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Raw Materials: Vinyl

As the controversy over its use rages on, vinyl—specifically, polyvinyl chloride—continues to be used widely in construction. Where does it come from, and where does it end up?

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Vinyl is the most versatile and widely deployed plastic in the construction industry. In the 1950s and '60s, manufacturers began mass-producing building components of vinyl, or polyvinyl chloride (PVC), and expanding the use of a material developed since the 1920s as a fake rubber. Today, they turn out millions of pounds of vinyl pipe in every size and shape, as well as vinyl siding, windows, decks, fences, rails, and wire coatings.

About 3 percent of vinyl is turned into roofing. To see vinyl come into beingfor the building industry, ARCHITECT watched the production of vinyl roof membranes at the plant of Sika Sarnafil in Canton, Mass. The manufacturing process at the plant starts with a powdery vinyl resin shipped by train from Louisiana, and it ends, many large rollers later, with neat 400-pound packages of a soft but tough roof sheathing wrapped around a 10-foot-long cardboard tube.

Because of vinyl's chemical parentage—it is about 57 percent chlorine, taken from salt, and 43 percent ethylene, derived from natural gas or petroleum—its use in construction (as well as in toys and consumer products) is hotly debated. The environmental group Greenpeace calls PVC the "most environmentally damaging of all plastics." The Healthy Building Network cites the numerous toxic substances attending PVC's manufacture (chlorine, inparticular) as reason to remove the material from buildings, and from production, entirely.

The Vinyl Institute, among others in the plastics industry, casts PVC's chlorine content as a plus because it means that less than half the material comes from fossil fuels. The trade group argues that PVC takes less energy to make than common alternative plastics and aluminum in construction, that it lasts a long time, and that it is increasingly recyclable. PVC pipes, notably, offer lower resistance to water flow than other kinds of pipe, requiring less energy for pumping. And Sika's vinyl roof membranes are white on their outer face, which enables them to reflect solar heat and keep buildings cooler than dark-colored roofs. A federal government study found that installing a "cool" roof of white vinyl can reduce air-conditioning demand at peak periods by 14 percent and throughout the day by 11 percent.

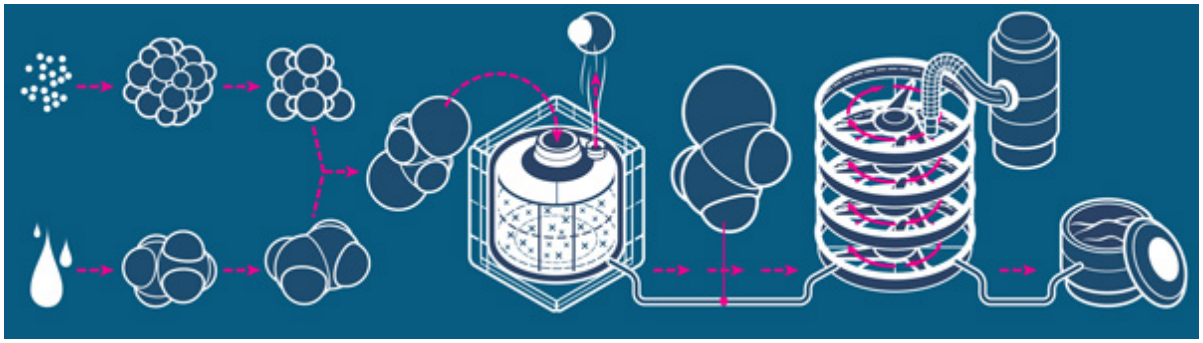
Yet, among sustainable-design specialists, vinyl is under intense scrutiny. Earlier in this decade, the U.S. Green Building Council (USGBC) convened a special panel of experts to address a push toward creating a credit in its LEED certification scale that would reward avoiding the use of PVC products in construction. After several years of study and gathering of public comments, the panel declined to support such a credit. Rather, its final report suggested that all materials, including PVC, needed both more thorough analyses of their sustainability in the context of practical alternatives and a harder focus on the end of their lifecycles, when they may wind up, for instance, in landfills or incinerators.

As for PVC itself, the panel concluded that formally discouraging the specification of some common PVC products, such as siding, windows, or pipes, could steer designers toward products whose impacts are, on the whole, more harmful to the health of people or the environment.

Although the PVC study panel left the material's status unchanged within the rating system, vinyl's case is hardly closed within the USGBC. The council's healthcare committee recently proposed that LEED discourage the use of materials involving substances known as persistent organic pollutants, which would rule out materials requiring the use of halogenated compounds

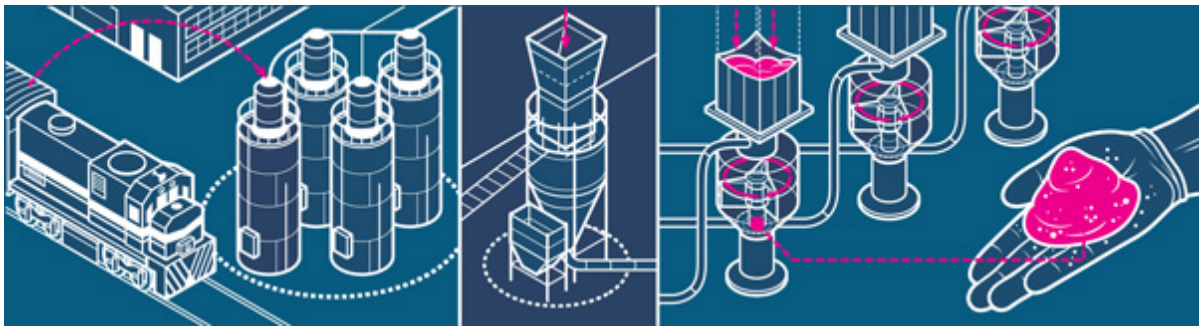
—and, hence, rule out the use of PVC. "You couldn't make PVC without halogenated compounds," says Scot Horst, the chair of both the PVC study panel and the USGBC's LEED steering committee. "The real problem is almost always related to the chlorine molecule," which has the potential to create dioxins when it burns at low temperatures. Disposal, he says, isthe crucial issue. As of this writing, official action on the healthcare committee's proposal was still pending.

"All materials have some sort of impact," says Horst. "By reducing impact in one way, you increase impact in some other way. There are trade-offs for every decision you make." Vinyl is a complicated material, the ultimate synthetic, and the current debate surrounding its use illustrates nothing so much as the enormous delicacy of evaluating any material's costs and benefits when the accounting is thorough.



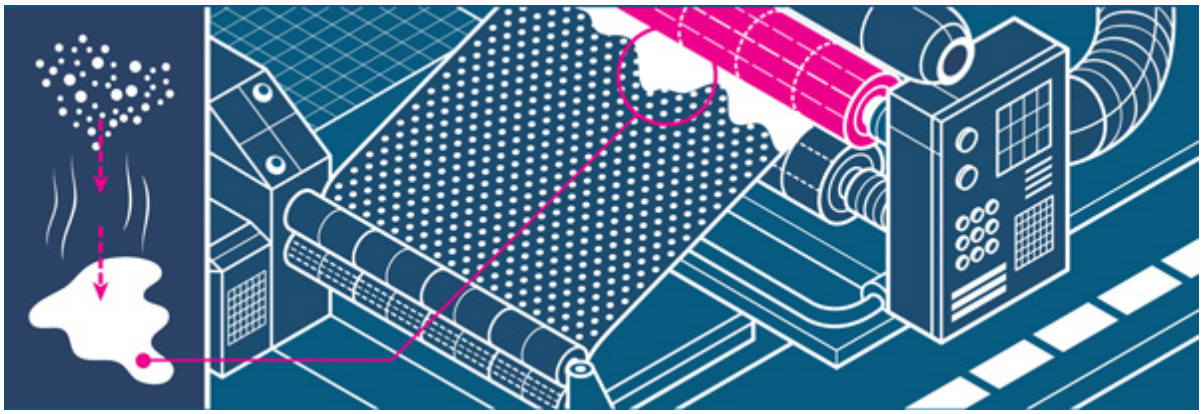
Jameson Simpson

MAKING VINYL RESIN At the Sika Sarnafil plant, vinyl roof membranes start with a powdery vinyl resin made with chlorine and ethylene. The chlorine comes from salt (sodium chloride) relieved of its sodium by electrolysis. Ethylene comes from "cracking" ethane, found in natural gas or petroleum. Next, the chlorine and ethylene are combined to produce ethylene dichloride, which is then cooked to make vinyl chloride monomer, or VCM; its by-product, hydrochloric acid, is drawn off. Typically, the VCM is turned into a polymer, or polymerized, by several hours' stirring in a chamber with small amounts of other chemicals that induce its formation into molecular chains of vinyl resin. Leftover VCM, which is said to be a carcinogen, is removed by vacuum and steam-stripped to prevent its presence in the finished batch of resin, which has a powdery consistency.



Jameson Simpson

MIXING Vinyl resin powder arrives at Sika's plant through the Worcester rail yards. It is stored outside in three large silos. The resin grains are blown inside the plant through ducts to overhead silos at the head of the production line. Nearby are mass quantities of dry additives hanging in fabric hoppers: They include plasticizers to enhance flexibility; stabilizers to prevent burning during processing and to block ultraviolet rays; and, sometimes, pigments. A large, cylindrical, high-intensity mixer combines the resin and additives at 200 F before cooling them to 70 F. When it's done, this "dry blend" feels like sugar to the hand.



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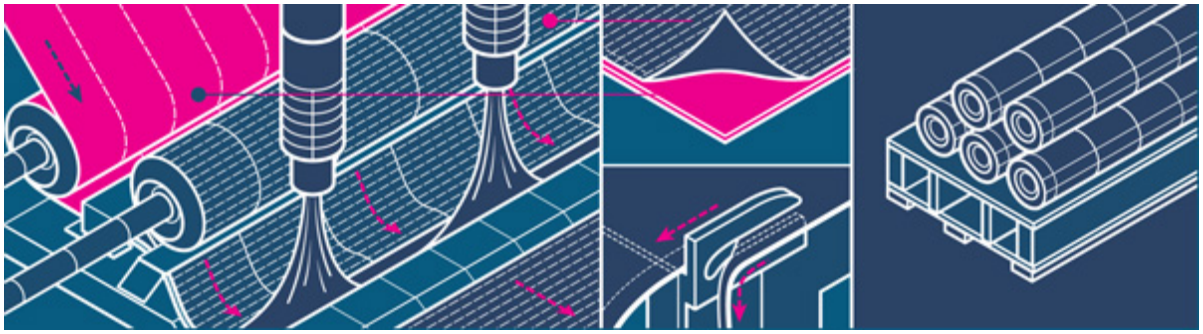
MELTING AND EXTRUDING The granular mix is melted at 300 F to make molten plastic. The material is then fed into the extrusion line's die, where a 3,400-pound roll of base fabric, a knitted polyester scrim 10 feet wide, unspools to receive a layer of the molten material across its surface as it passes between massive pairs of steel rollers—think of a gigantic pasta machine. Looking into the machinery, you can see the syrupy vinyl coating suspended just along the rollers' receiving edges. A bottom layer goes on the fabric first; thickness is checked by a gauge to within ten-thousandths of an inch. Then, a top layer goes on between another set of rollers. Out comes a recognizable roof membrane.



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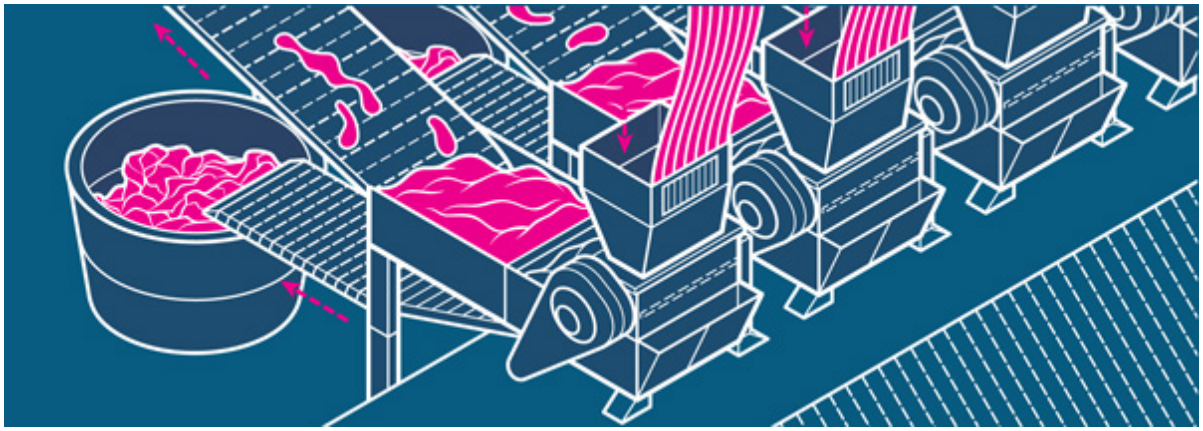
TREATING AND ROLLING Once the membrane has been machine-inspected, it moves between rollers that coat it with a lacquer, a water-based latex that protects it from ultraviolet rays and helps to shed dirt. It then goes through a dryer to cure the lacquer. Cameras inspect the surface for defects. A layer of nonwoven, needle-punched polypropylene felt may be fused onto the membrane. On a roof, the felt helps to prevent punctures, even out rough surfaces (such as atop asphalt roofs), and cover joints to mask surface irregularities. Next, the felt-backed membrane is stamped with a logo and passes through a trimmer to cut off the incomplete edges (which go to recycling) and then an edge marker, which applies thin lines of a water-soluble ink to help roofers guide their alignments during installation, as well as markings for fasteners. It then goes directly to packaging, where it is rolled onto large cardboard tubes. Sika's "contractor rolls" hold 150 feet of vinyl roof membrane weighing 400 pounds. They are wrapped in polyethylene sleeves and stacked, between stiff cardboard cradles, eight rolls to a pallet for shipping.



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RECYCLING Sika Sarnafil runs a separate plant at its Canton factory for recycling scrap cuttings from its production line. Because this material is clean, it is almost fully recyclable, whereas previously used roof membrane must be rid of impurities first, which is more complicated and costly. About 15 percent of Sika Sarnafil's new roof membrane is recycled material. The cuttings resemble long pieces of tape. Three grinders in a row reduce the material to progressively finer particles. The heavy PVC of the ground-up cuttings falls downward from the final crusher. The lighter portion of the material, which is the polyester backing fabric, travels upward and is compacted elsewhere for turning into construction blocks or burning for energy. The recaptured PVC, because it creates color variations, is melted to make up part of the back layer of a new membrane.

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END-OF-LIFE During its useful lifecycle in most applications, PVC rated fairly well when compared with alternative materials by the USGBC's expert panel in its 2007 study—except, notably, as flooring, given the gases it can emit indoors. But the panel expressed serious concerns about PVC's effects on human health as it starts to degrade or burn. Even at low temperatures, safety analysts say, decomposing PVC can give off toxic phthalate plasticizer compounds into the air. When it burns, it releases hydrochloric acid and dioxins, which pose potential health threats during building fires or, at the end of its life, in a burning landfill. (About 8,400 landfill fires are reported in the United States each year, according to federal government figures.) Allen Blakey, public affairs director for the Vinyl Institute, cites Environmental Protection Agency data that show landfill volumes holding steady and the use of PVC soaring while dioxin emissions have decreased. "Given that PVC production and use has grown, we should be seeing an upward trend in dioxin [releases]," if environmentalists' claims about PVC are true, he says. "But we're not. This is our most important piece of data."