HEALTHY BUILDING NETWORK

Avoiding Contaminants in Tire-Derived Flooring

A Healthy Building Network Report

by Jim Vallette

April 2013

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Foreword

Crumb rubber, derived from old tires, can be good for manufacturing high value and medium value new products. But care must be taken as these materials also contain toxic elements with potential exposures. The HBN report, "Avoiding Contaminants in Tire-Derived Flooring," is a critical primer for distinguishing the good and the bad aspects of using this material in industrial and consumer products. Its call for screening techniques is invaluable for determining highest and best uses for this material.

- **Neil Seldman**, co-founder and president of the Institute for Local Self-Reliance. Seldman is a social enterprise technician. He assists in the startup and expansion of recycling enterprises for profit and non-profit entities. Seldman is an advisor to the City of Los Angeles Zero Waste Program, also known as the Solid Waste Integrated Resource Program (SWIRP).

Acknowledgements

Tim Trial of ECORE, Karin Walmsley formerly of Dinoflex, and Margaret Buchholtz of Capri Cork worked hard to answer some difficult questions over the past year-plus. I appreciate their patience and willingness to work through this process. And I wish them all the best in their efforts to put good products on the market.

Many thanks to Dr. Kathy Michels for pointing me to recent journal articles on polycyclic aromatic hydrocarbons in crumb rubber.

Thanks also to our tremendous team at HBN, especially our operations director, Susan Sabella, for making sense of my words and this complex issue, and Meghan Lena for report design.

Executive Summary

The benefits of reusing tire scrap are obvious. It diverts millions of tires from the solid waste stream. It saves energy and resources. It avoids new or additional toxic manufacturing inputs.

Heaps of scrap tires are no better than reservoirs loaded with fly ash from coal fired power plants. Both fly ash and tire scrap are on the edge of being classified as hazardous wastes. Pollutants rise from festering pools of ash and smoldering piles of tires. The toxic compounds fall into nearby communities. Beneath these stews, heavy metals and polyaromatic hydrocarbons migrate into streams and aquifers.

But does shifting these wastes indoors represent a positive alternative?

Avoiding Contaminants in Tire-Derived Flooring describes the origins and fate of crumb rubber used in building materials. It concludes that tires contain a host of toxic ingredients to which people may be exposed when this material is brought into homes, schools, gyms and offices.

This Healthy Building Network investigation concludes with these recommendations:

- **Tire crumb processors should start screening tire crumb for toxic ingredients.**
- **Processors should obtain third-party certification that crumb does not contain toxic ingredients above thresholds of concern.**
- **Flooring manufactures should only use tire crumb that has third-party certified screening procedures.**

These are not current practices. **Given the current situation, the Healthy Building Network does not recommend the use of Tire-Derived flooring in interior applications, especially where children may come into direct contact with the flooring**.

Avoiding Contaminants in Tire-Derived Flooring challenges some common assertions from industry. Manufacturers have long stated that in cured materials, such as crumb rubber, constituents are bound in a matrix and will not be released at normal room temperature. However, volatilization through heat is only one of many methods that crumb rubber can degrade and expose humans and the environment to its toxic constituents. Other routes of exposure may occur through abrasion (cleaning), biodegradation, hydrolysis, photolysis, and oxidation.

Scientists are raising alarms about distillate aromatic extract, also called "aromatic process oils," used as softeners in tires. These oils can make up to 30 percent of a tire's mass. They contain some of the world's most harmful chemicals. The European Chemicals Bureau says this can be regarded as "a substance with Persistent Bioaccumulative Toxicant / very Persistent very Bioaccumulative impurities."

> ***"Recycling coal ash and shredded tires are solid waste solutions which create largely unexamined but potentially serious public health side-effects. As a result, we have a massive stream of hazardous waste disposal masquerading as a 'beneficial use.'"***
>
> - Jeff Ruch, Public Employees for Environmental Responsibility

As peer reviewed articles in *Environmental Science and Technology*, and *Chemosphere*, have noted, the presence of these "hazardous organic chemicals," "rich in polyaromatic hydrocarbons" represent a "potential previously unknown source of carcinogenic dibenzopyrenes to the environment."

There are indications that the tire industry – especially in Europe -- is reducing the use of this substance. While there may be progress underway, it is incomplete. And older tire treads are being recycled into crumb rubber. It is far too early to say crumb rubber is devoid of distillate aromatic extract.

The heavy metal, lead, poses another challenge to the safety of crumb rubber. Tires are picking up lead from the roadway, as they roll over old highway paint (containing lead oxide) and fallen lead tire weights.

Three independent sources of lead content in tire rubber have identified levels above the U.S. Consumer Product Safety Commission (CPSC)'s limit for children's products (100 parts per million).

> ***"At a minimum the assumption, absent detailed ingredient disclosure and analysis, that recovered/recycled materials are healthy for interiors needs to be thrown out."***
>
> - Jeff Gearhart, The Ecology Center

Other chemicals of concern in tires include styrene and carbon black nanoparticles.

Our report's findings also reveal an urgent need to tighten green building guidelines for recycled content. Many states and the federal government require or prefer recycled content products. Incentives for builders to specify recycled content continue to proliferate.

These recycling incentives have had few, if any, toxicological bounds. Contradictions occur when systems fail to balance recycled content attributes with other factors.

Avoiding toxic content must be part of the equation.

Only then will we stop bringing other industries' unhealthy wastes into our homes, hospitals, and schools.

Overview

Crumb rubber is tire scrap, granulated to a size of no more than a quarter-inch. This scrap does not include tire sub-assemblies, such as steel belts, which are removed from tires prior to processing. Crumb rubber can also include tire buffings, which retread shops shave from tires.[1]

The typical consumer interaction with crumb rubber is in sports surfaces, such as artificial turf fields, outdoor tracks, and loose fill on playgrounds. But some companies have developed interior building materials that incorporate crumb rubber, particularly in flooring products. (Other uses include asphalt and sealants, new tires, horticultural products, and animal bedding.)

The benefits are obvious, if temporary[2]:

- Reusing crumb rubber saves energy.
- It avoids new or additional toxic manufacturing inputs.
- Recycling also forestalls landfilling tire waste. Tire dumps pollute groundwater and can catch fire and smolder for months or even years.[3]
- And, it might be preferable to burning tire-derived fuel in kilns.

However, there are potential drawbacks. Some crumb rubber may contain heavy metals and other substances of concern, and reuse in the built environment may introduce these contaminants to building occupants.

Tires are complex products. The global supply chain for virgin tires makes understanding the environmental and health aspects of crumb rubber complicated. Tires made in China, for example, may contain chemicals that are not allowed in North America or Europe, such as lead oxide or certain process oils. Another factor is age: older tires are more likely to contain phased-out chemicals than newer ones.

Manufacturers acknowledge that testing of scrap tires and crumb rubber is infrequent, at best. **These factors indicate a need for vastly improved supply chain and product screening controls.**

One major ingredient of tire formulations contains very persistent, very bioaccumulative, toxic substances. Up to 30 percent of the weight of a tire can be this ingredient, a mixture known as "aromatic rubber process oil."[4] Tire manufacturers use these oils to facilitate the processing of rubber compounds. Recent journal articles have pinpointed these highly aromatic oils as significant sources of polyaromatic hydrocarbons in tire scrap.

Fortified supply chain controls and testing regimes would better assure the safety of crumb rubber.

The heavy metal, lead, is another significant potential concern our research identified in crumb rubber. Three independent sources have identified levels of lead in tires above the U.S. legal limit for lead in children's products (100 parts per million). Although most tests have found levels lower than 100 ppm, this suggests both that there are enough tires with unsafe levels of lead to warrant more rigorous controls on this material, and that such controls could eliminate this avoidable hazard.

Some manufacturers using crumb rubber products recognize this need, and a market opportunity, for improved practices. Fortified supply chain controls and testing regimes would better assure the safety of crumb rubber. This, in turn, could enhance consumer acceptance of their products.

Toxic Ingredients

Crumb rubber is derived from two post-consumer waste streams: tire retread shops (buffings) and scrap dealers (whole tires). The waste stream is vast: each year, according to the Scrap Tire Management Council, around 30 million tires are retreaded or reused, and 250 million tires are scrapped.[5] Combined, these sources could generate over 2.8 billion pounds of crumb rubber per year.[6]

Tires are complex and heterogeneous composites. Formulations vary widely between manufacturers, and any formulas are closely guarded trade secrets. The complexity and variability of manufacturing methods translates into variable impacts and potential exposures downstream, when this material is reused and incorporated into building materials.

Evaluating the potential scope of exposures requires a first step of identifying the chemical constituents of crumb rubber, including any residuals of process chemicals used to make these ingredients. The question of residual process chemicals becomes significant when they are present at certain levels of concern and have pathways for exposure.

Some argue that while there may be small amounts of residual process chemicals present in crumb rubber, preceding reactions – particularly vulcanization -- reduce the likelihood that upstream chemicals are present.[7] They point to documents that say these chemicals are probably not available at levels high enough to impact consumers, such as athletes on playing fields and children crawling on rubber flooring.

A report by Rachel Simon of the University of California, Berkeley, Laboratory for Manufacturing and Sustainability, for example, says, “The use of athletic fields made of recycled tires has… been called into question because of concerns regarding toxicity. Authorities are worried that because of the chemical content of the material, exposure by various means could endanger the health of field users, especially children.

However, extensive research has pointed to the conclusion that these fields result in little, if any, exposure to toxic substances."[8]

Synthetic turf manufacturers cite Ms. Simon's conclusion to support the contention that their products are safe. However, Ms. Simon also acknowledges that other researchers have "noted the present existence [of] 'knowledge gaps,' a lack of full understanding at the general theoretical level which renders the inquiries to some degree inconclusive."

It is too broad to suggest that all process chemicals used to make the ingredients of crumb rubber are present at levels that should trigger concern. However, an assumption that because crumb rubber is a vulcanized material, all ingredients are inherently bound and unavailable is certainly *too narrow* a view. Ms. Simon acknowledges in her report that: "Some compounds within the material will, over time, come to be released from the material and to enter the air"

Manufacturers often state that that in cured materials, like crumb rubber, constituents are bound in a matrix and will not be released at normal room temperature. However, volatilization through heat is only one of many methods of degradation. Abrasion through cleaning is one way to release toxic constituents from the materials.[9] Other pathways for releasing flooring ingredients include aging (the march of time) and hydrolysis (in which excessive dampness catalyzes reactions that release volatile chemicals).[10]

Our research shows significant crossover between ingredients listed as used in tire formulations and those listed as line items in crumb rubber material safety data sheets. Numerous government reports identify these ingredients, and some of the process chemicals used to make these ingredients, as being present in crumb rubber.

A recent State of California report, for example, says:

> "Many components of tire production remain intact through the life of tire recycling, which largely entails mechanical grinding and separation of subassemblies (to produce crumb rubber), followed by annealing or molding. Many chemicals in the polymers, such as vulcanizing agents, accelerators, plasticizers, etc. remain in recycled rubber. These chemicals are found in waste tire leachate, as well."[11]

The question of potential exposures to the chemical contents of recycled rubber remains poorly answered and very controversial, especially in the context of crumb rubber used in playgrounds and athletic fields used by children. Similar concerns have

been expressed about the lack of knowledge about lead and other heavy metals that may be in tire-derived rubber flooring.

Process oils

Most people think only of the rubber in tires, but a big part of the product contains a far less known, but more concerning, ingredient. Up to 30% of a tire's mass can contain a chemical mixture called "distillate aromatic extract" (CAS No. 64742-04-7, also known more commonly as aromatic process oil). Recent journal articles have pinpointed process oils as significant sources of polyaromatic hydrocarbons in tire scrap. These oils are loaded with highly persistent and bioaccumulative toxicants.

Process oils improve the flow characteristics of rubber compounds and the dispersion of fillers during the manufacturing of tires.[12] They are quite common in tire formulations. Recipes for Goodyear, PPG, and Uniroyal, published in 2008, list this process oil at between 4% and 13% in the tire tread mix.[13]

Material safety data sheets for rubber crumb show even higher potential proportions of this toxic chemical. SpectraTurf lists this chemical at "approximately 20%." An MSDS for RTI Ground Rubber (2002) lists it at "less than 25%" of the product by weight (RTI is part of Ecore International, which makes recycled rubber flooring products). And CRM, a recycler based in Rancho Dominguez, CA., lists distillate aromatic extract solvent as "approximately 25%."[14]

The *Global Automotive Declarable Substance List* (*GADSL*) requires suppliers to declare the presence of this chemical at levels above 0.01%. The GADSL is a global initiative by auto manufacturers, suppliers, and the chemical/plastics industries to facilitate communication about certain substances throughout the supply chain. Most crumb rubber flooring products on the market would easily exceed the GADSL reporting threshold for distillate aromatic extract.

Process oil is a complex combination of polycyclic aromatic hydrocarbons. The European Chemical Bureau has provisionally determined that this chemical as a whole should "be regarded as a substance with PBT/very Persistent very Bioaccumulative impurities."[15]

CalRecycle has noted that "exposure to carcinogenic polycyclic aromatic hydrocarbons (PAH) has been identified for the crumb rubber workers."[16]

In a 2011 peer reviewed study published in *Environmental Science and Technology*, scientists from Stockholm University called automobile tires "a potential source of highly carcinogenic dibenzopyrenes to the environment." These dibenzopyrenes -- present in the process oils -- accounted for almost all (92%) of the total PAHs in the tires that they examined.[17]

"Highly aromatic (HA) oils used … in the tire-manufacturing process are rich in PAHs, many of which are classified as carcinogenic/mutagenic environmental toxins with the potential to cause negative long-term effects both in humans and in the aquatic environment. The PAH concentration in these oils ranges between 10 to 30%," note Dr. Sadiktsis and team.

Another report, released this year, highlights "the presence of hazardous organic chemicals in surfaces containing recycled rubber tires." In the 2013 *Chemosphere* article, a research team from Universidad de Santiago de Compostela, Spain, found "extremely high" concentrations of PAHs, reaching values up to 1%. "One of the main components of extender oil is highly aromatic oil, which contains polycyclic aromatic PAHs in the range of 300-700 mg/kg."[18]

PBTs in Distillate Aromatic Extract
(CAS No. 64742-04-7)

Chemical	***CAS No.***	
Benzo(a)pyrene (BAP)	50-32-8	6.4 mg/kg
Perylene	198-55-0	5.1 mg/kg
Dibenz(a,h)anthracene	53-70-3	3.4 mg/kg
Indeno(1,2,3-cd)pyrene	193-39-5	10 mg/kg
Benzo(g,h,i)perylene	191-24-2	26 mg/kg
Pyrene	129-00-0	2.5 mg/kg
Benz(a)anthracene	56-55-3	2.6 mg/kg
Chrysene	218-01-9	27 mg/kg
Fluoranthene	206-44-0	0.7 mg/kg

Source: European Chemicals Bureau

There are indications that the tire industry – especially in Europe -- is reducing the use of this substance. Process Oils Inc., for example, markets Hyprene Black Oils as a cleaner alternative. "The Black Oils meet all PAH requirements set forth by the European Union and are currently being used extensively as replacements for high PAH extracts," reads their website. "The decision to develop this oil was influenced by tire producers and their desire to see an unlabeled aromatic alternative available in the United States."[19]

The tire industry's Rubber Manufacturing Association has been largely silent on this issue. But in a 2010 presentation to a rubber recycling conference, RMA Vice President Michael Blumenthal did signal some changes ahead: "Aromatic oil-free compounds and reduction on oils containing polycyclic aromatic hydrocarbons should reduce emissions," reads his presentation.[20]

While there may be progress underway, it is incomplete. And older tire treads are being recycled into crumb rubber. It is far too early to say crumb rubber is devoid of distillate aromatic extract.

Absent a global phase-out of its use in tire formulations, and/or screening by tire scrap processors to keep it out, crumb rubber should be presumed to contain significant amounts of distillate aromatic extract.

Lead in Tires and Crumb Rubber

Crumb rubber testing routinely finds the metals, lead and zinc.[21] Human health stakes are higher for lead than zinc, which presents more of an aquatic toxicity concern related to outdoor products.

Old tires gathered lead when they rolled along the road and collected the toxic metal from old highway paint and fallen tire weights.

Lead compounds have been part of tire formulations since 1839, when Charles Goodyear heated a mix of natural rubber, sulfur and white lead, and created the world's first melt-proof rubber blend.

More recently, lead oxide has been used as an activator in the vulcanization process, and may be present in scrap tire due to this historical usage.

The continued use of lead weights to balance tires creates another potential source for lead contamination. The recycling of crumb rubber may be transferring lead from these lead wheel weights from roadways into people's kitchen floors. Here's how:

To balance a tire, lead weights are clipped on to the tire and remain in place after the tires are balanced. Every car carries roughly a half-pound of lead wheel weights, according to two studies cited in a 2005 EPA study. Weights routinely fall off the car and onto the road. Passing traffic then pulverizes the malleable lead.[22]

"It's estimated that five percent of lead wheel weights fall off vehicles," explains a state of California video. "Passing traffic often then grinds the lead weights into particles that contaminate the surrounding area."[23] These lead particles are then available to be picked up in the rubber of tires passing over them.

In the European Union – and several US states – the use of lead weights for balancing is being phased out. But the use of lead weights remains legal at the national level in

the United States. A legacy of lead will remain in roadways for a long time even in those locales where the use of lead weights is being phased out.

Highway paint is another potential source of lead contamination of tires. From the 1930s, through the 1990s, yellow lane markers contained lead silicochromate pigment (CAS No. 11113-70-5).[24] (Manufacturers today provide road-marking paint that is heavy metal-free, but depends upon two-component epoxy chemistry.[25] Epoxy chemistry has toxicity challenges of its own since the endocrine-disrupting chemical bisphenol-A is a primary component.)

This lead from both paint and balancing weights is available to anything that comes in contact with the road surface and runoff, including passing tires. Liberty Tire Recycling, a crumb rubber processor, acknowledges that the presence of lead in recycled rubber surfaces is caused by lead becoming "entrained in the tread upon contact with the road surface."[26]

When tire tread is reused (and buffings are incorporated into crumb rubber), any lead present in that tread is incorporated into the finished product, absent manufacturer screening processes.

Sampling programs to date have found widely varying lead levels in scrap tires, and in crumb rubber used in playground and athletic fields.[27] Some samples exceed industry and government thresholds of concern.

Declaration and Regulatory Limits

Here are some key markers for levels of concern:

- The automaker Renault sets a declaration level for lead at 0.001%, or 10 parts per million (ppm), for components delivered by their suppliers. It prohibits materials that contain more than 0.1% (1,000 ppm) lead.[28]
- In 2008, the state of Washington prohibited the sale of children's jewelry containing more than 40 ppm lead.[29]
- Consumer Products Safety Commission regulations consider consumer products designed for children that contain at least 100 ppm of lead to be "banned hazardous substances under the Federal Hazardous Substances Act."[30]

It is an odd result that an automobile part should have should have both a disclosure requirement and a maximum allowable lead limit, and a preschool's floor or playground

cover should have neither. The latter threshold for children's products poses the most significant challenge to the sale of crumb rubber products in the US. The 100 ppm maximum -- which also requires third party testing and verification of compliance – has been in place since the beginning of last year (2012).

In 2012, Public Employees for Environmental Responsibility requested the CPSC to issue an advisory opinion classifying recycled tire products as children's products, which would in turn require crumb rubber products used in playgrounds and elementary schools to comply with the 100 ppm limit for lead.[31]

Test Results

Various industry sources contend that lead is not present in crumb rubber at levels of concern. Liberty Tire labels as "myth" the assertion that "crumb rubber contains an unsafe level of lead that can be hazardous to a person's health." The company says, "Frequent testing of crumb rubber products by leading producers of crumb rubber has yielded results that have **not exceeded 50 ppm**."[32]

The University of California, Berkeley, Laboratory for Manufacturing and Sustainability tested cryogenically produced crumb rubber provided by BAS Recycling of Moreno Valley, CA, for compliance with US limits on heavy metals content in children's product. "(T)he samples provided by BAS contained virtually no lead, at 20 parts per million…" reported Ms. Simon.

Independent government testing has produced different results. A California study says, "Analysis of combustible waste tires **shows lead at concentrations of 100 ppm** … in sample tire rubber combustion products."[33]

One EPA study sampled crumb rubber used in a playground, and found an alarming level of **440 ppm lead** -- more than four times the lead than the federal government allows in children's products.[34]

A 1989 study evaluated heavy metal levels in 29 new tires, of different brands, sizes, and countries of origin. Twenty-six tires contained less than 100 ppm of lead, but three samples had more. A Uniroyal tire (size P205/75A15) made in the US registered 155 ppm. A Samyoung tire (size 175/15) made in Korea had 236 ppm of lead. And a Marchal tire made (size 600/14), also made in Korea, topped the charts with 518 ppm lead -- five times higher than what the EPA now allows in children's products.[35]

Even industry-cited reports agree, however, that lead is an avoidable hazard that could be reduced if not eliminated in crumb rubber using fairly rudimentary screening processes. Ms. Simon of UC-Berkeley acknowledges that lead levels may vary by source, and points toward a more "judicious" selection process. "(L)ead exposure remains an object of some concern," she notes. "The results of experimental evaluation of lead in these (synthetic turf) fields have been thus far inconclusive…. Given the fact that lead levels in tires varies significantly according to production process, it seems safe to conclude that given judicious selection of crumb rubber fill prior to construction – that is, selection of material with low lead concentrations – lead exposure could be minimized significantly."

Other Chemicals of Concern

Distillate Aromatic Extract and lead are significant variables in crumb rubber. There are many other chemicals to consider.[36] These ingredients may remain available for release, before and after the tires are mechanically processed into crumb rubber.

Leachate and emissions tests of crumb rubber have identified process chemicals used in the manufacture of rubber. One of these is **styrene**, a monomer in the production of styrene butadiene rubber (SBR). The 2010 California study found "moderate emissions" of styrene in half of its samples.[37]

The State of California tested tire-derived flooring and found that 4 of the 11 products contain chemicals—naphthalene, in particular—that compromise indoor air quality.

Others have raised concerns about **carbon black nanoparticles** used in tire formulations and the limited knowledge about potential impacts of these materials. Between 25% and 35% of a typical tire is carbon black. An alliance of leading German health researchers has embarked upon a three-year health study of carbon black nanoparticles used in automobile tires and other plastic materials.[38]

Carbon black is a mixture of persistent bioaccumulative toxicants (PBTs), including **naphthalene, anthracene, and fluorene**. The California study recounts studies of leachates from tire waste that found naphthalene, "which may have originated from the rubber's carbon black constituent."[39] A Connecticut Agricultural Experiment Station (CAES) analysis determined that stormwater discharge from artificial turf fields likely contains semi-volatile organic compounds, including naphthalene.[40]

Potential Exposures

Most exposure studies have been conducted in outdoor applications, particularly synthetic turf fields and playground loose fill. People generally spend much more time indoors, in closer proximity to floors than outdoors on a field**.**

Small children have lengthier and more intimate contact with floor coverings than adults. They engage to a far greater degree in the type of hand-to-mouth contact known as "Pica" which can transfer contaminants from a floor covering in far higher concentrations than would be expected by adults. In the case of arsenic used in pressure treated wood in playground structures and ground covering, ATSDR has found for example that "children may be at a higher risk of exposure because of normal hand-to-mouth activity."[41]

A 2010 State of California report noted a lack of data about potential heavy metal exposures from tire derived rubber (TDR) flooring products: "(A)s there is little available data on the magnitude of metal content (or its mobility) in TDR flooring, **we recommend that CalRecycle assess the potential for heavy metal exposure specifically from flooring (especially for small children) in future research**."[42]

> *"Some compounds within the material will, over time, come to be released from the material and to enter the air."*
>
> - Rachel Simon, University of California, Berkeley Laboratory for Manufacturing and Sustainability

Again, Ms. Simon's study provides some hints of concern in artificial turf fields. **"(R)ecycled tires are substantially, though not entirely, inert. Some compounds within the material will, over time, come to be released from the material and to enter the air**," she writes**.** **"**(R)epeated use of the field could cause atomized particles of the field to be produced as barely noticeable dust, or 'particulate.' Such particulate could be inhaled by users of the field."

We have identified no studies examining whether the use of recycled rubber floors in buildings similarly atomizes crumb rubber ingredients. However, abrasion during any floor's service life routinely releases top layer ingredients as particulates.[43] As discussed earlier, there are other pathways to exposure, such as aging and hydrolysis.

The CPSC commissioner, Thomas H. Moore, has suggested that it does not matter whether lead is considered immediately accessible – it should be banned at certain levels regardless. At a May 2008 meeting, Commissioner Moore "indicated that the children's product issue was important because as contemplated in legislation passed by both Chambers, in general, children's products which contain lead above certain levels would be banned regardless to lead accessibility." According to notes from the meeting, "Commissioner Moore also indicated that it is his position that children's products should not contain lead."[44]

Screening for Toxicants

Some companies advertise that they "routinely" or "frequently" test their tire crumb. Recycled tire flooring manufacturers contacted for this paper provided testing data. But, these tests appear to be neither routine nor comprehensive.

One company, an integrated tire chip processor and flooring manufacturer, said it tests once a year, and targets four chemicals, including lead. These tests have not found lead above the 100 ppm threshold.

Other flooring producers obtain tire crumb from outside suppliers. One passed along a test from 2003. It tested volatile organic compound content, not heavy metals. The other company's tests were conducted in 2009, and were for leachate, not solid content. The test did not find lead in leachate above detection limits. Leachate tests are designed to identify constituents of solid wastes that will be released into groundwater when buried in a landfill. They are not designed to predict exposures from wear under foot traffic during use, although these tests are often promoted as answers to exposure inquiries.

Manufacturers recognize that more screening is needed.

"The inconsistent presence of a few chemicals … suggests occasional reliability problems for crumb rubber or processing chemicals sources. Manufacturers should screen sources of rubber and solvents used in rubber-flooring manufacturing for contaminants that are not essential to production."

- CalRecycle 2010

Healthy Building Network Recommendations

We look forward to the development of certified and comprehensive screening practices. Such practices are essential to ensure that chemicals of concern used in tire production – or gathered by tires during their service lives -- do not resurface in the built environment.

For scrap tire processors and flooring manufacturers:

Interviews with scrap processors and flooring manufacturers revealed a lack of institutional control over chemicals of concern in crumb rubber. The best practice we could find was one processor that ran limited tests on crumb rubber once per year. Most testing is for leachate, not content, which is not designed to predict exposures from wear under foot traffic during use.

Flooring manufacturers recognize that more screening is needed to ensure the healthfulness of their products.

Screening should occur at multiple points in the process, beginning with screening of whole tires, one by one, using for example, hand-held X-ray flourescene (XRF) devices. Since workers already handle tires one-by-one as part of the scrapping process, individual screening is practical as well as necessary.

Third-party certified secondary screening of tire crumb would provide additional quality and safety assurance. This would involve more sophisticated testing at regular intervals. Applicable methods include atomic absorption spectroscopy (AAS) and inductive coupled plasma mass spectrometry (ICP-MS) elemental analysis. These methods are standard in determining lead levels in paint.

Gas chromatography - mass spectrometry (GC-MS) analysis could also identify the presence of hazardous substances. A Spanish research team recently used this technique to test samples of eight tires, and "confirmed the presence of a large number of hazardous substances including PAHs, phthalates, antioxidants (e.g. BHT, phenols), benzothiazole and derivatives, among other chemicals. The study evidences the high content of toxic chemicals in these recycled materials. The concentration of PAHs in the commercial pavers was extremely high, reaching values up to 1 percent." (Llompart)

Given the prevalence of these substances in tires, flooring manufacturers should assume that these "toxic chemicals" are present in the crumb, especially when PAH-laden oils remain a common plasticizer in currently produced tires.

Flooring manufactures should request third party documentation that their suppliers have undertaken the above screening methods before incorporating crumb rubber into their products.

For consumers:

Until there is greater institutional control over crumb rubber supplies – measures that ensure that lead and PAH-laded process oils are not present above thresholds of concern -- **HBN does not recommend the use of tire-derived flooring in interior applications, especially where children may come into direct contact with the flooring.**

For green building policymakers:

Many states and the federal government require or prefer recycled content products.[45]

Incentives for builders to specify recycled content continue to proliferate. The US Green Building Council's Leadership in Energy and Environmental Design (LEED), the Collaborative for High Performance Schools (CHPS), and the carpet industry's NSF-140 sustainability standard have awarded recycled content for years. In 2012, the International Code Council joined the club with its International Green Construction Code. It requires that most of a project's materials contain at least 25% recycled content.

These recycling incentives have had few, if any, toxicological bounds. Contradictions occur when systems fail to balance recycled content attributes with other factors.

Systems that reward recycled content should correct this imbalance by:

1) Requiring every building product getting the recycled content credit to be fully disclosed. That is, the only products that would qualify are those whose ingredients (whether intentional or residual) are publicly identified, down to one hundred parts per million; and

2) Awarding those products that do not contain toxic chemicals.

Only then will we stop bringing other industries' unhealthy wastes into our homes, hospitals, and schools.

Endnotes

[1] *Reputable Retreading,* Tire Retread & Repair Information Bureau and California Integrated Waste Management Board video, uploaded to youtube on Sept. 7, 2010, available at: http://youtu.be/FDnwJ5MBHl0?t=2m41s; *Summary of Markets for Scrap Tires, US Environmental Protection Agency Office of Solid Waste, 1991; and, Using Scrap Tire and Crumb Rubber, Texas Department of Transportation, 2007* Annual Progress Report, available at: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/pdf/tirerpt.pdf

[2] Dr. Kathy Michels, who is concerned about the use of crumb rubber in playing fields, points out that these benefits are only temporary, as every eight years or so, the "30,000 pulverized tires per field actually end up unregulated in local landfills." Personal communication with author, April 1, 2013.

[3] "Tracy Tire Fire Site Remediation Services," Sukut construction webpage, http://www.sukut.com/component/option,com_ga/Itemid,/id,28/lang,en/task,view_details/

[4] "Other terms used for aromatic extracts are aromatic process oil, bright stock extract, distillate aromatic extract, process oil, solvent extract, rubber extender oil, and residual aromatic extract…. Very large quantities are employed in tire manufacture." From: *Revised Test Plan,* The Petroleum HPV Testing Group, Submitted to the US EPA, Sept. 11, 2008.

[5] "User Guidelines for Waste and Byproduct Materials in Pavement," US Federal Highway Administration website, at: http://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/st1.cfm

[6] According to *Scrap Tire News*, "On average, 10 to 12 pounds of crumb rubber can be derived from one passenger tire." See website, http://www.scraptirenews.com/crumb.php

[7] Vulcanization is the process by which sulfur forms a bridge, cross-linking large chains of polymer (synthetic or natural rubber) into an elastic article. Rachel Simon, cited below, says, "the mere presence of a substance is not necessarily cause for concern. For the most part, when these chemicals are present in tires, they occur in very small concentrations. Also, their presence does not automatically equal exposure. Tires are relatively, though not entirely, inert, and the vulcanization process that they undergo to prepare them for their second life as artificial turf renders them more, rather than less, stable."

[8] Rachel Simon, *Review of the Impacts of Crumb Rubber in Artificial Turf Application*, University of California, Berkeley, Laboratory for Manufacturing and Sustainability, prepared for The Corporation for Manufacturing Excellence (Manex), February 2010.

[9] As GreenScreen™ for Safer Chemicals v 1.2 draft guidance notes, "Any feasible transformation pathway may generate transformation products. Feasible transformation pathways include biodegradation, hydrolysis, photolysis, oxidation, combustion, etc. *The GreenScreen™ for Safer Chemicals v 1.2 Guidance for Hazard Assessment and Benchmarking Chemicals* (Draft, 2011). Available at:

http://www.cleanproduction.org/library/greenScreenv1-2/DRAFT_GreenScreen_v1-2_Guidance_2011_1018_v2.pdf

[10] "Hydrolysis has the effect of breaking down condensed materials to more volatile molecules… (For example,) by installing PVC flooring on poorly cured concrete, the secondary emission rate of 2-ethyl-1-hexanol is enhanced. The flooring traps moisture and the alkaline concrete catalyzes the hydrolysis. Weschler (2004) has suggested that associations between damp buildings and health complaints may be due to products of hydrolysis chemistry. " (Glenn Morrison, "Chemical Reactions Among Indoor Pollutants," chapter in Mihalis Lazaridis, Ian Colbeck (eds.), Human Exposure to Pollutants Via Dermal Absorption and Inhalation (Springer Dordrecht, 2010), p. 88.

[11] Public Health Institute, *Tire-Derived Rubber Flooring Chemical Emissions Study: Laboratory Report*, CalRecycle, October 2010, p. 14. (CalRecycle 2010) Available at: http://www.calrecycle.ca.gov/Publications/Documents/Tires%5C2011002.pdf

[12] See *Screening-Level Hazard Assessment: Distillate Aromatic Extracts,* US EPA, March 2012, available at: http://www.pharosproject.net/uploads/files/sources/1828/1355945471.pdf . See also: "Process Oils," IPOL, available at: http://www.sahpetroleums.com/images/pdf/ProcessOils.pdf

[13] Peter Ciullo, Norman Hewitt, *The Rubber Formulary* (William Andrew, 2008)

[14] "Crumb rubber: Material Safety Data Sheet," SpectraTurf, Feb. 15, 2006; "CRUM RUBBER MATERIAL SAFETY DATA SHEET," CRM, LLC, undated; TRC, "Review of the Potential Health and Safety Risks from Synethetic Turf Fields Containing Crumb Rubber," prepared for the New York City Department of Health and Mental Hygiene, May 2008, p. 35.

[15] ECB - PBT Working Group - Evaluation of the PBT/VPVB properties of CAS No. 64742-04-7, undated. Available at: http://www.pharosproject.net/uploads/files/cml/1355942773.pdf

[16] CalRecycle 2010, p. 5.

[17] Ionnis Sadiktsis, Christoffer Bergvall, Christer Johansson, and Roger Westerholm, "Automobile Tires – A Potentail Source of Highly Carcinogenic Dipenzopyrenes to the Enviornment," *Environ. Sci. Technol.* 2012, 46, 3326−3334

[18] Llompart.

[19] "All Products," Process Oils Inc. webpage, http://processoilsinc.com/products/

[20] Michael Blumenthal, "Changing Tire Technology & Its Impact on Rubber Recycling," RAC / RMA Rubber Recycling 2010, Toronto, Ontario, Canada.

[21] Zinc oxide is commonly used in current tire formulations, which is a concern for outdoor applications. Ms. Simon's study notes that the "presence of zinc in leachate from crumb rubber fields remains problematically high.

[22] Office of Pollution, Prevention and Toxics, *Occupational Exposures and Environmental Releases of Lead Wheel-Balancing Weights,* US Environmental Protection Agency, August 1, 2005. See also: Robert Root, "Lead Loading of Urban Streets by Motor Vehicle Wheel Weights." *Environmental Health Perspectives*, October 2000; and, Economic and Policy Analysis Branch, Economics, Exposure and Technology Division, *Use and Substitutes Analysis for Lead Wheel-Balancing Weights in Response to TSCA Section 21 Petition*, Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency, July 20, 2005.

[23] *Lead Wheel Weights*, video by the California Department of Toxic Substances Control, uploaded to Youtube on May 4, 2010. Available at: http://youtu.be/7GMG80KjOUI?t=35s

[24] "About Vogel Traffic Services," website, http://www.vogeltraffic.com/aboutus.html

[25] Division of Engineering Services, Guideline for Selecting Materials and Standard Special Provisions for Traffic Striping and Pavement Marking," California Dept. of Transportation, Sept. 2006. Available at: http://www.dot.ca.gov/hq/esc/ttsb/chemical/pdf/striping_guideline_sept06.pdf

[26] *Crumb Rubber Impact Studies*, Liberty Tire Recycling, 2009, p. 3

[27] This research summary does not recite results from artificial turf fields. An historical source of lead in artificial turf fields is unrelated to crumb rubber: some fibers used on the surface layer of these fields contains lead chromate pigment, according to CPSC documents. U.S. synthetic turf manufacturers appear to have phased out the used of lead chromate pigment in the past decade. See: http://www.cpsc.gov/library/foia/meetings/mtg08/artificialturf5_12.pdf

[28] Global Automotive Declarable Substance List, available at: www.mdsystem.com/html/data/bgo_gadsl_imds.xls

[29] "More than half of low-cost jewelry tested contained high levels of toxic chemicals, new study shows," Seattle Post-Intelligencer, March 13, 2012, at: http://blog.seattlepi.com/boomerconsumer/2012/03/page/4/

[30] Consumer Product Safety Commission, *Children's Products Containing Lead; Determinations Regarding Lead Content Limits on Certain Materials or Products; Final Rule*, 16 CFR Part 1500, published in *Federal Register*, August 26, 2009.

[31] Jeff Ruch, "RE: Advisory Opinion Request – Recycled Tire Product Classification," letter to Ms. Cheryl Falvey, Office of the General Counsel, Consumer Product Safety Commission, July 12, 2012.

[32] "CRUMB RUBBER: Separating the Myths from the Facts," Liberty Tire brochure, 2010

[33] *Effects of Waste Tires, Waste Tire Facilities, and Waste Tire Products on the Environment*, California Integrated Waste Management Board, May 1996. Other studies have found samples that exceed 100 ppm of lead in artificial turf, but it is unclear whether these testing programs distinguished between crumb rubber and artificial grass samples.

[34] Office of Research and Development, *A Scoping-Level Field Monitoring Study of Synthetic Turf Fields and Playground*, National Exposure Research Laboratory, December 2009, p. 37 Available at: http://www.epa.gov/nerl/features/tire_crumbs.html

[35] Muhammad Sadiq, Ibrahim Alam, Aarif El-Mubarek, and H. M. Al-Mohdhar, "Preliminary Evaluation of Metal Pollution from Wear of Auto Tires," *Bull. Environ. Contam. Toxicol.* (1989) 42:743-748.

[36] For example, elemental chlorine is present in tires, according to the WRI bulletin, and a 1991 EPA tire pyrolysis study. WRI said chlorine, typically, represents 0.15% of a tire by weight. And EPA said chlorine is present in higher quantities in tires than in most coals. The presence of chlorine in tires is particularly relevant for disposal. When tire waste is burned, dioxins are formed "by the reaction of chlorine in the presence of zinc oxide," which acts as a catalyst. "TIC strives for greater tyre safety," Tyre Industry Council (UK), press release, Oct. 24, 1990; also, Control Technology Center, *Burning Tires for Fuel and Tire Pyrolysis: Air Implications*, US EPA, December 1991, p. 1-5.

[37] *CalRecycle 2010*, p. 31.

[38] "How dangerous are carbon nanoparticles?," press release, Fraunhofer ITEM, August 10, 2010.

[39] *CalRecycle 2010, p. 15.*

[40] *Artificial Turf Study: Leachate and Stormwater Characteristics*, Connecticut Department of Environmental Protection, July 2010, p. 15. Available at: www.ct.gov/dep/lib/dep/artificialturf/dep_artificial_turf_report.pdf

[41] "Public Health Statement for Arsenic," Agency for Toxic Substances & Disease Registry, available at: http://www.atsdr.cdc.gov/phs/phs.asp?id=18&tid=3

[42] *CalRecycle 2010*, p. 63. (CalRecycle is the California Department of Resources Recycling and Recovery, which has been encouraging the use of Tire-Derived rubber in consumer products.)

[43] Durability measures, such as the Taber Abrasion Test, measure the service life of a product by weight loss over time. The typical test measures a year's worth of commercial traffic wear. A Taber test of one recycled rubber flooring product line measured four percent weight loss. See["The Evolution of Rubber Tile," Dinoflex Group, November 2008, available at: http://pharosproject.net/uploads/files/sources/61/Evolution%20Brochure-Nov2008.pdf

[44] "Log of Meeting on Artificial Turf Products," Consumer Products Safety Commission, May 12, 2008

[45] See, for example, the State of California's website, "Certifying Postconsumer Recycled-Content," http://www.calrecycle.ca.gov/buyrecycled/stateagency/Certify.htm ; and, the U.S. General Services Administration's guidelines for Recycled Content Products at: http://www.gsa.gov/portal/content/105366