2017-2030 Sustainability Action Plan
THE MILLER HULL PARTNERSHIP, LLP

RED LIST V1.0

• ~~Polyvinyl Chloride (PVC)~~ • Cadmium • Chlorinated Polyethylene and Chlorosulfonated Polyethylene • Chlorobenzenes • Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs) • Chloroprene (Neoprene) • ~~Halogenated Flame Retardants (HFRs)~~ • Chromium VI • Chlorinated Polyvinyl Chloride (CPVC) • Formaldehyde (added) • ~~Hexavalent Chromium (Hex 6)~~ • Lead (added)• Mercury • Polychlorinated Biphenyls (PCBs) • Perfluorinated Compounds (PFCs) • ~~Phthalates~~ • Polyvinylidene Chloride (PVDC) • Short Chain Chlorinated Paraffins • Wood treatments containing Creosote, Arsenic or Pentachlorophenol • ~~Formaldehyde~~ • Volatile Organic Compounds (VOCs) in wet-applied products • ~~Alkylphenols Asbestos Bisphenol A (BPA)~~

MILLER HULL RED LIST V1.0

1. PVC
2. Halogenated Flame Retardants
3. Hexavalent Chromium (Hex 6)
4. Phthalates
5. Formaldehyde
6. BPA

PRECAUTIONARY PRINCIPLE:

When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.

Left Image: A view of downtown Seattle from the photovoltaic rooftop of the Bullitt Center, Seattle, WA

WHAT is it?

"Because infinitesimal doses of dioxin are enough to cause health damage, the only level of dioxin exposure that should be considered acceptable from a public health perspective is zero."

Joe Thornton, *Encironmental Impacts of Polyvinyl Chloride Building Materials*[15]

- **Poly Vinyl Chloride**, commonly abbreviated **PVC**, is the world's third-most widely produced synthetic plastic polymer. PVC is largely used in construction because it can be more effective in weight, cost, and performance than traditional materials such as copper, iron or wood in pipe applications.
- The production of PVC results in the release of toxins including dioxins. The burning of PVC results in the release of dioxins. Additives of PVC can be toxic to users. The manufacturer and incineration of PVC also creates and releases dioxins, which cause a wide range of health effects including **cancer, birth defects, diabetes, learning and developmental delays, endometriosis, and immune system abnormalities.** One type of dioxin present in PVC is the most potent **carcinogen** ever tested. These toxin's primary pathway into the human body is through inhalation.
- The chemicals present in PVC are known as persistent biocumulative toxins (PBT's) which mean they will persist in the environment and species around the world indefinitely.
- A common myth is that PVC can be recycled. PVC never completely breaks down in the environment, it cannot be recycled and interferes with the recycling of other plastics.[1]

WHY do we care?

As architects, we care because...

- As **one of the most common building products**, PVC is a toxic chemical largely used in building materials such as pipes, electric cables, photo-effect wood finish, window frames and sills, fascia, siding, weather boarding, flooring, ceiling tiles, interior cladding, and more.
- Healthy Building Network research shows vinyl (PVC) is the number one driver of asbestos use in the US. The vinyl/asbestos connection stems from the fact that PVC production is the largest single use for industrial chlorine, and chlorine production is the largest single consumer of asbestos in the US.
- More than 70% of PVC is used in building and construction applications. This makes the building and construction industry the single largest product sector consuming chlorine, bearing sizable responsibility for the ongoing demand for asbestos.[2]

As building owners, we care because...

- **Potential health and environmental hazards during the use phase** could include the release of toxic substances from largely plasticized PVC products into the indoor or natural environment.
- Studies have linked dust containing phthalates from homes with PVC flooring with an increase in asthma, rhinitis and eczema. **The presence of PVC flooring in the child's bedroom was the strongest predictor of respiratory ailments.**[3]
- The average American's exposure to the dioxin in PVC poses a calculated risk of cancer of greater than 1 in 1,000 – thousands of times greater than the usual standard for acceptable risk. The incidences were higher in multiple family dwellings where a higher percentage of PVC flooring was found.[4]
- The use of PVC as a building material contributes to the **degradation of indoor air** and is **linked to respiratory symptoms in children and office workers.** The plasticizers with which it is treated pose clear threats, at background level, to fetal development of the male reproductive tract and may also damage sperm cells in adult males.[5]
- **Disposal Issue:** Landfilling or burning of PVC causes toxic plasticizers and metal based stabilizers to leach into the environment through soil, water and air exposure.

PVC

As contractors, we care because...

- The greatest risk of exposure is to workers in production facilities and those who work with the products during construction, primarily through inhalation.

HOW to make a change

"Exposure to a single PVC fire can cause permanent respiratory disease… Due to its intrinsic hazards, we support efforts to identify and use alternative building materials that do not pose as much risk as PVC to fire fighters, building occupants or communities."

Richard M Duffy, International Association of Fire Fighters[6]

While many health and environmental problems are associated with PVC, the construction industry has been unaware of its true cost and long considered it as a cheap convenient material. There exist a variety of cost effective materials with less health hazard to workers, building users, and the general public that perform equally well.[7]

Alternative Options

Products with Vinyl	Safer Alternative Material	
Piping	**Cast Iron, Steel, Concrete Vitrified Clay, Lead-free Copper (interior only), HDPE (high density polyethylene),un-crosslinked PEX, Polypropylene**	Depending on the plumbing application, a wide range of materials can be used to construct pipes for hot and cold potable water, as well as waste pipe and sanitary drains.
Resilient Flooring	**Cork, Linoleum, Rubber**	Cork and linoleum both source their primary ingredients from plants and natural minerals. Be sure to select a cork floor made without a PVC backing. While rubber flooring is based on styrene-butadiene chemistry and has a number of concerns, a 2009 evaluation of resilient flooring from the Healthy Building Network still indicated it as a preferred option over PVC.
Carpet Backing	**Polyvinyl Butyral (PVB)**	Some carpet backing and other flooring products can contain a PVC backing. Be sure to ask the manufacturer for a product that has an alternative bio-based backing that is less harmful and persistent than PVC.
Wall Covering	**Textiles, Polyethylene**	Fabrics offer an alternative to PVC wall coverings. Xorel, made by Carnegie Fabrics, features a polyethylene fabric made from sugar cane rather than petroleum.
Wall Protection	**Aluminum, Bio-based Polymers, Stainless Steel, Zinc**	Metal sheeting and plates offer a simple alternative to PVC wall protection, while some corn-derived polymers are also entering the market.
Window Blinds and Shades	**Textiles, Polyethylene, Aluminum**	When specifying fabric shades, avoid PVC-coated, stain resistant, anti-static, or other surface treatments that may introduce unwanted hazards. Anti-microbial coatings are not needed and have more harmful human health effects.
Window Frames	**Aluminum, Wood, Fiberglass**	Wood, fiberglass and aluminum window frames are readily available in a variety of colors. Vinyl window frames have been found to have significant moisture infiltration and leaking failures years after installation leading to costly lawsuits, mold issues and high building energy uses.

Table 1. Substitute Materials for Common PVC Building Components and Interior Finishes[8]

WHAT is it?

- **Flame retardants** are chemicals added to products to delay or prevent ignition and the spread of fire. They are used in levels of about 1% to 30% of the weight of foam or plastic found in products such as textiles, furniture, baby products, electronics, building insulation, surface finishes and coatings, wire and cable. Flame retardants are broadly classified into **halogenated** and non-halogenated flame retardants. Bromine, chlorine, fluorine and iodine, are the elements in the chemical group known as halogens.[9]

- Flame retardants are associated with **reduced IQ** (similar to lead poisoning), **reduced fertility, birth defects, and hormonal changes**. Many are similar in structure or even identical to banned chemicals such as DDT, Mirex and PCBs.[10] When these products ignite, the chemicals can **produce the toxic gases** that cause most **fire deaths and injuries**.

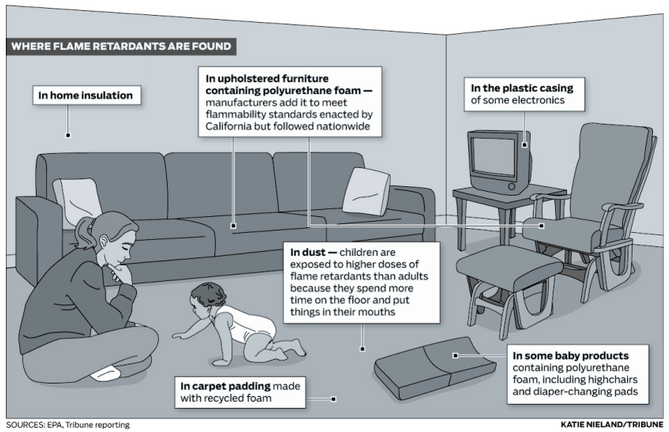
WHY do we care?

As architects, we care because...

- Halogenated flame retardants (HFR's) are used in building materials such as surface finishes and coatings.
- Our specifications have the power to drive market change for safer materials.
- Flame retardants can come into direct contact with building occupants.
- LEED materials credit for "Building Product Disclosure and Optimization".

As building owners, we care because...

- Flame retardants are a **human health concern**, and building users will have direct contact with building materials that contain Halogenated Flame Retardants.
- Product treated with HFR's are toxic and **cannot be recycled**. Thus, they are either burned or placed in landfills. When burned, toxins are released into the air; and when landfilled, toxins can leach into water and soil, affecting food and water supplies.[11]



Halogenated Flame Retardants

As contractors, we care because...

- **Occupational exposure:** HFR's release toxins during manufacturing, transportation, and construction process.

HOW to make a change

No, we do not need flame retardants for fire safety.

- Surprisingly, flame retardants, as used to meet current standards for furniture and baby products, do not increase overall fire safety. While they may delay ignition a few seconds, they will eventually burn and can produce the toxic gases that cause most fire injuries and deaths.

- Halogenated Flame Retardants: HFRs are added to too many building materials – even when they are not needed. Fire scientists, toxicologists, and even firefighters are raising alarm bells around the world. **There is no significant fire safety benefit from HFRs** in foam or wiring behind walls or under concrete slabs, yet current US codes requires HFRs in these applications. Sadly, during a fire, HFRs release significantly more smoke and very toxic gases that harm/kill occupants and firefighters. **The European Union has already banned some HFRs, but the US lags behind.** There is currently a concerted effort in the green building movement to remove HFRs from materials when there is no added fire safety benefit.[12]

- Policy actions are taking such other factors into consideration. For example, the updated California Furniture Flammability Standard (TB117-2013), which has implemented in January 2014 is based on a smolder test for fabric, which is where the majority of fires begin. **The new standard does not lead to the use of flame retardants, so it will now be possible to have increased fire safety without harmful chemicals.**[13]

"Instead of adding new fire retardant chemicals that ultimately may be shown to cause health problems, we should be asking whether we need to use these chemicals or if there are other ways to achieve equivalent fire safety..."

Arlene Blum, a biophysical chemist and visiting scholar at the University of California, Berkeley[14]

Alternative Options

- **Preventing ignition with fire safe cigarettes, candles, lighters**, and other strategies is less expensive, more effective, and healthier than adding flame retardants to many of the products in our homes.

- **Select fabrics, building insulation and furniture foams without HFR's.**

- To increase fire safety, there are insulation and furniture products available without HFR's.

- **Alternatives-GREEN Flame Retardants: Compro FR-60**
  Compro FR-60-P is a safe, non toxic, non halogen, flame retardant. It is designed for flexible foams. Other polyols without flame retardant are also available and can be used on polyester, epoxy, and a variety of other coatings including plastics in aromatic systems. In aliphatic systems, request Compro FR-60-PA. They provide a variety of features for these coatings outside of excelled flame retardancy such as impact strength, flexibility, and water repellency. On saturated polyester resins cured with melamine such as our Compromel, Compro FR-60-P will impart film thickness and greater chemical resistance. In PET coatings it will facilitate cast and mold properties and reduce stress and strain afterwards.[15]

WHAT is it?

- **Hexavalent Chromium** (known as **Cr^6** and **Hex 6**) is a toxic form of chromium in the environment, which occurs naturally but it is usually produced by industrial process. Chromium's ability to easily react with other elements can produce hard coatings. Its **properties include corrosion-resistance, durability and hardness**.

- Hex 6 is classified as a **human carcinogen (cancer-causing)**, Chronic inhalation of Hex 6 has been shown to increase risk of **lung cancer** and may also **damage the small capillaries in kidneys and intestines**. Other adverse health effects associated with Hex 6 exposure, according to the National Institute for Occupational Safety and Health (NIOSH), include **skin irritation or ulceration, allergic contact dermatitis, occupational asthma, nasal irritation and ulceration, perforated nasal septa, rhinitis, nosebleed, respiratory irritation, nasal cancer, sinus cancer, eye irritation and damage, perforated eardrums, kidney damage, liver damage, pulmonary congestion and edema, epigastric pain, and erosion and discoloration of one's teeth.**[16]

WHY do we care?

As architects, we care because...

- It is **used in chrome plating** and **as an alloy in the production of stainless steel**, as well as **in anti-corrosion and conversion coatings**. It is used to produce CCA (chromated copper arsenate) that is applied as a preservative **in the treatment of structural timber**.[17]
- Hexavalent Chromium is a toxic chemistry that is commonly used on building materials for surfaces coating, such as ductwork, steel studs and plumbing fixtures.
- The process of working with Hex 6 content will severely effect human health.

As building owners, we care because...

- Owners create the demand for Hex 6 and have the power to reduce the demand.
- Most industrial output of Hex 6 occurs in water but coal burning also increases air concentration. Most of the chromium in air will eventually settle and end up in waters or soils. We currently lack confirmed knowledge and clear guidelines concerning the level at which Cr^6 in drinking water becomes a public health hazard. (Refer to the Precautionary Principle)
- A lawsuit concluded that Pacific Gas & Electric (PG&E) had contaminated groundwater in the California town of Hinkley, leading to a high number of cancer cases.[18]

As contractors, we care because...

- A major source of worker exposure to toxic Cr^6 occurs during "hot work" such as welding on stainless steel and other alloy steels containing chromium metal.[19]
- **Excess lung cancer** found in heavily exposed workers through inhalation of chrome plating, chromate pigment production, use of pigments, spray paints and coatings.[20]
- Workplace exposure to Cr^6 may cause health effects such as lung cancer, irritation or damage to the nose, throat, and lung (respiratory tract), irritation or damage to the eyes and skin.[21]

Hexavalent Chromium (Hex6)

HOW to make a change

No, we don't need Hexavalent Chromium for hard coating.

Alternative Options

- Metal coil used in steel stud framing and ductwork are available without the Cr^6 coating upon request. **Ask Manufacturers to eliminate the "passivation coating" that contains the hexavalent chromium and ensure that any coatings use are RoHS** (Restriction of Hazardous Substances, pronounced: row-haas) compliant. RoHS is a European materials standard that prevents, among other toxins, hexavalent chromium.

- **Anodized Aluminum** is an alternative material for Chrome Plating.
- **Stainless Steel** without passivation coating is an alternative for pigments in paint/textiles.

- **Trivalent chromium (known as Cr^3)** plating is an alternative to Hexavalent Chromium in industrial process. From a health standpoint Cr^3 is intrinsically less toxic than Cr^6. Because of the lower toxicity it is not regulated as strictly, which reduces overhead costs. Other health advantages include higher cathode efficiencies, which lead to less chromium air emissions; lower concentration levels, resulting in less chromium waste and anodes that do not decompose. However, taking into account the Precautionary Principle, not enough information is known about the full human and environmental health effects of Cr^3. [22]

Table 2. Summary of Non-Chromium Substitutes for Hard and Decorative Chromium Baths[23]

	Cr^6 Possible Substitutes	Notes	Vendor / Product
Electroplated nickel	Nickel-tungsten-boron	Uses conventional plating equipment and operates similar to a conventional nickel plating bath; may be more costly than hex chrome	AMPLATE
	Nickel-tungsten-silicon-carbide	May provide higher plating rates and higher cathode current efficiencies; may provide better throwing power and better wear resistance; may be more costly than hex chrome	Takada Inc.
	Tin-nickel	Good corrosion resistance in strong acids, breaks down above 320c, less wear resistance than hex chrome	
	Nickel-iron-cobalt	Vendor claims twice the wear resistance and 2.6 times the corrosion resistance of hex chrome; same color can be obtained	Shining Surface Systems, METTEX6 http://www.surfacesystems.com
	Nickel-tungsten-cobalt	Contains no chloride or strong chelators; can be used in rack and barrel plating; good corrosion resistance except in marine environments; may tarnish; contains ammonia	Enthone, Enloy Ni-150 http://www.afonline.com/articles/00sum03.html
Non-nickel electroplate	Tin-cobalt	Plate on nickel; decorative only	Seaboard Metal Finishing, Seachrome www.seaboardmetalfin.com
		Plate on decorative nickel and nickel alloy; may be used in racking; mildly alkaline	Enthone, Achrolyte
		Great color, light blue cast; no ammonia; no fluorides; no chlorides	MacDermid, CROMVET
	Cobalt Phosphorous	Nano-crystalline deposit produces extreme hardness; Plating current waveform modification (electrically mediated deposition) used to produce nanocrystalline deposit.	Integran Technologies, Inc. http://www.integran.com/
Electroless	Electroless nickel -nickel-tungsten -nickel-boron -nickel-diamond composite -nickel-phosphorous -nickel-polytetraflourethylene	Possibly less hardness and abrasion resistance than hex; no build up on corners	Abrite, Millenium series, www.abrite.com MacDermid, NiKlad Sirius Surface Technology Micro Surface Corp.
Other Methods	HVOF (high velocity oxygenated fuel) thermal sprays	Hardness and wear resistance similar to hex chrome; limited to line-of-sight applications.	
	Physical vapor deposition (PVD) -titanium nitride	Greater hardness than hex chrome with a thinner coating; less corrosion resistance	
	Ion beam-assisted PVD	Line-of-sight; thinner coatings give same properties as other thicker coatings	Skion Corp.
	Plasma spray-titanium carbide	Aluminum, steel, carbon steel, titanium substrates	A-Flame Corp.
	Chemical vapor deposition	Vacuum deposition; not limited to line-of-sight; resistant to acids; high deposition rate	
	Ion implantation	Ions are implanted – no thickness; non-line-of-sight	Southwest Research Institute
	Powder coating	Vacuum metallization (PVD) – has met OEM wheel industry testing requirements including ASTM B117, GM4472P, GM9508P, GM9682P, and GM6	PermaStartm-Goodrich Technology Corp.
	Laser cladding	Non-line-of-sight; nickel carbide coating	Surface Treatment Technologies

WHAT is it?

- **Phthalates** know as “plasticizers,” are used to make plastics such as polyvinyl chloride (PVC) more flexible or resilient. They are a group of industrial chemicals used as esters of phthalic acid and are most **commonly found in plastics** and primarily in PVC **as plasticizers to increase their flexibility, transparency, durability and longevity**.[24]

- Phthalates are used in a wide range of common products, **from plastics to perfumes**, and are **easily released into the environment**. Because they are not chemically bound to products, leaching, migration, and evaporation during use can occur, resulting in human exposure. Phthalates can be taken into the body in different ways, both through food, breathing and through the skin.

- Phthalates are suspected of **disrupting hormones** and may be related to **several chronic diseases in children**, like **asthma and allergies**. Some phthalates such as DEHP have been linked to **reproductive problems** including **shorter pregnancy duration** and **premature breast development** in girls and **sperm damage** and **impaired reproductive development** in boys. Some studies have also found a correlation between phthalates and **obesity**.[25]

WHY do we care?

As architects, we care because...

- **Building materials are the largest end use for PVC**. Major uses of flexible PVC in buildings include carpet backing, resilient flooring, wall coverings, acoustical ceiling surfaces, upholstery textiles, roof membranes, waterproofing membranes, and electrical cord insulation. And they can be released from PVC in to the air. Phthalates can be found in other building products besides just PVC.
- LEED materials credit for “Building Product Disclosure and Optimization”. [26]
- The Environmental Protection Agency (EPA) currently lists 8 chemicals in their Phthalate Action Plan to evaluate and limit the use of.

As building owners, we care because...

- Phthalates cling to dust and can then be breathed in by building occupants with children being the most easily affected.
- Occupants and tenants have many opportunities to come in direct contact with Phthalates.
- Phthalates are moderately persistent in the environment. They can be degraded biologically or chemically in the presence of air in days or weeks; in anaerobic conditions, like those often found in groundwater, little if any degradation occurs, with a hydrolysis half-life of 2000 years.[27]

As contractors, we care because...

- Eating, breathing and skin contact, as well as blood transfusion, are all ways that Phthalates make their way into our bodies. Workers have direct contact with toxic Phthalates during construction and manufacturing process.

Phthalates

HOW to make a change

No, we don’t we need Phthalates in building materials.
Avoiding unnecessary plastics, or fragrances and resins removes these toxic chemicals.

Alternative Options

The available data suggest that non-phthalate plasticizers present fewer human health hazards than phthalates. This is not the same as saying that there are no health hazards associated with these non-phthalate plasticizers. **It is important to remember that plasticizers – phthalates or not – will migrate from products causing building occupants to be inevitably exposed to them.** However, some phthalate-free plasticizers raise fewer concerns than others.[28]

- **Two bio-based products** – Grindsted Soft-n-Safe (made by Danisco/DuPont) and Polysorb ID 37 (made by Roquette) are well studied and appear to be the least toxic of the six non-phthalate plasticizers reviewed.

- **Di-(2-ethylhexyl) terephthalate (DEHT)**, sold by Eastman Chemical under the trade name Eastman 168, fares better than DINP (Di-isononyl phthalate) in most health and environmental hazard endpoints. However, further study is needed due to uncertainties surrounding endocrine disruption and reproductive toxicity.

- **Hexamoll DINCH (Diisononyl cyclohexane-1,2-dicarboxylate)** also compares favorably overall to DINP, including for carcinogenicity and developmental toxicity. However, DINCH uses DINP in its manufacture and DINCH is less biodegradable and more persistent in the environment than DINP.

- **Eastman Chemical’s dibenzoate plasticizers**, sold under the Benzoflex trade name, compare well with DINP, but contain substances that are more ecotoxic and have the potential to bioaccumulate.29

Products with Phthalates	Safer Alternative Material
Vinyl Flooring	EPDM Type Rubber, Natural Linoleum, Polyolefin flooring
Paints and Lacquers	Phthalate-free Paints and Coatings
Electrical Cabling	Polyethylene or Rubber Sheathed Cables
Carpet Backing	Recycled PET and Glass Carpet Backing

Table 3. Substitute Materials for Common Phthalates Building Components and Interior Finishes

WHAT is it?

- **Formaldehyde is a colorless, strong-smelling, and flammable gas.** Pure formaldehyde is extremely reactive. For this reason, it is often mixed into chemical compounds to form a stable substance. Formaldehyde is used in a wide spectrum of products. Examples include shampoo, lipstick, nail polish, some glues, ink, paint and wrinkle-free fabrics, and building materials, such as sealants and wood composites as a binder.[30]

- The US Environmental Protection Agency (EPA) describes formaldehyde as causing '… watery eyes, burning sensations in the eyes and throat, nausea, and difficulty in breathing in some humans. High concentrations may trigger attacks in people with **asthma**. There is evidence that some people can develop a sensitivity to formaldehyde. It has also been shown to cause cancer in animals and may **cause cancer in humans**. Health effects include **eye, nose, and throat irritation; wheezing and coughing; fatigue; skin rash; severe allergic reactions.**'[31]

WHY do we care?

As architects, we care because...

- In construction, formaldehyde is still widely used in **pressed-wood products**, such as **particleboard, plywood, and fiberboard; glues and adhesives; permanent-press fabrics; paper product coatings; and certain insulation materials**.[32]
- Higher formaldehyde levels are usually found in newer homes or homes with new construction. The levels decrease over time due to off-gassing. Formaldehyde levels also increase with increases in temperature and humidity.[33]
- Formaldehyde is a human carcinogen found in composite wood products. Those who live in mobile homes or spend time in portable buildings or classrooms are especially at risk. Gas can be released into the air naturally and increases with temperature rise.

As building owners, we care because...

- Formaldehyde exposure is a special concern for children and the elderly. If children or elderly people are in your home, it is important to reduce their exposure to formaldehyde.
- Formaldehyde has been known to cause cancer in laboratory animals and could possibly cause cancer in humans. There is no known maximum threshold level and no known level below which there is not a threat of cancer. The risk of getting cancer from formaldehyde depends upon the amount and duration of exposure.[34]

As contractors, we care because...

- Formaldehyde is a chemical used widely to manufacture building materials and products, such as glue in fiberboard. Formaldehyde is also a by-product of combustion and certain other natural processes. Thus, it may be present in substantial concentrations both indoors and out.[35] Workers have direct contact with toxic formaldehyde during construction process.

HOW to make a change

No, we don't need Formaldehyde.
Wood is one of the primary products that contain added formaldehyde and with some effort it is possible to avoid these hazards.

Alternative Options

- Pressed wood adhesive alternatives include those labeled "formaldehyde-free" or "low-emitting" or those made from phenol-formaldehyde (such as oriented strand board, softwood plywood or exterior grade plywood) generally emit lower levels of formaldehyde. However, formaldehyde-free can still mean that lower levels of formaldehyde are allowed so **requesting "no added formaldehyde"** is the best course of action.[36]

- Hardwood plywood and softwood plywood or oriented strand board can be manufactured using alternative adhesives, such as the soy-based resin developed for wood panel applications by Columbia Forest Products. Note that one of the resin feedstocks is epichlorohydrin, which is a probable human carcinogen that can result in negative impacts on respiratory and hematological systems.

- **Composites of wood fiber** and **polypropylene thermoplastics** are used extensively as substitutes for wood lumber, and are being developed for use in wood panel applications.[37]

- **Soybean protein modified with sodium dodecyl sulfate** can also be used as an alternative resin for wood fiber medium density fiberboard preparation.

- Other composite wood products, such as softwood plywood and flake or oriented strandboard are produced for exterior construction use and contain the dark, or red/black-colored phenol-formaldehyde (PF) resin. As the name implies, formaldehyde is present in this type of resin also, but composite woods that contain PF resin generally emit formaldehyde at considerably lower rates than those containing Urea Formaldehyde (UF) resin.

- The most widely used completely formaldehyde-free alternative resins are **MDI (methylene diphenyl isocyanate) and PVA (polyvinyl acetate)**. Despite its name, PVA is not closely related to PVC. Without chlorine in its molecule it avoids many of the worst problems that PVC has in its life-cycle.[38]

- Alternative building materials include those made from non-wood sources (e.g., recycled paper, rammed earth, metal, stone and brick) or solid wood. Agricultural fiber alternatives can come from crops grown specifically for fiber (e.g., kenaf and bagasse) and residues of crops grown for other purposes (e.g., corn stalks/cobs and cotton stalks).[39]

Products with Formaldehyde	Safer Alternative Material
Binders	**Methylene diphenyl diisocyanate (MDI)** **Soy Flour**
Foam Carpet Backing	**Foam Carpet Backing**
Paint & Coating Preservative	**Unknown**
Laminates	**Solid Surface, Solid Wood, Tile, Concrete**

Table 4. Substitute Materials for Common Formaldehyde Building Components and Interior Finishes

WHAT is it?

- **Bisphenol A (BPA)** is a chemical produced in large quantities for use primarily in the production of polycarbonate plastics and epoxy resins. BPA can also be found in certain paints or coatings such as powder coat.[40]

- Scientific studies have linked BPA to a range of health effects including, **endocrine disruption** (decreased sperm production in men, early puberty in girls, fertility issues, greater chance of miscarriage, endometriosis, stimulation of early mammary gland development, and ovarian dysfunction), **obesity, heart disease, thyroid disruption, neurological effects, cancer, insulin resistance, diabetes, food tolerance issues, decreased cognitive function**. This chemical leads to **genetic issues** that impact not just our children, but our grandchildren and future generations by changing our DNA.[41]

WHY do we care?

"A poison kills you, a chemical like BPA reprograms your cells and ends up causing a disease in your grandchild that kill him."

Fredrick vom Saal, Biology Professor, University of Missouri

As architects, we care because...

- BPA is a toxic chemical component of epoxy resins used in a wide range of building materials, including **high performance coatings** (paints, floor sealers, and other protective coatings), **adhesives and fillers** (caulk, grout, mortar, and putty), **fiberglass binders**, and **cement additives**.[42]
- Epoxy resins are also in some electronic equipment, industrial tooling applications, and materials used in the art, aerospace and marine industries.[43]
- With 90% of the population testing positive for BPA and a growing body of science raising increasing concern, responsible specifiers do not need to wait for regulatory action, but can take a precautionary approach to protect building occupants and manufacturing and installation workers. Low VOC products are available that can replace epoxy paints and other epoxy-based products and still meet the needs of health care facilities.[44]

As building owners, we care because...

- The major human exposure route to BPA is diet, including ingestion of contaminated food and water. Building occupants may have direct contact with BPA because it is used to form epoxy resin coating of water pipes. In older buildings, such resin coatings are used to avoid replacement of deteriorating pipes.[45]

As contractors, we care because...

- In the workplace, while handling and manufacturing products which contain BPA, **inhalation and dermal (through skin) exposures** are the most probable routes.[46]

HOW to make a change

No, we don't need BPA.

Alternative Options

Sometimes found in paints and coatings, there are alternative ways to provide a BPA-free finish, like **mill finish** or **coatings without BPA**.

- **Use BPA-free products**. Manufacturers are creating more and more BPA-free products. Look for products labeled as BPA-free. If a product isn't labeled, keep in mind that some, but not all, plastics marked with recycle codes 3 or 7 may be made with BPA.[47] However, BPA-free may not mean a product is safe as there may be regrettable substitutions that are less safe or more unknown like BPS.

- BPA is used in the production of polycarbonate (PC) plastics (used in food contact materials, such as baby bottles and food containers) and epoxy resins (used as protective linings for canned foods and beverages and as a coating on metal lids for glass jars and bottles) that come into contact with a wide variety of food. Some alternatives to BPA-containing materials for PC bottles and containers and epoxy can linings are available on the market or proposed for use. However, at present, there appears to be no single replacement for BPA for all food contact applications. Furthermore, data on the safety of some of these replacement materials are limited or nonexistent.[48]

- For polycarbonate, replacement materials include those polymers that are currently used to make bottles and containers for food packaging applications, including glass, polypropylene, polyethersulfone, polyethylene terephthalate, high-density polyethylene, PVC, polyamide and silicone. An example of a new alternative to PC is Tritan copolyester. While polyesters, polyacrylates, vinyl resins and oleoresins are available, they do not have the same performance characteristics and are not exact replacements of BPA-based epoxy resins. For example, alkyds (polyester modified with fatty acids) cannot be used for interior can coatings for beverages and food because of their susceptibility to hydrolysis and chemical attack.

- It is important to note that any of these new or existing alternative materials would need to be assessed for appropriate functionality and safety using state of the art methodology and scientific knowledge. [49]

Products with BPA	Safer Alternative Material
Protective Coating	Numerous alternatives
Epoxy Resins	Numerous alternatives
Wire/Electronic Sheathing	PET Plastics
Polycarbonate Plastics	PET Plastics

Table 5. Substitute Materials for Common BPA Building Components and Interior Finishes

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