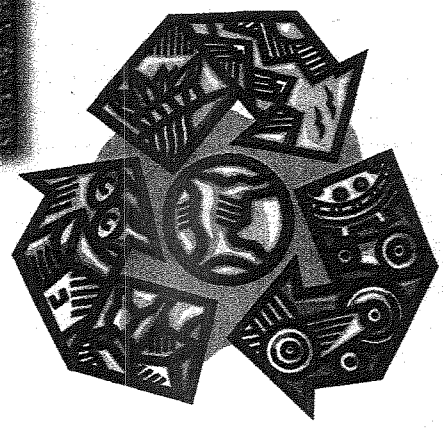
Does Vinyl Have a Place in Sustainable Design?



by Tak Abe

In its myriad uses, vinyl combines the attributes of traditional materials with advanced performance properties, including durability, versatility, low maintenance, and improved energy efficiency. It has been specified for use in many different types of non-residential applications, ranging from resilient flooring (sheet and tile) and fenestration applications (*i.e.*, window frames, glass doors) to wall coverings for commercial interiors.

In electrical applications, the material is frequently selected for wire and cable insulation/jacketing, along with rigid non-metallic (NM) conduit and cable management systems. PVC (polyvinyl chloride) is employed in several piping applications, including water delivery, sprinkler systems, sewage transport, and drain/waste/vent (DWV). Vinyl's durability also makes it suitable for fencing, decking, railing, and other outdoor living products (*i.e.*, pergolas, arbors, gazebos, and bridges), along with roofing membranes and exterior siding for light commercial buildings, assisted living facilities, apartment buildings, and office parks.

However, awareness of vinyl's benefits is often undercut by a perceived notion the material—its production, its use, and its disposal—is harmful to the environment. Organizations such as Greenpeace have referred to the vinyl industry as "one of the 'most toxic-producing industries on the planet,"[1] while the Healthy Building Network (HBN) has charged the material contains/emits carcinogens harmful to human health.[2]

Many of the attacks on vinyl's 'greenness' stem from gross exaggerations of scientifically accepted understanding. Far too many in the construction/design community have inadvertently absorbed this misinformation, which means the discussion about vinyl occasionally centers more on fiction than fact.

There are typically three charges leveled against vinyl, one for each stage of the material's life:

1. All vinyl production is inherently bad for the environment.
2. Once installed, vinyl emits carcinogens, and is therefore bad for the indoor environment.
3. In the waste stream, disposed vinyl emits toxins and pollutes the environment.

In the interest of providing some balance to the controversy, this feature explores these criticisms, and explains why properly specified vinyl has a place in sustainable design.

Vinyl production charges

The negative claim fervently underscored by the previous Greenpeace quotation rises from the creation of VCM (vinyl chloride monomer) during the vinyl production process. While VCM's status as a carcinogenic gas is indisputable, there is less certainty concerning the harmful levels emitted into the environment.

Until the 1970s, when VCM's effects (specifically, angiosarcoma, an otherwise rare form of liver cancer) became more widely known, vinyl plant workers were exposed to the gas as it was released into the work environment. However, since 1975, the Occupational Safety and Health Administration (OSHA) has enforced strict regulations concerning VCM emissions—limiting the maximum workplace exposure to an average of 1 ppm over an eight-hour shift.

Due to these regulatory changes, vinyl factories have overhauled their production systems to recycle VCM off-gas back into a closed system. As a result, there have been no documented cases of angiosarcoma amongst vinyl product factory workers who began their careers after controls procedures were reformed. Emissions management have proved so effective zero VCM was detected during peer-reviewed air monitoring studies.[3] Since it enacted its air toxins rule in 1976, the U.S. Environmental Protection Agency (EPA) reports the nation's overall VCM emissions into the environment were cut by 362.9 t (400 tons) per year for a decade,[4] resulting in a lifetime distribution cancer risk to less than one in a million persons, per EPA risk characterizations.[5]

Similar claims about the emission of harmful levels of dioxin have likewise proven to be either outdated or unfounded. Since EPA controls and regulations were enacted in the 1970s, dioxin levels in the environment have decreased significantly—from 1987 to 1995, emissions dropped by 80 percent. As a result of these improved controls, household fireplaces and vehicle exhaust each account for more dioxin emissions than vinyl manufacturing (whose annual emissions need only be measured in grams).[6]

U.S. environmental regulations have been emulated in Europe and Japan, where strict emissions controls are also mandated to protect the safety of the environment and vinyl plant workers.[7] According to the European Commission's (EC's) 2004 report, *Life-cycle Assessment of PVC and of Principal Competing Materials,* "VCM emissions during polymerization can be minimized most effectively by installing so-called 'close-lid operations,' or in other words... a closed loop production process. Most modern processes apply this technique."[8]

Vinyl use charges

Since VCM is released during the vinyl production process, some may erroneously believe the carcinogen remains after the material is created. However, VCM gas is chemically transformed into solid PVC—a compound that does not revert to its previous state.[9]

Likewise, the notion vinyl emits other carcinogenic chemicals into the indoor environment, affecting indoor air quality (IAQ), is incorrect. Since PVC is a stable compound, it can only give off potentially toxic levels of dioxin when burned at low temperatures (such as those found in a wildfire), or heated to near-combustion levels.[10] Granted, a building fire could bring forth dioxins, but virtually all building materials emit toxins when burned.

Many forms of vinyl contain plasticizers (including phthalates) for increased pliability, and these substances migrate/emit out of the matrix over long periods. However, the majority of claims citing plasticizers' toxicity is based on research conducted on rats repeatedly exposed to the substance until they developed cancer. To produce the same carcinogenic effect in humans, a person would need to daily ingest 500 g (17.6 oz) of the plasticizer for 100 days—far more than what is found in typical vinyl installation.[11] When the National Institutes of Health (NIH) conducted its own toxicity study, the group concluded the risk to humans was low.[12]

Vinyl disposal charges

The third charge leveled by vinyl's critics is the material's entry into the waste stream (and subsequent 'decomposition') yields dioxin emissions and leached toxic chemicals into an ecosystem's groundwater. However, as noted previously, PVC does not emit dioxin unless burned at low temperatures. Additionally, when burned at high temperatures in properly certified incinerators, vinyl combustion no longer produces dioxin.[13] Thus, vinyl in the waste stream is only a concern when the facility lacks proper fire controls or adequate incineration processes. (As an aside, since vinyl lasts longer than many alternative materials, it tends to enter the waste stream at a lesser rate than other products.)

As for the notion vinyl 'decomposes' in the waste stream, recent claims of leached vinyl chloride into landfills have proven this false. In one case, the California Integrated Waste Management Board found the probable cause of such chemicals in the ecosystem to be "microbial action on chlorinated solvents," such as those found in household cleansers.[14] Indeed, some waste management facilities go so far as to line their landfills with vinyl to prevent the contamination of the local ecosystem and groundwater by their refuse.[15]

Green virtues of vinyl

In many ways, vinyl may be better for the environment than some of the building products widely touted as 'green-preferred.' For example, a 1999 study, *Environmental and Economic Impact Analysis—Flooring Materials,* the U.S. Department of Commerce (DoC) attempted to establish a

yardstick for measuring various manufacturers' green product claims. In preparing their study, the department eventually selected six criteria to measure a product's overall eco-friendliness.

1. Solid waste (*i.e.* impact upon the waste stream).
2. IAQ (*i.e.* impact upon the indoor environment).
3. Nutrifaction/eutrophication (*i.e.* impact upon the facilitation of unhealthful organisms).
4. Acidification (*i.e.* impact upon acid rain generation).
5. Global warming (*i.e.* impact upon the planet's average ambient temperature).
6. Resource depletion (*i.e.* impact upon consumption of natural resources, including fossil fuels).

DoC compared typical daily use and disposal, along with the products' manufacturing, transportation, and installation processes—in short, a life-cycle analysis (LCA). For the solid waste criteria, vinyl surfacing was deemed better for the environment overall than linoleum because it lasted longer once installed (especially higher-grade and sheet vinyl surfaces), resulting in less waste over time.[16] (For example, 70 percent of all vinyl goes into products in use for a decade or longer.)

The study also found many types of installed vinyl flooring emit less volatile organic compounds (VOCs) than alternative materials. Independent, small-chamber environmental testing (designed specifically to emulate real-world conditions) demonstrated some proprietary vinyl surfaces were found to emit less VOCs than linoleum and rubber—averaging half the VOC emissions of rubber, and one-tenth that of linoleum.[17]

In the categories of nutrifaction, acidification, and global warming, vinyl was also deemed to have less environmental impact than linoleum. Only in terms of resource depletion was vinyl considered on par with alternative materials. As a polymer, the material requires more fossil fuel consumption than other products, specifically during its production.

It is important to note there are various studies dissenting or corroborating some of these conclusions. For example, the U.K. Department for Environment, Food, and Rural Affairs' (DEFRA's) *Life Cycle Assessment of Polyvinyl Chloride and Alternatives* notes linoleum outperforms vinyl in some areas due to the greater fuel energy required. (However, it also states the products' feedstock compositions means more total energy is required to produce linoleum than vinyl over an equivalent life span.) The study also says vinyl results in 19 percent more carbon dioxide (*i.e.* greenhouse gas) emissions than linoleum.[18] The European Commission's (EC's) Directorate General Environment study, *External Environmental Effects Related to the Life Cycle of Products and Services,* also puts linoleum ahead of vinyl in 'primary energy,' and in air acidification.[19]

In an analysis using the National Institute of Standards and Technology's (NIST's) Building for Environmental and Economic Sustainability (BEES) 3.0 software, generic linoleum and vinyl composite tile (VCT) were compared, using a maximum transportation distance of 1609 km (1000 mi).[20] The 'Environmental Performance' was set as 100 percent of the weighting, and EPA weight values were used (*i.e.* major group element = interiors, group element = interior finishes, individual element = floor coverings). The software analysis showed vinyl outperforming linoleum in overall environmental performance, eutrophication, and indoor air quality. On the other hand, linoleum performs slightly better in comparisons on life-cycle acidification, and is the clear 'winner' in terms of global warming impact and fossil fuel depletion.

Still, vinyl manufacturers are finding ways to create greener, proprietary materials with ultra-low VOC plasticizers, 'dry-erase' wear layers that can reduce mopping/dumping chemical-laden runoff water, and/or 50-percent recycled content that meet the U.S. Green Building Council's (USGBC's) Leadership in Energy and Environmental Design® (LEED®) requirements.

Conclusion

Although A/Es and product manufacturers alike share the passion for the potentials of green design, reason and scientific fact must always temper this passion—otherwise, far too many specifiers could find themselves pulled into a quicksand of hyperbolic rhetoric.

The truth is vinyl is not the environmental destroyer it is occasionally portrayed as—neither during its current modes of production, nor its typical use, nor after its disposal. To the contrary, on the central criteria of solid waste generation and IAQ, vinyl surfacing is better over its life cycle than many of its alternatives. While these conclusions are perhaps counter-intuitive, the truth is these deductions have the unassailable benefit of resting upon empirical evidence.

Notes

[1] Toloken, Steve. "Greenpeace, [Vinyl Institute] squabble over Habitat," *Plastics News* (March 2004) p. 23.

[2] Healthy Building Network. "Comments on the PVC Study Methodology of the USGBC's LEED [Technical and Scientific Advisory Committee] TSAC," www.healthybuilding.net (January 2004).

[3] Forrest, Jolly, Holding, and Richards. "Emissions from

Processing Thermoplastics," *Annals of Occupational Hygiene.* Vol. 39 [1995] pp. 35 to 53.)

[4] It is also worth noting EPA estimates the annual VCM emission to be 1045 t (1152 tons) nationwide. See the group's "Fact Sheet: Proposed Air Toxics Standards for Polyvinyl Chloride and Copolymers Production Facilities" from December 4, 2000.

[5] Visit EPA's Air Toxics Web site at www.epa.gov/ttn/atw, and search for "Key Risk Assumptions and Limitations."

[6] Visit the Chlorine Chemistry Council's Web site for toxics release inventory (TRI) dioxin data, www.trifacts.org.

[7] Visit the European PVC Portal, www.ecvm.org, and select Science, and then Vinyl Chloride Monomer.

[8] The full European Commission document can be most easily accessed through the Vinyl Institute's site, www.vinylbydesign.com.

[9] As one vinyl manufacturer puts it, one cannot un-cook an egg. See also the previously cited article at www.ecvm.org.

[10] Visit www.ecvm.org and select Science, and Waste Management.

[11] See "PVC and Alternatives in Use" on the Chlorophiles' Web page, www.ping.be/~ping5859, for more information. (The Cholorphiles comprise over 2000-members of the Belgian and Dutch chlorine/PVC industry.)

[12] The Center for the Evaluation of Risks to Human Reproduction (CERHR) of NIH's National Toxicology Program (NTP) has expert panel reports accessible at cerhr.niehs.nih.gov.

[13] On page 96 of the European Commission's *Life Cycle Assessment of PVC and of Principal Competing Materials,* the report states "recent studies show the presence of PVC has no significant effect on the amount of dioxins released through incineration of plastic waste."

[14] For more information, see the California Air Resources Board's *Study of Vinyl Chloride Formation at Landfill Sites in California* at www.arb.ca.gov.

[15] Visit the Vinyl Institute's site, www.aboutbluevinyl.org, and search for "Allegations & Facts about Vinyl Manufacturing."

[16] The European Commission's *Life Cycle Assessment of PVC and of Principal Competing Materials* agrees. On page 94, it states, "PVC products are highly durable; durable products are potentially replaced less frequently... PVC material requires little maintenance and repair due to its chemical, mechanical and thermal properties. This also has a positive influence on the environmental performance of the life cycle."

[17] See Alpha Environmental Testing's *Material Test Report* (October 2001).

[18] Visit www.defra.gov.uk/environment/consult/pvc.

[19] Visit europa.eu.int/comm/environment, and select Resources, followed by Publications, and then Studies and Reports.

[20] BEEs provides users with direct comparisons between environmental performance and life-cycle cost. It can be downloaded through bfrl.nist.gov.oae/bees.html.

Additional Information

Author

Tak Abe is COO and executive vice president of sales and marketing for Lonseal Corp. A graduate of Waseda University (Tokyo, Japan), he has headed up Lonseal's U.S. operations since 1972, when the Japanese corporation first came to the United States. Abe can be contacted at (310) 830-7111.

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Abstract

Despite vinyl's many advantages as a building material, misconceptions about its supposed environmental/health ill-effects have altered the way some see the versatile polymer. This article serves to explore the facts—and fallacies—surrounding how vinyl is produced, and what happens to it once it has entered the waste stream.