Prescription for Healthier Building Materials:

A Design and Implementation Protocol

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AIA ARUP

Foreword

In 2014, the AIA adopted the Materials and the Built Environment position statement:

> "The AIA recognizes that building materials impact the environment and human health before, during, and after their use. Knowledge of the life cycle impacts of building materials is integral to improving the craft, science, and art of architecture. The AIA encourages architects to promote transparency in materials' contents and in their environmental and human health impacts."
>
> – *AIA 2014 Annual Report*

Materials matter, and this document offers project teams a protocol to put these words into action. The protocol guides owners, design professionals, contractors, and facilities managers toward best practices for choosing and installing products that are healthier over their full life cycle for humans and the environment. Unlike chemical avoidance list approaches, which have their place, this guide does not declare any bans on specific materials or product content. Instead, we seek to:

- outline a framework for designing and building with healthier materials on projects
- identify useful resources to aid project teams in the selection of safer alternatives
- educate readers about the harms of certain types of substances found in building products

Building materials matter

Over the last decade, a growing body of environmental health research has shown that commercially available products, including building materials, commonly contain chemicals known or suspected to be hazardous to human health. Given that most people spend about 90 percent of their time indoors[1], and that many of these chemicals now appear regularly in urine and blood samples[2], there is growing belief that our buildings are exposing us to hazardous chemicals. In addition to impacts on building occupants, hazardous materials can pose impacts on people and natural systems across materials' life cycles, during extraction, manufacturing, installation, and disposal. How can the design and construction industry address these concerns?

Several chemical avoidance lists, which identify chemicals to be avoided in building products, have been developed as one response to this development. As another response, greater transparency has become a motto for a growing materials health movement, and manufacturers are increasingly asked to disclose product chemical content beyond what regulations require. However, these lists and disclosure documents have been challenging to implement because of limited understanding of where these chemicals occur in products, how best to avoid them (e.g., whether to identify safer alternatives or forego them altogether), and how to prioritize such directives among other materials and product selection criteria.

[1] Klepeis, et al. (2001). The National Human Activity Pattern Survey (NHAPS). *Journal of Exposure Analysis and Environmental Epidemiology*, 11: 231-252.

[2] Centers for Disease Control and Prevention (CDC). (2009). *Fourth National Report on Human Exposure to Environmental Chemicals*. Atlanta, GA: CDC, National Center for Environmental Health. Accessed 3 November 2016.

The Need for a Roadmap to Healthier Materials

The authors of this document have found that "reduced toxicity" and "healthier materials" are not easily specified by building owners, and approaches for tracking and documenting compliance with these objectives are not yet codified. The nearest precedent to bridge this gap was a guide for the United Kingdom, authored by Ove Arup & Partners, published in 1997 and then reissued in its 2nd edition in 2011. The Good Practice Guide to the Selection of Materials in Building Construction became a guidance document that changed the approach design teams took to selecting materials on building projects. As quoted from the British Council for Offices:

> "This document was designed to encourage a change in emphasis, from the exclusion of materials to ensuring good practice in their selection. This objective was achieved, as consequently contract specifications referred to that document rather than the materials exclusion list."

While relevant in concept, the existing UK guide is not appropriate for use in the United States for several reasons. Unlike in the US, the European Union has put in place several regulations since the guide was published, such as the REACH program and Consumer Product Labeling requirements. These regulations have helped address many EU marketplace concerns related to chemical hazard identification in construction products. In contrast, the lack of such regulation in the US has led to a vast array of tools for project teams and design firms that are primarily targeted towards American practitioners. Also, the project delivery process in the UK and EU is more often design-build and less risk-averse.

Shaping materials health outcomes

This protocol seeks to produce a navigational guide that is appropriate to the American design and construction industry.

It provides:

- detail on the science and policy context for healthier materials
- an approach owners and project teams can take to turn the vast array of chemical substances, certifications, and chemical avoidance lists into a manageable set of shared references
- examples of how to turn values around health and transparency into clearly-written goals and scope of work, approachable targets, and clear roles and responsibilities for a project
- an overview of approaches to implementing healthier materials—from favoring disclosure to prioritizing avoidance of selected substances
- an introduction to common disclosure and optimization tools to guide your project team
- common barriers in implementing healthier materials into projects—and how to address them
- examples from practice that demonstrate different approaches to prioritizing healthier materials in a variety of project types

While this protocol is written from a design perspective, it is intended for everyone working in this field. Designers are key players in evaluating and selecting building materials but designers are far from the only ones who shape the material health outcomes for our projects or our planet.

Acknowledgments

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Acronym glossary

AEC	Architecture, Engineering, and Construction
BPA	Bisphenol A
BPS	Bisphenol S
BPDO	Building Product Disclosure and Optimization
C2C	Cradle to Cradle
CDC	Centers for Disease Control
CSI	Construction Specification Institute
EPA	Environmental Protection Agency
EPD	Environmental Product Declaration
EWG	Environmental Working Group
FDA	Food and Drug Administration
GGHC	Green Guide for HealthCare
GSLT	GreenScreen List Translator
GSPI	Green Science Policy Institute
HBN	Healthy Building Network
HM	Healthier Materials
HPD	Health Product Declaration
IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality
ILFI	International Living Future Institute
KP	Kaiser Permanente
LBC	Living Building Challenge
LEED	Leadership in Energy and Environmental Design
LEEDv4	LEED version 4
LEM	Low-Emitting Materials
LT	List Translator (synonymous with GreenScreen List Translator or GSLT)
MSDS	Material Safety Data Sheet
OPR	Owner's Project Requirements
OSHA	Occupational Safety and Health Administration
P+W	Perkins+Will
PBT	Persistent, Bioaccumulative Toxicant
PFC	Perfluorinated Compound
PPM	Parts per Million
PVC	Polyvinyl Chloride
REACH	Registration, Evaluation, Authorization, and Restriction of Chemicals
SBS	Sick Building Syndrome
SDS	Safety Data Sheet
SFO	San Francisco International Airport
SPeAR	Sustainable Project Appraisal Routine®
TSCA	Toxic Substances Control Act
TURA	Toxics Use Reduction Agency
WHO	World Health Organization
VOC	Volatile Organic Compound

Understanding background and context

SECTION HIGHLIGHTS:

- Why you should be concerned about selecting safer materials for your projects.
- Understanding chemical transparency and hazard reduction in product selection and design.
- How purchasing power can be leveraged in the push toward a healthier materials market.

Why should we be concerned about what is in the products we use to make and finish our buildings and furniture?

01

THE WEIGHT OF EVIDENCE FOR SELECTING HEALTHIER MATERIALS

A growing body of environmental studies and reports demonstrates the connection between chemical exposure from certain materials and human health. This offers a big opportunity—and strong motivation—for architects and designers to more carefully consider the materials they choose, and for owners and facility managers to be more selective in the products they authorize for purchase or buy directly.

Research by the Environmental Working Group (EWG)[3] in 2005, for example, analyzed the levels of pollutant chemicals found in infants[4] for a large group of industrial chemicals, including many used in building products. The study identified "early life exposure to environmental pollutants"—many of which are leading suspects for the rise in cancer, nervous system disorders, preterm births and low birth weight, and reproductive system defects among Americans—in cord blood, or blood found in the umbilical cord of the infant at birth.[5]

A 2012 report by the World Health Organization (WHO) and the United Nations Environment Programme acted as an international call to action, showing the global ubiquity in commercial products of endocrine-disrupting chemicals linked to many types of cancers, fertility and pregnancy complications, and even obesity. Its authors noted the positive health effects that result when governments take action to reduce exposure, such as bans or restrictions of specific endocrine-disrupting chemicals.[6]

Market-driven efforts can also bring these positive effects, and they often do so more quickly than regulation, which can take significant time to develop, adopt, and implement. Through the selection of safer materials, architects and project teams have the ability to reduce human exposures to toxic chemicals and make communities healthier.

> "The true burden of environmentally induced cancer has been grossly underestimated. With nearly 80,000 chemicals on the market in the United States[7]– many of which are used by millions of Americans in their daily lives and are un-studied or under-studied and largely unregulated – exposure to potential environmental carcinogens is widespread."
>
> *– President's Cancer Panel, 2010*

[3] The Environmental Working Group is a non-profit, non-partisan organization dedicated to protecting human health and the environment. The organization specializes in research and advocacy in the areas of toxic chemicals, agricultural subsidies, public lands, and accountability. Its stated mission is "to use the power of public information to protect public health and the environment.

[4] Environmental Working Group (EWG). (2005). *Body burden: The pollution in newborns*.Washington, D.C.: EWG. Accessed 28 October 2016.

[5] Environmental Working Group. (2005). *Human Health Problems on the Rise*. Washington, D.C.: EWG. Accessed 4 Jan. 2017.

[6] Bergman, Ake, et al. (Eds.) (2013). *State of the Science of Endocrine Disrupting Chemicals* - 2012. Geneva: World Health Organization.

[7] Schwarzman, M. and M. Wilson. (2009). New Science for Chemicals Policy. *Science*, 236, 1065-1066.

REGULATORY GAPS AND THE PRECAUTIONARY PRINCIPLE

But, doesn't the government regulate chemical safety? Yes—and no. Chemicals intended to be absorbed into the human body such as those in food, medicine, and cosmetics are subject to regulation by the US Food and Drug Administration (FDA), while the US Environmental Protection Agency (EPA) regulates almost everything else, including high-volume industrial production chemicals.[8] There are about 84,000 chemicals currently included in the EPA's registry of synthetic chemicals,[9] which was created as part of the Toxic Substances Control Act (TSCA) in 1976.

The issue? Although it was widely regarded as ineffective, TSCA held a long tenure as the primary federal chemical policy, from 1976 through its update in 2016, known as the Lautenberg Act.[10,11,12] When TSCA was created, the EPA grandfathered in all 62,000 chemicals that were in industrial use at the time.[13] This sweeping move assumed that these chemicals were safe for their intended uses, as defined by the manufacturer. Despite a growing body of literature showing the risks that many of these chemicals pose to human and environmental health, and despite updates made to the law in 2016, the majority of those 62,000 chemicals have yet to undergo testing, and continue to be commercially available.[14] Additionally, TSCA did not require health and safety testing for new chemicals.[15] The Lautenberg Act mandates, for the first time, that the EPA review the risks these chemicals pose.[16] The statistics included in Figure 1 reflect numbers last estimated under TSCA. They are anticipated to change as the Lautenberg Act is implemented and the chemicals once assumed safe under TSCA are reviewed.

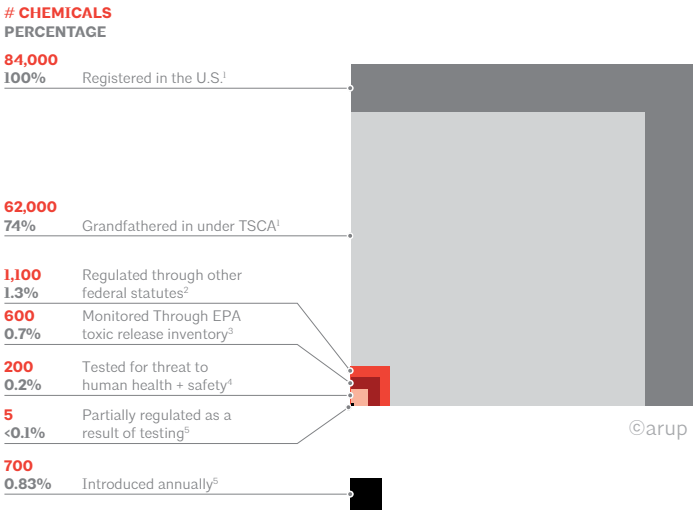


FIGURE 1
Progress in federal chemicals testing and regulation, last estimated under TSCA.

SOURCE
S. Tepfer 2016

[8] The Bureau of Alcohol, Tobacco, Firearms and Explosives, within the Department of Justice, regulates the sale, possession, and transportation of explosives in interstate commerce.

[9] Schwarzman, M. and M. Wilson. (2009). New Science for Chemicals Policy. *Science*, 236, 1065-1066.

[10] Dernbach, J.C. (1997). The Unfocused Regulation of Toxic and Hazardous Pollutants. *Harvard Law Review*, 21: 1-57.

[11] Denison, R. A. (2009). Ten Essential Elements in TSCA Reform. *Environmental Law reporter*, 39: 10020-10028.

[12] Schwarzman, M. and M. Wilson. (2009). New Science for Chemicals Policy. *Science*, 236: 1065-1066.

[13] Schwarzman, M. and M. Wilson. (2009). New Science for Chemicals Policy. *Science*, 236: 1065-1066.

[14] Frank R. Lautenberg Chemical Safety for the 21st Century Act. US Environmental Protection Agency. 2016.

[15] Under TSCA, manufacturers and suppliers were not required to conduct health and safety testing, and the Government Accountability Office found that, under TSCA, they did not typically conduct it voluntarily. Additionally, the EPA has used its authority to test fewer than 200 of the 62,000 grandfathered chemicals since it began reviewing them in 1979 (GAO Report 2005).

[16] Denison, R.A. (2016). *How the Frank R. Lautenberg Chemical Safety for the 21st Century Act amends the Toxic Substances Control Act of 1976 (TSCA).* Washington D.C: Environmental Defense Fund. Accessed 14 February 2017.

In the meantime, largely due to these regulatory gaps, very little information exists about the toxicity of chemicals in industrial use. In the absence of robust toxicity information, many environmental health scientists and policymakers promote the **Precautionary Principle**, which empowers decision makers to exercise caution in advance, rather than wait for absolute scientific proof of chemical health or safety. It provides a way for organizations to step around the widespread lack of data: "When the health of humans and the environment is at stake, it may not be necessary to wait for scientific certainty to take protective action."[17] This approach places the burden of proof of safety on the producer.

Internationally, the Precautionary Principle has formed the basis of REACH, the EU's overarching chemicals regulation. Domestically, the cities of San Francisco and Berkeley, California, have adopted the Precautionary Principle as the basis for environmental policy decisions.[18,19]

In addition to these municipal-level adoptions, many designers, consultants, and other stakeholders from across the building industry have expressed a commitment toward a precautionary approach to their material selection decisions.[20] As one example, the architecture and design firm Perkins+Will has developed an online portal that includes substances classified by regulatory entities as harmful to human and/or environmental health, and are commonly found in building materials. The tool encourages users to take a precautionary approach to material specifications by aggregating toxicity data and providing information about available alternatives to materials that include hazardous chemical contents.

[17] Science and Environmental Health Network (SEHN). (no date). *Science & Environmental Health Network - precautionary principle: FAQS*. Eugene, OR: SEHN. Accessed 28 October 2016.

[18] San Francisco Department of the Environment. (2016). *Guiding Principles*. San Francisco, CA: City and County of San Francisco. Accessed 28 October 2016.

[19] City of Berkeley. (2006). *Precautionary Ordinance*. Berkeley, CA: City of Berkeley. Accessed 10 December 2016.

[20] Perkins+Will (2009). The Precautionary List. The Precautionary List is not a directive, or "do not use" list, but is a reference list of substances to use with caution. The distinction is important because education of clients and design teams will result in the informed choices appropriate for each project, within the standard of professional care. The Precautionary List was compiled from authoritative government lists, screened for their likelihood of appearing in building projects, and the availability of viable alternatives.

MARKET RESPONSE AND THE CALL FOR TRANSPARENCY

While the design of healthier environments has most often focused on space programming, daylighting, and views, building materials are increasingly receiving attention[21,22].

Industry stakeholders, including design firms and non-governmental organizations, have developed numerous assessment schemes and tools to aid designers and other interested parties in learning about and managing the chemicals found in building products (e.g., the Pharos Project, the LBC Red List, and the Perkins+Will Precautionary List, among others). New tools continue to emerge, like Portico and HomeFree. Driven by these and other voluntary initiatives, market transformation in the building sector outpaces regulatory development by a significant margin. This is reflected in Figure 2, which compares the progress of federal and state-level chemicals policies over the last four decades against the development and adoption of relevant building industry resources in the last decade alone.

In particular, since the adoption of LEED Version 4 (LEEDv4) in October 2016, all new LEED projects now have the opportunity to address toxicity in buildings via new Materials and Resources (MR) credits. LEEDv4's new MR credits not only aim to reduce toxicity, but to expand publicly available information and promote the growth of knowledge around this topic. What LEED has termed "disclosure," the industry has often referred to as "transparency."

Transparency stems from the idea that knowing what is in our products is a necessary first step toward making more informed decisions about the materials we use, especially around how materials impact human health and well-being.[23]

Why Transparency?

Food labeling provides an analogy to the desired outcomes of this effort. Imagine you are at the store buying a chocolate bar. It is possible that you may base your selection, in part, on the nutritional and ingredient information provided on the chocolate bars' labels. You use this information knowing that it is comprehensively and consistently reported—a confidence that would be even more critical if you had a severe peanut allergy, and must avoid even trace nut content. Your decision-making would be guided by which labels report tree-nut-free ingredients and manufacturing facilities. This potentially life-saving knowledge is possible because ingredients are consistently disclosed in their entirety.

Now, imagine how such a label could better educate your building product selections: a list of a product's chemical contents, disclosed to a comprehensive and consistent threshold, with these chemicals' corresponding potential impacts to human and environmental health provided in parallel.

[21] McGraw Hill Construction. (2014). The Drive Toward Healthier Buildings: The Market Drivers and Impact of Building Design and Construction on Occupant Health, Well-Being and Productivity. Bedford, MA: McGraw Hill. Accessed 9 June 2017.

[22] McGraw Hill Construction. (2016). The Drive Toward Healthier Buildings: The Market Drivers and Impact of Building Design and Construction on Occupant Health, Well-Being and Productivity. Bedford, MA: McGraw Hill. Accessed 9 June 2017.

[23] American Institute of Architects (AIA). (2016). *Materials Transparency and Risk for Architects*. Washington D.C.: AIA. Accessed 10 November 2016.

FIGURE 2

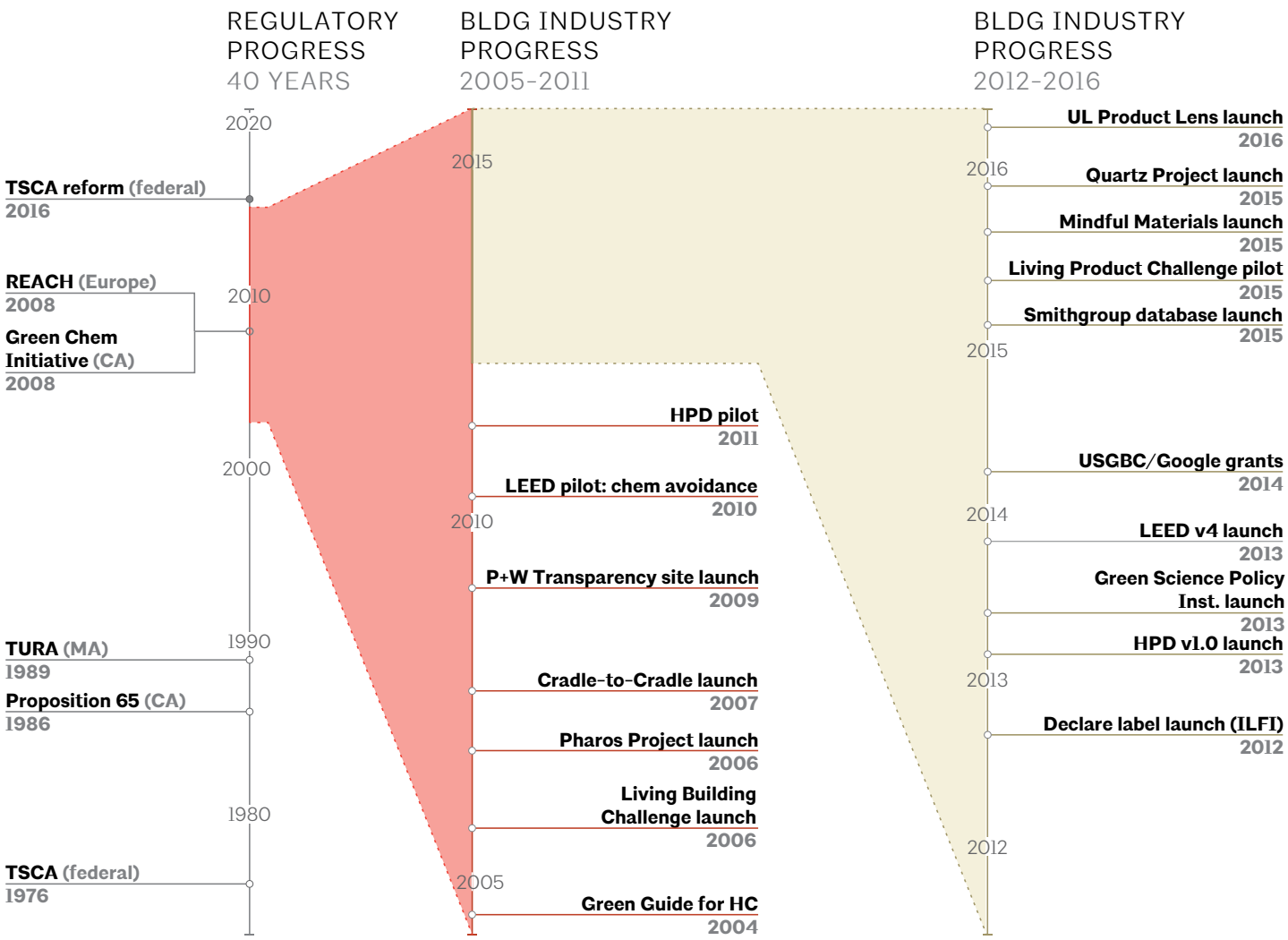


FIGURE 2

Credit: US regulatory and building industry chemical initiatives: 1976-2016.

SOURCE

S. Tepfer, 2016.

Despite wide support for the ultimate aim in material content disclosure, getting there comes with several challenges.

Some building materials suppliers and manufacturers may be reluctant to publicly disclose chemical contents due to a range of concerns: giving away confidential business information, losing market-share if a revealed chemical is shown to cause either real or perceived harm, potential liability for using a substance known or suspected to cause harm, the costs of making significant changes within their supply chains, and the lack of a guaranteed reward in their investments.

Owners share some of the same fears about liability: if their new building is a "healthier" environment, are existing facilities then unhealthy?

> "In comparing new buildings to older existing buildings, there can be huge imbalances in processes."
>
> – *Vince Digneo, Adobe [sustainability strategist]*

Even some architecture and design firms worry about liability: are they taking on more scope than their professional registrations and insurance allow? AIA published a white paper discussing this issue, concluding that architects' professional standard of care does not make them liable for material health impacts.[24]

Additionally, contractors, installers, and fabricators are under the usual pressures of time and budget to complete the project. Who has time to do the research necessary to understand and implement these additional performance criteria?

Tips for addressing these, as well as many other reasons people in the buildings industry give for not attending to healthier materials on projects, are found under the "Overcoming common barriers" section.

[24] American Institute of Architects (AIA). (2016). *Materials Transparency and Risk for Architects*. Washington D.C.: AIA. Accessed 10 November 2016.

PROGRESS IN PRODUCT TRANSPARENCY

While a broad group of stakeholders from across the building industry have collaborated to make significant progress in promoting chemical transparency and hazard reduction, this is just the tip of the iceberg. The number of projects that have pursued healthier materials goals is very small compared to the number of buildings constructed or renovated annually. Additionally, the number of products with fully disclosed ingredients is small compared to the number of building products on the market, as shown in Table 1.

Still, the fact that these numbers have grown 100-fold in five years shows how a small increase in participating projects has significantly contributed to the ever-growing body of material content information. Imagine the rise in count if all firms made even a small effort in asking for material health information for their projects.

Progress in product transparency in the building industry	
Certification/Declaration Scheme	Product Count [as of February 2017]
Health Product Declaration	2,167
Cradle to Cradle Certification*	173
Declare Label	359
Commercially available building products**	200,000+
*Cradle to Cradle numbers include full certifications for building products only. Material Health certifications are not included. **DesignerPages, November 2016	

TABLE 1
Progress in product transparency in the building industry.

> "Transparency can become so powerful. 'There's this inherently toxic chemical in the product. Why is that there? Maybe it has some irreplaceable purpose, but maybe it doesn't and there are ready substitutes, or maybe there aren't, but you don't know unless you have the conversation. And you can't have the conversation without the transparency starting point...The request for transparency helps the internal change agent."
>
> *–Sustainability Director at a global carpet modular flooring manufacturer*

Of further note, product and material content transparency has predominantly focused on finishes and fixtures, as shown in Figure 3.

It is commendable that manufacturers of products that so strongly affect indoor environmental quality are already aware of these disclosure and optimization schemes, and are participating in relatively high numbers. Ultimately, however, transparency efforts must aim for more consistent participation across all Construction Specification Institute (CSI) divisions because when considering life-cycle phases besides the use phase, problematic substances persist in nearly all (see "pervasiveness of toxic substances in building products").

> "We are growing a database with mindful Materials, but the struggle has been with the exterior materials. It'd be nice if there were more even distribution and interest and participation from manufacturers."
>
> *– Crystal Barriscale, HKS [architect]*

Manufacturer participation in these efforts is market-driven: manufacturers are more willing to address healthier materials criteria when they see demand for it. In that spirit, this document seeks to provide an accessible entry point for projects of all scales and types to critically examine the materials used to create and renovate buildings and spaces.

FIGURE 3

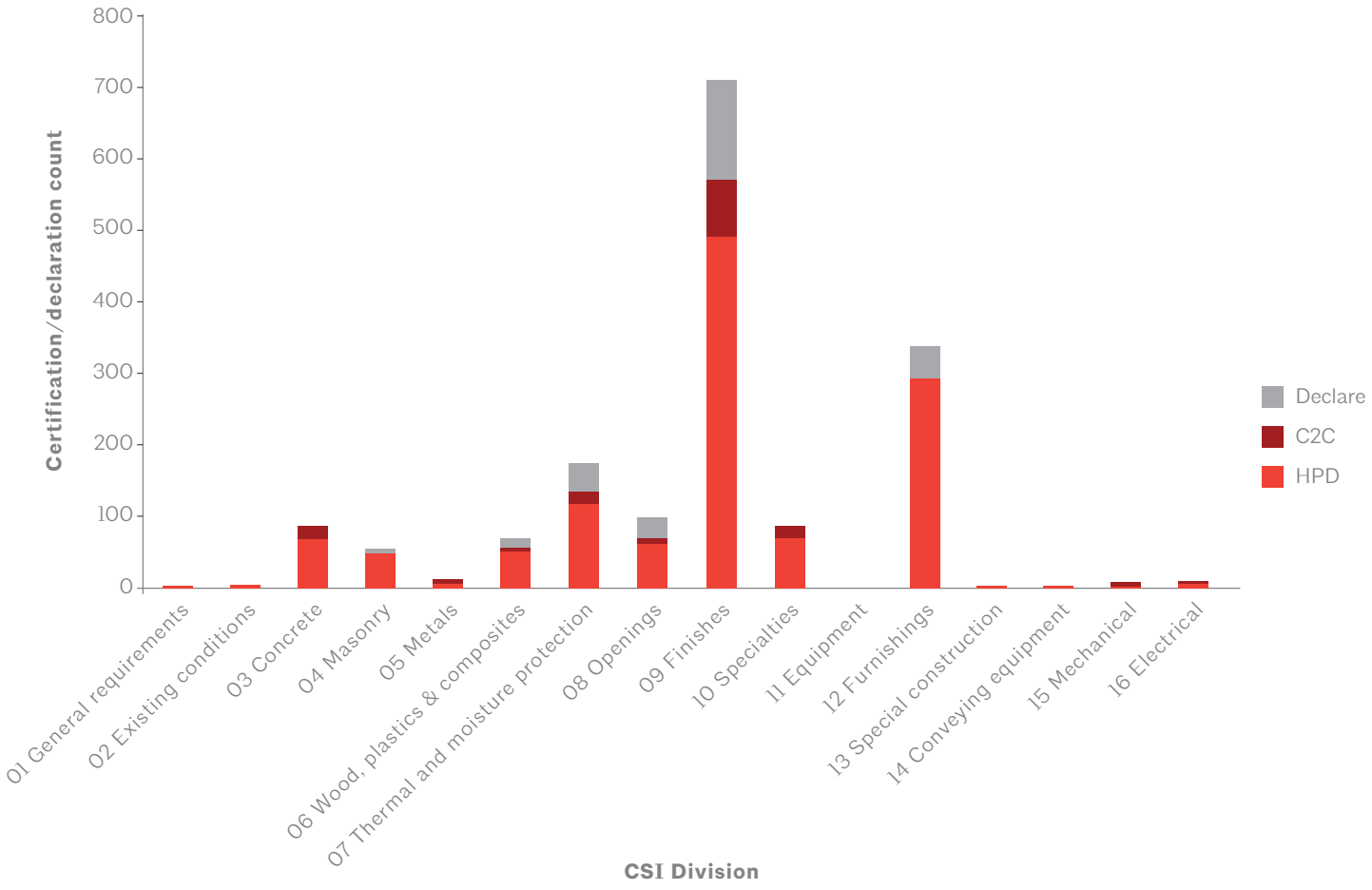


FIGURE 3

Building industry disclosure/optimization certification counts as of November 2016.

SOURCE

Arup 2016

HEALTHIER MATERIALS IN CONTEXT

In practice, healthier materials criteria must be situated in a broader context. Designing for health is not limited to materials selection, and material selection is not only based on health criteria. A healthier built environment requires careful attention to much more than just materials, just as healthier communities are not created through the design and construction of a single building. The material quality of a space, how the design of that space promotes physical activity and social interactions, and other architectural features, such as access to natural daylight, views, and biophilic elements (i.e., design that contains or emulates aspects of nature), are documented to have significant impacts on human physiology and mental health.[25,26]

This requires designers to consider how to promote health at scales much larger than materials and to consider how material selection may contribute to or detract from health promotion beyond the footprint of the building. Simultaneously, in selecting materials, designers must consider a range of attributes that extends beyond human and environmental health impacts. Figure 4 situates the scope of this document in this broader context by showing what may be considered in the selection of a single product or material.

While the scope of this document is limited to materials impacts on human and environmental health, in practice, health issues must be considered across multiple design scales, and materials toxicity must be considered in conjunction with many other criteria. Some resources allow project teams to examine these attributes, and many others, in parallel.

The diagram in Figure 5 shows one approach to assessing trade-offs across multiple material attributes, including several health and environmental impacts, for a single product.

In addition to looking across attributes, assessing trade-offs requires looking across product and material life cycles. Health and environmental impacts may occur at any point in a material's life cycle, from ecosystem disruption during extraction, to pollution caused during manufacturing, to occupant exposure while installed in the building, to emissions during product use, and finally to the release of hazardous substances at the end of the product's service life. This host of concerns not only raises questions about the process of considering health and environmental impact, but also about the goal of material selection itself: do we aim for the selection of the "right" material or selection of the "best" option? How are these terms defined, and by whom?

In the past several years, we've seen the development of a variety of assessment schemes that evaluate material health information in the context of broader multi-attribute certifications. Some of these schemes, like the one included within Cradle to Cradle (C2C) product certification, are described in detail in the Implementing a Healthier Materials plan section of this document. The schemes provide valuable information to guide material selection, but also make clear that, in considering many complex criteria together, there are no perfect products.

[25] Kellert, S.R. and E.O. Wilson. (Eds.) (1995). *The Biophilia Hypothesis*. Washington, D.C.: Island Press.

[26] In a November 2016 report for a confidential client, Perkins+Will completed a literature review of studies conducted around the topic of biophilia and positive physiological outcomes. 25 studies were identified as relevant to the client. Exemplars:

An, M., et al. (2016). Why We Need More Nature at Work: Effects of Natural Elements and Sunlight on Employee Mental Health and Work Attitudes. PLOS ONE, 11(5).

Benfield, J., et al. (2015). Classrooms With Nature Views: Evidence of Differing Student Perceptions and Behaviors. *Environment and Behavior*, 47(2): 140–157.

Beute, F., & Y. de Kort. (2014). Salutogenic effects of the environment: review of health protective effects of nature and daylight. Applied Psychology. Health and Well Being, 6(1): 67–95.

[27] American Institute of Architects. (1998). Environmental Resource Guide. New York, NY: John Wiley & Sons.

FIGURE 4

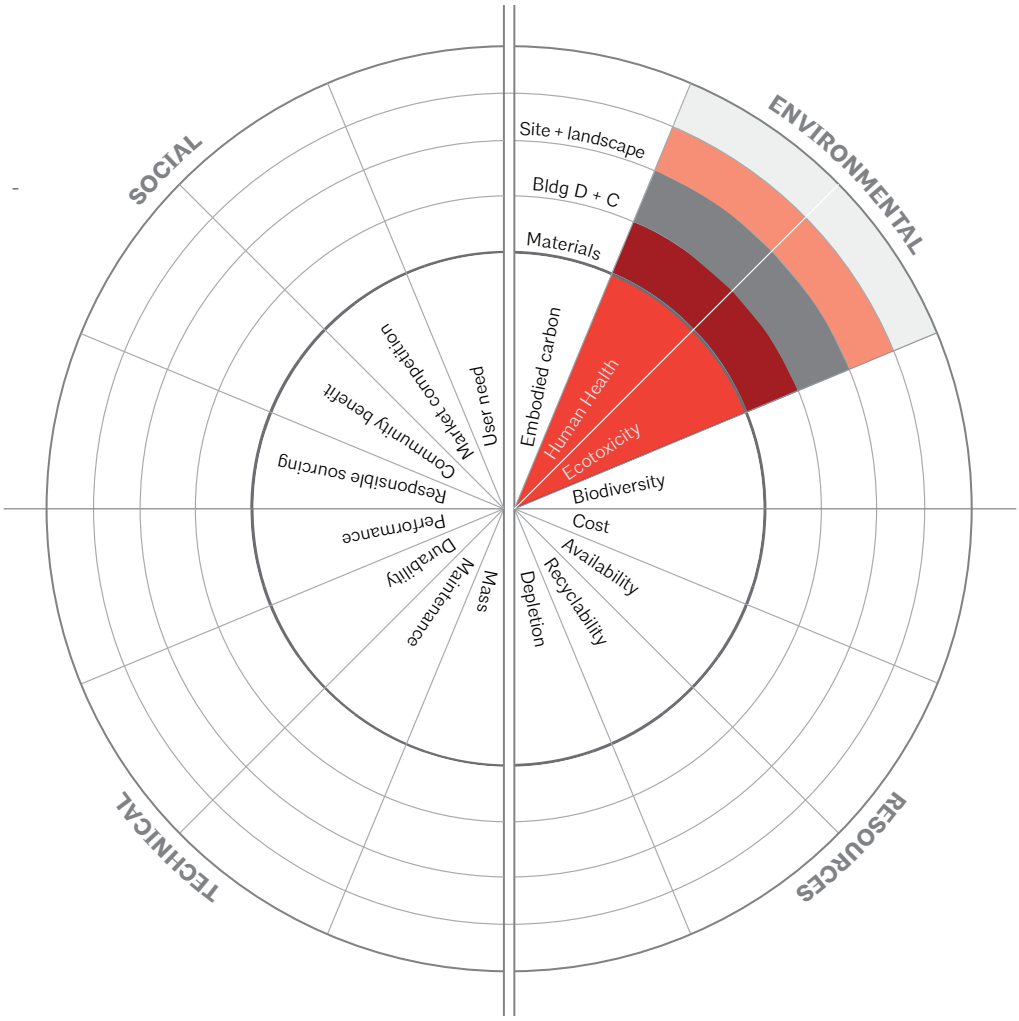


FIGURE 4

The concentric circles depict increasingly large spheres of influence on environmental, social, technical, and resource attributes. Building materials, with a sphere of influence residing within building design and construction, are represented by the smallest circle; however, materials have life cycle implications that extend beyond even the footprint of the building or its site. This extended influence is represented by the color gradient, where darker color corresponds to stronger influence.

SOURCE

S. Tepfer, 2016.

FIGURE 5

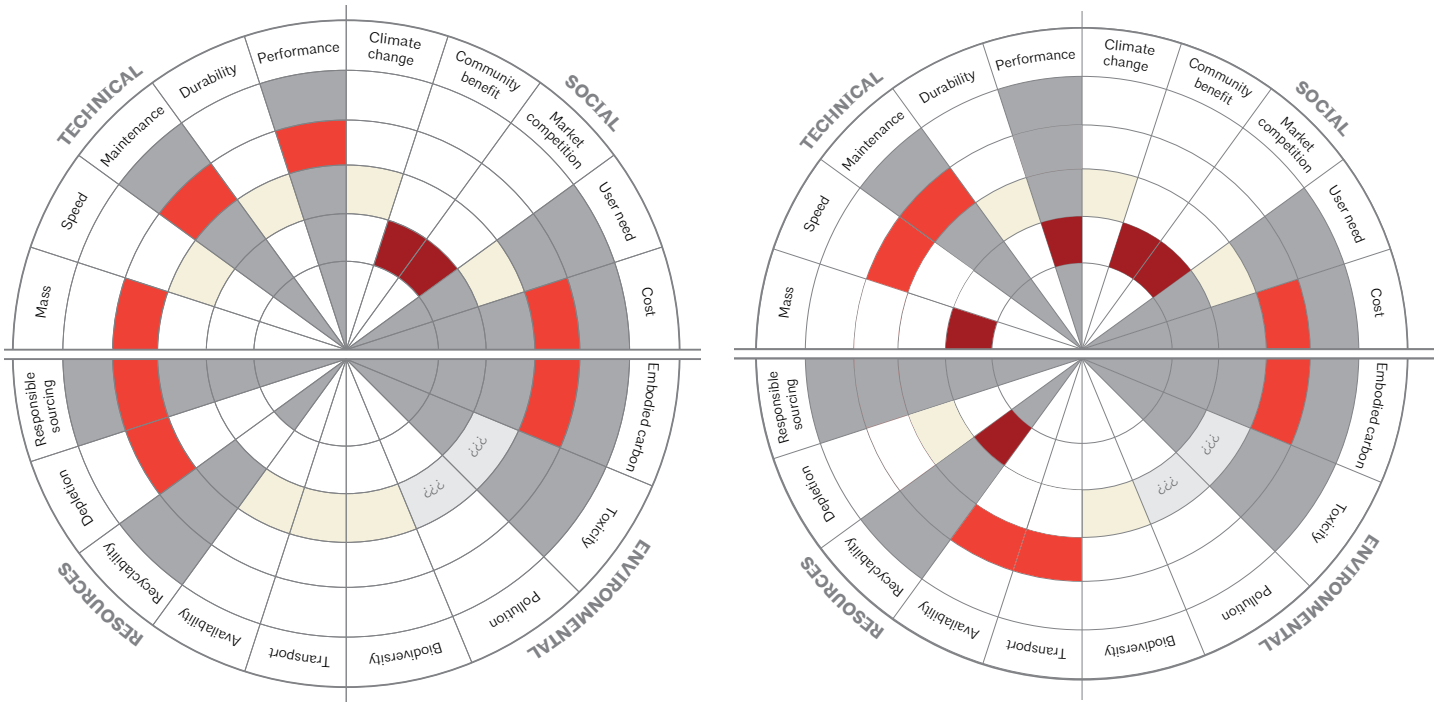


FIGURE 5

These radial diagrams represent one framework to assess multiple material attributes, and trade-offs between two or more products, including several human and environmental health issues, in parallel for a given product. In diagrams of this type, performance is indicated by proximity to the center and radial positions categorize the various types of impact being considered.

SOURCE

Additionally, sources of pollutants to our indoor environment are not just limited to materials—they're extremely varied, and only a subset come from materials. Table 2 illustrates the host of pollutant sources in buildings, of which building materials make up only one category.

Common sources of pollutants that enter the indoor built environment					
Outdoor sources brought indoors	Consumer products used indoors	On-site equipment + furniture	Building materials and construction activity	Space uses within or adjacent to the building	Inadequate maintenance
Tracked/blown in dirt/ pollen/dust animal dander/tobacco	Tobacco products	Office equipment	Plywood/ compressed wood	Laboratory	Heavily loaded filters
Local traffic	Art supplies	Cooking equipment	Construction adhesives	Medical office	Contaminated/ shredded duct lining
Loading dock traffic	Pens & paper products	Upholstered furniture	Asbestos products	Hair/nail salon	Dirty drain pans
Construction dust	Personal products	Transformers	Insulation	Cafeteria	Condition of mechanical room
Pest fecal matter	Print/ Photocopy	Humidifiers	Wall/floor coverings	Exhaust from major tenant (e.g. dry cleaner)	Pools or stagnant water on roof
Soil gas	Dry cleaning	Underground fuel storage tanks	Carpets/carpet adhesives	Trash and refuse area	Damper settings
Sewer gas	Solvents	Combustion appliances (boilers, stoves, furnaces, flues, generators)	Wet-applied building products	Cooling tower mist (pathogens, Legionella)	Faulty economizers
	Foodstuffs	Refrigerants	Painting, roofing, sanding	Restroom exhaust	Boiler/flues
	Cleaning products	Lubricants	Renovation/remodeling	AHU relief vent	Pressure differentials
				Landscaping chemicals, fertilizers, etc.	Fan malfunctions

TABLE 2

Common sources of pollutants that enter the indoor built environment. Source: Simon Turner (Healthy Buildings, Inc., 2017).

SOURCE

Healthy Buildings, 2017

The 1970s discovery of "Sick Building Syndrome" (SBS) elevated awareness of some of the pollutants in Table 2. The occurrence of SBS demonstrated how buildings with poor indoor air quality, moisture management, and even acoustic and lighting performance, can and do lead to occupant illness.

Code requirements have significantly reduced the extent to which buildings make people sick by increasing ventilation requirements and mandating better moisture control. However, these code requirements do not address many pollutant sources, so any aim toward healthier buildings will require a more comprehensive approach in both thoughtful design and construction and in a preventative operations and maintenance strategy.

More recently, a business case has emerged for going above these preventative requirements and proactively using design to promote occupants' well-being.[28] This comes from realizing that the design of our physical space affects many aspects of physical, social, and psychological well-being, well beyond indoor environmental pollutants. For example, providing access to views of nature in patient rooms in hospitals has been shown to shorten postoperative recovery stays and reduce postsurgical complications.[29]

Careful attention to material selection can contribute to healthier buildings in ways beyond the content and life cycle of the material itself:

- **Air quality:** Materials can absorb or emit VOCs, which affect air quality.
- **Daylighting:** Materials can brighten or darken a space, diffuse light or create uncomfortable glare.
- **Moisture management:** Materials can either prevent or allow the diffusion of moisture across the weather barrier and within HVAC systems.
- **Acoustic performance:** Materials can absorb or reverberate sound within a space.

The past few years have also seen the introduction of the WELL and FitWel building standards, which include many strategies that address stress, nutrition, fitness, pollutants, sanitation, toxics, sleep, comfort, posture, mobility, biophilia, and other attributes of the built environment.[30] While more research is needed to confirm that these strategies correspond to healthier populations, the idea of designing and operating buildings to provide optimal conditions for occupant health has become a very compelling objective.

All-in-all, "health" is more than the mere absence of disease: the CDC defines it as a resource that enables people to live long, productive, and fruitful lives.[31] While a consideration of the materials that comprise our buildings should not be the sole focus of creating a healthier built environment, the aspiration would be incomplete without it.

[28] Kramer, et al. (2014). *Building for Wellness: The Business Case*. Washington, D.C.: Urban Land Institute (ULI).

[29] Ulrich, R. (1984). View through a window may influence recovery. *Science*, 224(4647): 224-225.

[30] WELL is a rating system of the International WELL Building Institute. https://www.wellcertified.com/ FitWel is a scorecard developed and tested by the Center for Active Design. https://fitwel.org/ and https://centerforactivedesign.org.

[31] Centers for Disease Control and Prevention (CDC). (2016). *Well Being Concepts*. Atlanta ,GA: CDC. Accessed 5 January 2017.

THE DESIGNER'S ROLE IN GROWING A HEALTHIER MATERIALS ECOSYSTEM

In 2016, the total dollar value of American construction work was estimated at $1.2 trillion.[32] This purchasing power can be leveraged in the push toward a healthier materials market. Designers can participate in this effort by integrating healthier materials in a range of ways: 1) redesigning or simplifying assemblies to replace or remove unwanted materials; 2) revising specifications to allow for alternate materials with different performance characteristics to be used in place of unwanted materials; or 3) working with manufacturers to reformulate products using safer chemicals while still meeting the desired performance criteria.

Figure 6 shows how the earlier healthier materials are considered within a project timeline, the more opportunities there are to explore options across the material, assembly, or chemical levels. As the design process progresses, the range of viable options becomes increasingly limited.

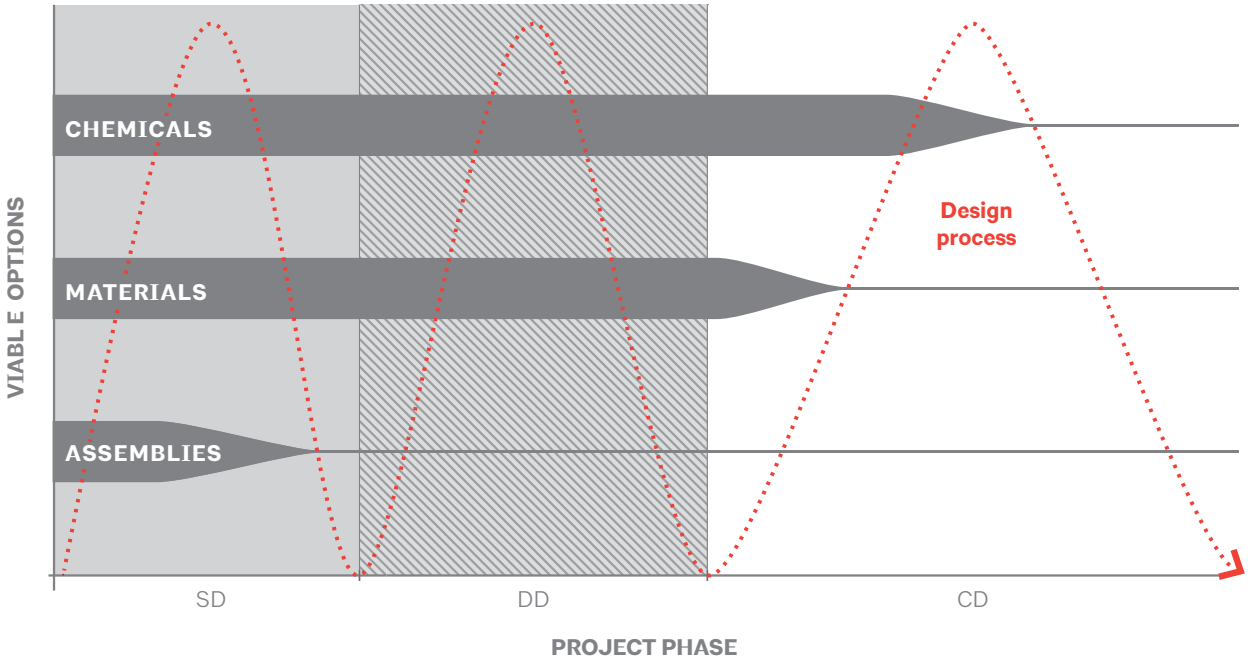


FIGURE 6
Opportunities for integration of healthier alternatives at the assembly, material, and chemical scales diminish as the design is developed.

[32] US Census Bureau. (2016). *Value of Construction Put in Place at a Glance*. Washington, D.C.: US Census Bureau. Accessed 14 February 2017.

The Value of Construction Put in Place Survey (VIP) provides monthly estimates of the total dollar value of construction work done in the US The survey covers construction work done each month on new structures or improvements to existing structures for private and public sectors. Data estimates include the cost of labor and materials, cost of architectural and engineering work, overhead costs, interest and taxes paid during construction, and contractor's profits.

When safer materials already exist in the marketplace and it is simply a matter of selection, the window of opportunity is the widest and may continue through late design. Designers can also avoid hazardous chemicals through choice of assembly, eliminating the need for some materials at all. At this level, the window of opportunity is narrower than for material selection, as assembly options are typically chosen earlier in the design process.

In contrast, while chemical reformulation of a desired material to remove potentially harmful ingredients appears to impose the fewest restrictions upon the design, the complexity of the manufacturing process and supply chain for most building products makes this approach difficult to implement. But even though stakeholders operating at later stages in the life cycle (like building designers and owners) usually have little direct influence upon this domain,[33] chemical reformulation can improve multiple products, and these advancements become available to all future projects.

Over the project phases, it is also important to consider not only prescriptively specified materials, but also performance-based products most typically selected by the general contractor or subcontractor, such as adhesives, fasteners, and touch-up paints. These are time-consuming products to specify and may be overlooked in the materials vetting process, particularly for tenant improvement projects, which are designed and built on shorter timelines.

In all cases, reducing the inherent hazard of a building product or material nearly always requires the attention of multiple stakeholders across that product or material's value chain.[34]

[33] Waage,S., et al. (2005). Fitting together the building blocks for sustainability: a revised model for integrating ecological, social, and financial factors into business decision-making. *Journal of Cleaner Production, 13*: 1145-1163.

[34] Scruggs, C.E. (2013). Reducing hazardous chemicals in commercial products: proactive company strategies. *Journal of Cleaner Productio*n, 44: 105-114.

Creating a Healthier Materials Plan

SECTION HIGHLIGHTS:

- The importance of working with your team and your clients to develop a comprehensive Healthier Materials (HM) plan.
- The seven essential elements of an HM plan and tips for writing them.
- References to tools and resources.

02

FIRST THINGS FIRST: EXPECTATIONS, OUTCOMES, AND BUY-IN

Identifying and addressing concerns about healthier materials is new to many in the building industry, and engaging in this issue can have far-reaching impacts on choosing building materials. To make the process manageable, and to ensure that project teams are driving toward the desired outcome at each step in the process, a written **Healthier Materials plan (HM plan)** should be developed to serve as a central point of reference, goal-setting document, and information-sharing resource.

Before developing the HM plan, however, the first step is defining the owner's expectations and the architect's services in a formal **Scope of Work**. This document should clearly outline the purpose of the HM plan, what it will be used for, and what its limitations are to avoid any misunderstandings as the project progresses.

After the Scope of Work is established, the HM plan should be developed in conjunction with the **Owner's Project Requirements (OPR)**, so that it can be referenced in the OPR. This is typically during the concept or schematic design phases, because creating an HM plan during or after the design development phase is often too late.

Seven essential elements of an HM plan are outlined below. Collectively, these elements serve as the framework for implementation. It is often helpful to have someone who is knowledgeable with the many assessment tools and implementation options involved in generating the HM plan so that the project team does not accidentally replicate existing tools or workflows that are already available to them.

1. THE "WHAT" AND THE "WHY": ESTABLISHING GOALS AND SCOPE

Defining the goal and scope sets the foundation for the remainder of the HM plan. It describes "what" the plan is trying to achieve, as well as the purpose of the work, or the "why." This, in turn, should drive the parameters of implementation. While the scope of this document is intentionally limited to human health impacts, project teams may also want to consider how to factor in other impacts to people and planet.

The owner, as well as any stakeholders they find relevant, should define the goal and scope. This process requires the owner to decide:

- whether to focus on material content transparency or on the avoidance of specific chemicals
- whether to adhere to risk assessment, rely on hazard avoidance, or both
- how much of the project should be assessed
- whether the project seeks to participate in third-party systems such as LEED, Living Building Challenge, or WELL certification (these options are described in more detail in the Implementing a Healthier Materials plan section)

> "I would definitely recommend making sure that you have all the players on hand in the beginning if you want to achieve these materials credits or goals at all."
>
> – *Kena David, BCCI [sustainability manager]*

The goal should be a values statement that clearly aligns with the decisions the owners made to the questions above (see Appendix C for some examples). Clearly stating the goal and scope will enable the owner to refer back to this section whenever there is a question about why the HM plan was developed, particularly when materials decisions arise that impact cost or schedule.

> "Having owner buy-in from the beginning has been instrumental for success and for gaining traction across project teams. Having them there and saying, 'These are the goals. Please work with us to figure out how to achieve them by selecting preferred products that meet our requirements,' has been huge."
>
> – *Nicolette Sanfilippo, Stōk [sustainability consultant]*

2. PRIORITY-SETTING: MAXIMIZING IMPACT WITHOUT BREAKING THE BUDGET

Most projects are constrained by budget, schedule, personnel, and other resources. These realities demand some type of prioritization so that the available resources are invested to maximize the project goals. It is important to realize that a single project can't do it all, and healthier materials selection is too often abandoned when an "all or nothing" mentality is adopted. This guide aims to enable projects to make incremental improvements, as some improvement is better than none at all.

> "Toxics are everywhere, and we have an abundance of potential subjects to work on, so prioritizing is the hardest part."
>
> – *Mark Palmer, SF Department of the Environment [senior green building coordinator]*

A few suggestions for prioritization are given below:

- high-touch/occupied areas
- interior materials (within the waterproofing membrane)
- high-volume materials
- by health endpoint, e.g., carcinogenicity
- by chemical, e.g., a given chemical avoidance list
- product/chemical combinations of concern specifically for the project
- areas serving more vulnerable occupants, e.g. children, elderly, and people with health conditions
- materials that represent the highest percentage of the construction cost
- materials for which chemical information is readily available (a more accessible starting point)
- materials for which there is very limited chemical information readily available (a high-advocacy approach)
- product categories for which many safer alternatives currently exist
- product categories for which few safer alternatives currently exist (see the "Lack of alternative products" section)
- relevance to health "story" intended to promote the project

When multiple prioritization criteria are desired, it may be helpful to provide a weighting system or workflow, which filters or flags product categories that call for greater attention. Flagged products would warrant a more stringent more targeted, deeper level of research and manufacturer outreach, or some other tactical investment of the project's limited resources.

> "It has to be an algorithm: If available, pick this. If design/cost/timing all fit, then go for it. The question is, what do you do when none of them fit the desired criteria?"
>
> – *Vince Digneo, Adobe [sustainability strategist]*

3. WHAT SUCCESS LOOKS LIKE: DEVELOPING MEASURABLE TARGETS

This step should establish measurable criteria that define success for the project. The target should reinforce the goals and priorities described in the previous steps. Some rating systems criteria have targets already defined. For example, LEED requires that a minimum of 20 products used on the project meet the disclosure requirements to achieve one point in the Building Product Disclosure and Optimization credit related to healthier materials. In contrast, the WELL standard requires 50 percent of products by cost have published disclosure documentation, and it limits the eligible product categories to those used in interior finishes. Some additional ideas for targets include:

- percentage of items by total count within the defined scope that meet the requirements
- number of items within the defined scope that meet the requirements
- percentage of items by cost within the defined scope that meet the requirements
- number of products whose manufacturers change their product formulations or redesign their products to meet the project requirements
- number of products whose manufacturers are transparent about their product's contents, as a result of the advocacy and requests received for the project

> "There are specific products that the client and design teams mandate across the board for aesthetics. We knew that if we targeted those products, we would be able to influence all products, rather than those that vary from project to project... We also target full spaces. If we are targeting a specific chemical concern in one material, yet that same chemical of concern is used in another material within the same room, then our efforts toward healthier work environments is less impactful. We look holistically and prioritize getting chemicals of concern out of all applicable material applications within a given space."
>
> – *Katie Bachman, Stōk [sustainability consultant]*

4. THE "HOW": DEFINING METHODOLOGY AND METRICS

Once HM targets are established, the next step is to identify and choose tools to measure progress. A wide variety of resources are available — there are disclosure tools that provide more information about individual products, tools for finding and/or collecting product information, tools for tracking the vetting of product and material options for use on a project, and tools for showing goal achievement. A few of the most popular product-level and project-level tools are described in "Understanding and utilizing product disclosure and optimization tools."

Choosing the right tool requires matching its intent and the information it provides with the goal and scope of the project. For example, if the objective is the avoidance of specific ingredients, a list of substances that are not to be used in the project should be the primary reference guide. (Note that some third-party rating systems may require the use of a predefined chemical *avoidance* list of materials. In these cases, it may not be possible to rely only on tools that rate products as "best in class" but lack information about their specific content). On the other hand, if the objective is chemical *transparency*, then manufacturer statements that simply confirm the product does not contain certain substances may fall short of the owner's desire to fully understand the complete makeup of the building products.

In either case, the HM plan will need to establish some minimum requirements for acceptability of the resources. The following three requirements are the most fundamental:

1. **Defining disclosure threshold.** How much of the product or material needs to be disclosed? The most common options in published schemes are 90 percent, 99 percent, 1,000 ppm, or 100 ppm (see Table 3). One threshold may be defined for the project, or thresholds can be defined for specific product categories.
2. **Level of verification.** Is the information self-reported or third-party verified?
3. **Agenda.** What type of organization does the tool come from, what is their governing structure and mission, what points of view do they represent?

See the "Understanding and utilizing product disclosure and optimization tools" section for more details.

The table in "Understanding and utilizing product disclosure and optimization tools" can help to identify which third-party resources are most appropriate to use within the HM plan (see Appendix C for more detailed examples).

What is a PPM?

In the same way that "per cent" means "out of a hundred", "parts per million" or "ppm" corresponds to "one part out of a million parts." It is a way to describe the concentration, or amount, of a given chemical that is present in another chemical or mixture of chemicals. "Parts-per" notations can be used for any unit of the same measure. For example, one ppm corresponds to one drop of water diluted into 50 liters or about 32 seconds out of one year. A higher "parts-per" value corresponds to a higher concentration. This is relevant because different chemicals can cause adverse health effects at different concentrations (see "Understanding background and context" for more details).

	<- Coarse screening				Fine screening ->
% by weight	>1%	1%	0.1%	0.01%	0.001%
Parts per million	> 10,000 ppm	10,000 ppm	1,000 ppm	100ppm	1 ppm (1,000 ppb)
For some context...		one drop of water diluted into 2 tablespoons	one drop of water diluted into 1 cup	one drop of water diluted into 1 pint (half a liter)	one drop of water diluted into gas tank of a compact car (50 liters)
Or..		3 seconds out of 5 minutes	4 seconds out of one hour	3 seconds out of 8 hours	3 seconds out of one month

TABLE 3
What is PPM?

SOURCE
Wikipedia

5. THE "WHO": OUTLINING ROLES AND RESPONSIBILITIES

This step asks the team to determine who fulfills the following roles and responsibilities among the primary parties on a project, including the owner, designer/specifier, builder, and operator. Essential activities that should be established and assigned include:

- **Researching products and materials.** This includes looking for or requesting product information from manufacturers on products and materials necessary to meet the HM plan. The Implementing a Healthier Materials plan section provides information about some of the existing tools available to support this research.

> "Project and facilities managers are under constant deadline and cost pressures. On the margin, with smart decisions to be made, they have to go with what they know. On the other hand, forward-thinking procurement specialists might take the initiative to investigate all the criteria in balance and end up becoming the point person."
>
> – *Vince Digneo, Adobe [sustainability strategist]*

- **Selecting and specifying materials.** This includes incorporating the HM goals in product specifications and ensuring that when particular products are listed by name or manufacturer, these products meet the HM goals and other performance objectives. It is important to note that when manufacturers are asked for information that will help their products get specified, there is a much stronger incentive for them to respond. If the team waits until after the scopes of work have been awarded to the subcontractors and their suppliers, they have much less leverage to obtain the information they need.

> "We facilitate, rather than dictate, what the specs are. It's a stakeholder process. We're in conversations with a Green Building Task Force about whether the furniture and carpet specs are going to be workable for them."
>
> – *Chris Geiger, SF Department of the Environment [municipal toxics reduction coordinator]*

- **Tracking progress.** It's critical to maintain a tracking tool to report on progress toward meeting the HM goals and requirements during each design phase of the project. Obtaining reliable material content data at high disclosure levels requires follow-through and collaboration with manufacturers and a tracking tool is also useful for documenting this outreach and correspondence (see Appendix B for a sample tracking spreadsheet).

> "If manufacturers get the message from the marketplace that half-hearted transparency is good enough, then that's all they'll ever provide. Because it's not easy."
>
> – *Sustainability Director at a global carpet modular flooring manufacturer*

Tracking may be coordinated in partnership with the builders so that it may be handed over to them upon start of construction.

> "It was a huge accomplishment to start to develop a tool that translates and digitizes all of the product tracking into a piece of data that, at the end of the job, can be learned from for the owner and everyone on our side."
>
> – *Raphael Sperry, Arup [senior consultant]*

- **Procuring products.** This includes ensuring that the products purchased and used on the project are as specified.

> "We had to develop all new templates and tools for our LEED v4 projects. We found that we needed to embed more training and sample references within our subcontractor buyout forms so they would be familiar with what these new acronyms meant."
>
> – *Natalie Wheating, Webcor [sustainability analyst]*

- **Reviewing contractor submittals.** This ensures that the materials to be purchased match the specification of HM goals. If they are substituted, they should still be reviewed for compliance with HM goals.

> "We had to prioritize in the submittal process because, as with any project in New York, it moves fast and there are demands, so we had to prioritize what materials were reviewed up front and get to the lower priority ones later, rather than let it really impact the schedule."
>
> – *David Briefel, Gensler [sustainability director, senior associate]*

- **Inspecting the site**. Walking the job site during construction helps to ensure that the products arriving to the site and being installed are those selected for meeting the HM requirements.
- **Compiling the final report.** Documenting final outcomes of implementing the HM plan with respect to achieving the goals and any specific targets.
- **Coordinating handover.** This includes compiling a building materials manual that documents any product selections that may need special maintenance, cleaning, care, repair, or replacement by a party on the owner- or design-side; and reviewing this manual with a party on the operations-side.
- **Upholding operations and maintenance requirements.** This includes ensuring that HM requirements are met, as detailed in the building materials manual.

While these are the project-level roles, there are a number of ways individuals and firms can have a role within the industry movement towards healthier building products, even if they are not on a project that has healthier materials requirements (see Appendix G).

Defining roles and responsibilities should also clarify the consequences of not following through on the HM plan's execution. This could include:

- **Rejecting the submittal if the product has not been vetted and pre-approved.** The implications for the construction schedule should be thoroughly discussed and agreed with the builder, submittal reviewers, and owner.
- **Not fulfilling healthier materials responsibilities results in withholding, and potentially loss, of the retainer.** The outcomes used to determine whether responsibilities were fulfilled should be clearly stated and agreed beforehand, and limited to those in full control of the team member being held responsible.

Examples of establishing these roles and responsibilities assignments are available in the sample HM plans in Appendix C.

6. STAYING ON TRACK: ONGOING REVIEW AND DOCUMENTATION

During design, tracking gives those involved the ability to see progress towards the project targets and serves as a useful tool to ensure the goals are going to be met. This is particularly helpful for the team to understand how any particular exceptions to requirements for a given product would impact project-wide targets. In the process of tracking, project team members can flag issues that need an owner's decision so that they can budget sufficient time to stay on schedule.

For the construction phase, adding an HM review to the traditional submittal tracking and review process is often essential to ensure targets have been met in the as-built condition, particularly in the case of substitutions. Like the typical submittal process, there should be a method for review and approval of specified products and substitutions to ensure that any healthier materials criteria are submitted for review.

> "Being upfront about the timeline and knowing the long lead times was really helpful... We asked the General Contractor, with the help of the architect, to move things around and change up what they normally did to get extra time for long lead time items that needed extra vetting up front."
>
> – *Eileen Quigley, NRDC [sustainability manager]*

Some projects may also choose to institute a method of verification of installation, such as having specifiers or a commissioning agent perform spot-checks on site. Note that this is not in the conventional scope of specifiers and commissioning agents and should be discussed beforehand.

> "The challenge for purchasing is, what if we have everything in place, but an unideal product ultimately gets procured, it is likely because somewhere along the way, the communications broke down. What's the process for making it right or doing it better the next time?"
>
> – *Vince Digneo, Adobe [sustainability strategist]*

In both design and construction, documentation is critical for showing who made decisions—and based on what rationale—for product selections or substitutions. This can help protect the project team when deviations occur that were dictated by the owner, or when adherence to the HM plan requirements were upheld despite cost or schedule impacts. The project team should compile this documentation in a final report at the end of construction. The Perkins+Will case study in the "Considering healthier materials in practice" section shows how key parts of a final report could look.

7. ENSURING A SUCCESSFUL HANDOFF: DEVELOPING A BUILDING MATERIALS MANUAL

A building materials manual is designed to hand over essential information to the facilities operations team, in the same way such a manual functions within a commissioning process. It should include information regarding maintenance, warranties, repair, replacement, cleaning, and general care that may be specific to the products installed on the project. Building owners who manage their own buildings may wish to use this as the starting point of a feedback loop in which they continually collect and input from the building management team regarding in-use performance of products over time and make adjustments to the company design standards accordingly. More detail on what to include in the building materials manual are in the sample plans in Appendix C.

> "For communicating to project teams, for a big project, we pull a green team of end users, for example custodial supervisors and janitorial cleaners, and have a series of meetings to discuss what works for them. Sometimes they pilot test products. In the end it's vital to have their input on what is a realistic set of specs for the city-wide contract."
>
> *– Chris Geiger, SF Department of the Environment [municipal toxics reduction coordinator]*

Implementing a Healthier Materials plan

SECTION HIGHLIGHTS:

- How to determine a client's priorities and select the best approach to materials health.
- Understanding the differences between approaches favoring disclosure and those prioritizing avoidance of selected substances.
- An introduction to common disclosure and optimization tools to guide your project team.

03

"We can only do so much without the client. By being so engaged in the process, the client was able to get a lot more out of us...I think it's critical to have that champion at the decision-making level within the client's organization who is watching this topic and engaged with it."

– Suzanne Drake, Perkins+Will [Research Director, Senior Associate]

The following sections provide several approaches to tracking how material choices align with the project's healthier materials goals and scope.

1. **Adopting a stance** is a necessary first step in using any of these approaches. It sets the stage for determining which approach would best suit the owner.
2. The **established frameworks approach** derives target criteria from published disclosure and assessment schemes, such as Cradle to Cradle, Declare, and GreenScreen. Target criteria can be defined uniquely for the project or in a way that is consistent with voluntary rating systems such as LEED or Living Building Challenge.
3. The **avoidance-based approach** assesses how well a project has avoided specific chemicals of concern. This section discusses both the binary chemical avoidance list approach and a more nuanced approach that assesses chemical avoidance for specific portions of the project.
4. The **transparency-based approach** looks at the extent that chemical contents of the materials on the project have been disclosed.
5. The **mapping approach** compares material choices on a spectrum and can be used for either avoidance- or transparency-based protocols.

ADOPTING A STANCE

To better inform which of the available approaches are the best fit for a given project, we recommend that, as part of the first step of writing an HM plan, teams clarify the owner's stance on two key aspects that underlie each of these tools: (1) the importance of either chemical transparency, chemical avoidance, or both; and (2) the importance of addressing hazard, risk, or both.

Each of the tools most commonly used in the implementation of HM criteria either focus on *transparency*, which is the extent to which the chemical contents of a product are identified (like the ingredients list on a nutrition label), or on chemical *avoidance*, which confirms that a product is free of one or more chemicals of concern. Some tools combine both.

Here are two examples that contrast chemical transparency and avoidance:

Health Product Declarations (HPDs) report the chemical contents of a product without requiring the avoidance of specific chemicals. HPDs require product manufacturers to disclose chemical contents to a given threshold (see "What is ppm?"), and this disclosure threshold must be clearly indicated. By producing an HPD, the manufacturer is not required to remove any specific chemicals. Instead, the HPD provides a consistent reporting format among different products and recognizes manufacturers who share more information than is currently required by regulation. A project that requires HPDs to be used in this way is focused on *transparency*.

In contrast, a Bronze-(or higher) level **Cradle to Cradle (C2C) Material Health Certificate** requires the removal of chemicals on the C2C Banned List, while public chemical disclosure is not required for certification. Instead, chemicals are disclosed to a third-party assessor. This protects the manufacturer's intellectual property and assures users that certain substances are not present, but it does not inform designers of what is in the product or aid in potential innovation from shared public knowledge. A project that seeks C2C certified products, especially if it only accepts certain certification levels (e.g., Bronze) or above, prioritizes *avoidance*.

Once the project team clarifies whether chemical transparency or the avoidance of specific chemicals is most important to the owner—or both are equally important—those priorities should inform which of the available disclosures and certifications are the best fit for the project.

See Tables 4 and 5 to understand which product schemes and building programs focus on ingredient disclosure, aka "transparency", or hazard optimization, aka "avoidance".

The team will also need to consider how to prioritize risk versus hazard assessment when selecting tools for the project. In the building industry, the most commonly used material health assessment schemes tend to focus on chemicals' inherent *hazard* properties, which are typically based on assessing toxicological and epidemiological studies (i.e., has the substance ever shown potential for toxicity in laboratory tests on animals?). In contrast, many toxicologists evaluate *risk*, which not only takes into account a chemical's *hazard*, but also the likelihood of exposure, how exposure can occur, and level of *exposure* at which a substance may cause harm.

Protecting against hazard is the more precautionary approach, as risk is often difficult to assess. In the absence of data, risk assessments require theoretical modeling and extrapolation. Accordingly, risk assessments require significant expertise and resources, and they are highly data-intensive. Rather than relying on risk assessments, the building industry has started to adopt a precautionary, hazard-based approach. This typically uses list-based screenings to determine whether a hazard exists for a given material. As a specific example, a project team may weight hazard heavily in its consideration of persistent, bioaccumulative toxicants (PBTs) because their environmental persistence makes it difficult to predict their environmental fate.

Risk, hazard, and exposure: defining terms

Chemical risk is dependent upon both hazard and exposure.

Chemical hazard is the potential to cause harm. Hazard is assessed for different types of harm, or toxicity (e.g., carcinogenicity, endocrine disruption, etc.).

In contrast, chemical exposure is the measured or estimated amount of a given chemical to which a population or ecosystem is exposed. Exposure assessments typically evaluate the frequency, intensity, and duration of a given exposure. Risk is the likelihood that harm will occur at typical exposure levels to a given hazard.

Adapted from US EPA's Risk Assessment Basics (EPA 2017).

While the Precautionary Principle suggests avoiding hazard altogether, this is not always practically possible, and these cases require more nuance than an either/or approach can provide. In some cases, a hazard-based approach is appropriate, while in others, a risk-based approach that considers exposure, even qualitatively, can be helpful when comparing alternatives. It will likely be impossible to find a perfectly benign material, so analyzing certain aspects of chemical exposure, even at a high level, that are specific to the project can help inform decision-making.

As the owner, design team, and consultants consider the hazard and/or risk of the materials on a project, there are many important questions to consider:

- What harm can this substance cause? (What are its intrinsic hazards?)
- Who is most vulnerable to these hazards?
- What types of exposure are most problematic (resulting from touch, inhalation, etc.)?
- How much of the substance is considered harmful? (At what dose?)
- Is that level of exposure likely, given how the material is used on the project?

These questions can be researched using several online resources, and through dialogue with manufacturers. As noted in the AIA's *Materials Transparency and Risk for Architects* white paper, architects are not professionally qualified to provide a service to owners in which they evaluate and make decisions based on the "health risks" of chemicals. Thus, the owner should consider hiring a materials consultant with a background in chemistry, materials science, or toxicology to evaluate manufacturer-supplied information when such an evaluation is desired. Still, simply asking these questions of multiple manufacturers augments a market signal, and releases information from the confines of a single or few manufacturers. The need to respond could also prompt manufacturer action towards reduction of hazardous content.

Because tools vary in how they assess and weight hazard and exposure, it is important for teams to develop a project-specific stance and use that stance to inform which tools are preferred on the project. For example, both the **C2C Material Health Certificate** and **UL Product Lens** methodologies consider exposure scenarios while the **Declare** assessment methodology does not.

For further information about risk and hazard assessment in context of the built environment, please refer to the AIA's *Material Transparency and Risk for Architects*[35] and BuildingGreen's *Avoiding Toxic Chemicals in Commercial Building Projects*.[36]

[35] American Institute of Architects. (2016). *Materials Transparency and Risk for Architects*. Washington D.C. Accessed 10 November 2016.

[36] Atlee, J., et al. (2012). Avoiding Toxic Chemicals in Commercial Building Products. Brattleboro, VT. Accessed 10 August 2016.

ESTABLISHED FRAMEWORKS FROM RATING SYSTEMS

Building industry rating systems have promoted the use of many material content disclosure and assessment tools, though in different ways. Rating systems differ in the assessment tools and certifications they promote, how these are weighed against each other, and how compliance is demonstrated. Table 4 summarizes each of these systems' requirements, as well as the assessment tools that they promote.

As the matrix shows, requirements vary, including:

- how products are counted, whether cost-based or simply numeric
- the scope of products that may be counted toward compliance, which may range from exclusively interior finishes and furnishings to all products entering the project site
- the reporting threshold required for compliance

An established tool can be used as the basis for an HM plan, but it's also possible to use various product disclosure and assessment tools to create a custom methodology for a specific project (see worksheets in Appendix A).

	Type	Assessments + Programs									Scope		Compliance						
Rating system crtiteria	Date	HPD	C2C full certification	C2C mat'l health cert.	Declare	BIFMA level	Green Screen	REACH	PTD	UL product lens	Ingredient disclosure	Hazard optimization	Percentage by cost	Number of products	All products	Certain applications	Reporting minimum	Included products	Reporting threshold
LEED MRc4: material ingredients	2014	■	■	■	■	■	■	■		■	■	■	■	■			20 products 25% (by cost)	Permenantly installed products	100 to 1,000ppm
LEED v4 pilot credit: hazard/ exposure	2016											■		■			5 products 2 manuf.	Permenantly installed products	100 to 1,000ppm
LBC 3.0 Red list	2014				■							■			■		All products	All products	100ppm
WELL 25: toxic material reduction	2015											■				■	25% (by cost)	Chemical avoidance in some applications	100ppm
WELL 26: material safety	2015	■	■	■	■						■	■	■				25% (by cost)	Interior finishes/ furnishings	100ppm
WELL 97: material transparency	2015	■	■	■	■						■		■				50% (by cost)	Interior finishes/ furnishings	100 to 1,000ppm

TABLE 4
Building industry rating system requirements, compared.

CHEMICAL AVOIDANCE-BASED APPROACHES

Chemical avoidance lists

Once solely used by suppliers and manufacturers for upstream chemical screening, the building industry has recently adopted "chemical avoidance lists"—also known as "red lists," "banned lists," "restricted substances lists," or "black lists"—as tools for informing material selection. Project teams aim to avoid building products that contain chemicals on discrete, predefined lists. And building industry rating systems,[37,38] product certifications,[39] design firms,[40] and owners[41] have all developed and published chemical avoidance lists.

The following chemical avoidance lists are publicly available and frequently referenced in the building industry. A more comprehensive set of lists are available within the Pharos database.[42]

- Living Building Challenge (LBC) Red List (Imperative 10)
- C2C v3.0 Banned List
- Perkins+Will Precautionary List[43]
- EPA Chemicals of Concern - Action Plan Published[44]
- REACH Substances of Very High Concern List[45]
- LEEDv3 2009 for Healthcare MRc4.1 and MRc4.2: PBT Source Reduction and MRc5: Furniture and Medical Furnishings
- LEEDv3 2009 for New Construction MRpc54: Avoidance of Chemicals of Concern
- WELL v1.0 Feature 25: Toxic Material Reduction

[37] International Living Future Institute (ILFI). (2014). Living Building Challenge 3.0. Seattle, WA: ILFI. Accessed 22 November 2016.

[38] Green Guide for Healthcare (GGHC). (2004). Accessed 22 November 2016.

[39] Michael Braungart Design Chemistry (MBDC). (2012). *Material Health Assessment Methodology: Cradle to Cradle Certified Product Standard Version 3.0*. Charlottesville, VA: MBDC. Accessed 21 May 2016.

[40] P+W; The Precautionary List is not a directive, or "do not use" list, but is a reference list of substances to use with caution. The distinction is important because education of owners and design teams will result in the informed choices appropriate for each project, within the standard of professional care. The Precautionary List was compiled from authoritative government lists, screened for their likelihood of appearing in building projects, and the availability of viable alternatives.

[41] Kaiser Permanente, Google

[42] Pharos. Healthy Building network. 2016.

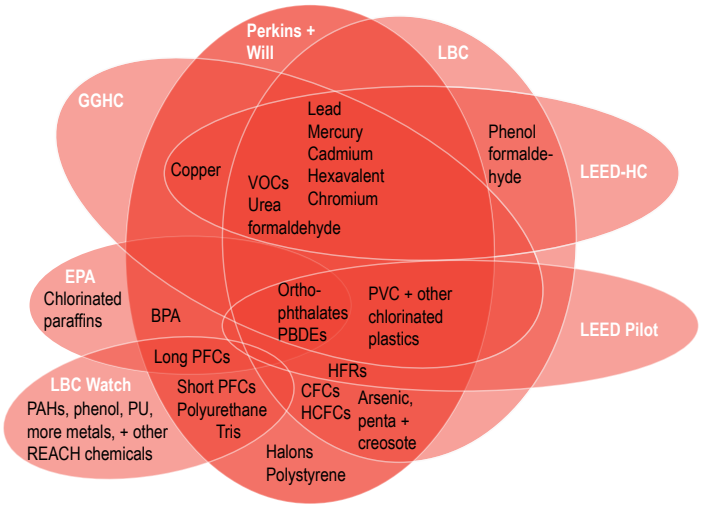
[43] The Precautionary List is not a directive, or "do not use" list, but is a reference list of substances to use with caution. The distinction is important because education of clients and design teams will result in the informed choices appropriate for each project, within the standard of professional care. The Precautionary List was compiled from authoritative government lists, screened for their likelihood of appearing in building projects, and the availability of viable alternatives.

[44] This list consists of chemical groups raising serious health or environmental concerns that have been flagged for EPA action. It aggregates four EPA lists.

[45] The European Chemicals Agency (ECHA) maintains the REACH Substances of Very High Concern (SVHC) list, which is maintained per EU regulation. Companies have legal obligations resulting from the inclusion of substances in the SVHC list if the produce or supply the listed substances on their own, in mixtures, or in articles.

While the basis for these lists is usually to target "worst-in-class" chemicals, it is not always obvious why a given chemical appears on a particular list. Some are referenced from substance lists developed by governmental or non-governmental toxic control agencies that base their listings on known or strongly suspected hazards, while other substances may appear on a list to advance a particular agenda, such as moving away from fossil fuels when ample alternatives exist for a particular product or material.

The divergence in chemical avoidance list methodologies and motivations results in inconsistencies among lists, as shown in Figure 7.



Courtesy of Healthy Building Network

FIGURE 7
The overlap of specific chemicals among the following lists (clockwise starting at top): CPA-HBN Red List in Pharos, Perkins+Will Precautionary List, Living Building Challenge Red List, LEEDv3 2009 for Healthcare MRc4.1 and MRc4.2: PBT Source Reduction and MRc5: Furniture and Medical Furnishings, LEEDv3 2009 for New Construction MRpc54: Avoidance of Chemicals of Concern, Living Building Challenge Watch List, EPA Chemicals of Concern – Action Plan Published list, and Green Guide for Healthcare substances targeted for reduction.

The commonalities among the lists depicted in Figure 7 include:

- addressing chemical hazards beyond indoor air pollutants
- containing some PBTs, or toxic substances like mercury, that move up the food chain and often spread from their origination point to areas with no perceived risk
- considering negative effects that occur either upstream ("supply chain" impacts) or downstream ("end-of-life" impacts) in the life cycle of the substance
- including substances that have shown negative effects at very low concentrations (e.g., cadmium and mercury) within a living body

Despite these commonalities, the lists are neither consistent in how they overlap, nor in how they define the chemical groups they include. As a result, in practice, the chemical avoidance list approach presents a confusing array of choices, and it is not clear how to choose among them or how to prioritize within them. The best guidance is to understand the philosophy behind the list and determine if that philosophy is aligned with the values of the owner.

Chemical avoidance lists also leave room for regrettable substitutions because they are inherently finite in length and do not provide preferred replacements. BPA (bisphenol A) provides a useful example of the danger of this. BPA was recently publicized as a substance to avoid in food packaging and baby bottles.[46] In response to this market-driven call for substitution, manufacturers released "BPA-free" products, but did not disclose what they were using instead. In one

[46] "State Laws on BPA." Consumers Union. 14 August 2012. Washington, D.C.: Consumers Union. Accessed 2 February 2017.

example, independent testing determined BPA was replaced by Bisphenol S (BPS), which, while not included on most chemical avoidance lists, has similar chemical functionality and hazard concerns to BPA.

As one approach to curb regrettable substitutions, The Green Science Policy Institute (GSPI) has identified six chemical classes of concern (the "Six Classes") that contain many chemicals that are both harmful and ubiquitous in everyday products, including building materials. Unlike a list of specific chemicals, the GSPI classes are defined based on molecular structure and/or functional use (see Appendix F).

Furthermore, chemical avoidance lists do not provide a clear path to chemical disclosure, as compliance does not provide information about the actual contents of a given material.

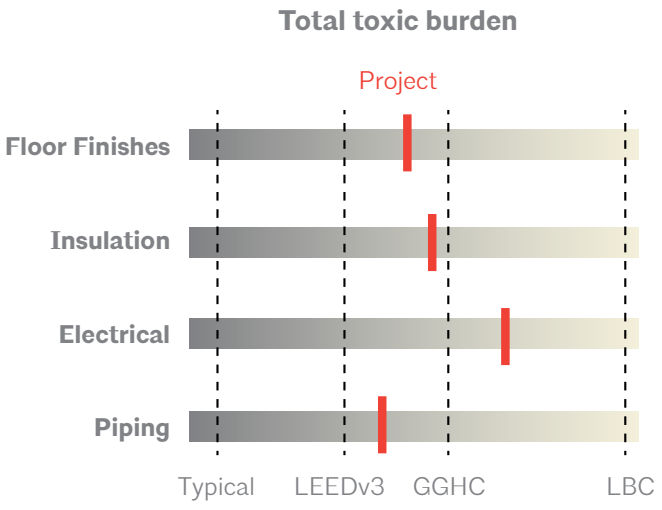


FIGURE 8
The Total Toxic Burden approach can be used to track progress across multiple product categories and against multiple third-party benchmarks.

SOURCE
©Arup, 2015

Total toxic burden

This approach, a variant on the chemical avoidance list approach, tracks the amount of hazardous chemicals that have been avoided in a project compared to a baseline palette of products. It does not imply that the quantity of a toxic chemical directly correlates with the extent of the burden; rather, it seeks to provide feedback to the project team about the progress made.

The baseline palette assumes that all materials typically found to contain certain hazardous chemicals do contain them. Thus, the project only takes credit for reductions when it selects an alternative product that avoids these chemicals of concern. In contrast to the black and white objective inherent in most chemical avoidance lists, this approach better supports the notion that any improvement on a project is worth recognition. It also allows increased flexibility in choosing which chemicals the project should avoid, and it allows the team to use any combination of disclosure documents that it deems acceptable to support the findings. The approach can either use benchmarks preset within the tools, or attempt to track numeric reductions as the acceptable metrics. Figure 8 shows how this approach might be used to track progress across multiple product categories and against multiple third-party benchmarks.

Appendix B provides an example plan and demonstration spreadsheet that shows one method for tracking reductions quantitatively.

TRANSPARENCY-BASED APPROACHES

In contrast to a pure avoidance-based approach, project teams may choose to focus entirely on chemical transparency as the HM goal of their project.

> "Sunlight is the best disinfectant. You have to get everything known before you can fix it."
>
> – *Richman Neumann, Urban Fabrick [sustainability consultant]*

Examples include:

- LEEDv4 MRc4 Building product disclosure and optimization (BPDO) - material ingredients Option 1
- WELL v1.0 Feature 97: Material Transparency

As described earlier, the goal of transparency is to drive change throughout a product's supply chain, ideally all the way to chemical research and development labs. While selection of products with greater ingredient disclosure may not directly reduce the toxic burden on a particular project, it moves the industry toward healthier materials across multiple future projects. A project focused on transparency leverages its purchasing power to send a market signal that better chemical content information for building products is important. Project teams may also prefer this path because it does not require them to evaluate the disclosed chemicals and associated hazards.

The mindful MATERIALS[47] database and collection tool is a useful way to both find and ask manufacturers for information related to chemical disclosure. The majority of information tracked by mindful MATERIALS has a direct correlation to the LEEDv4 MR BPDO - material ingredients Option 1 credit, as well as the other two BPDO credits in LEED.

Mindful Materials stands out from other databases in that it aims to centralize all building product disclosure and optimization information, which many agree is essential for scaling up both the selection process and the availability of preferred products.

For more information on mindful Materials and other opportunities to engage with organizations that seek to advance the practice of healthier material selection, see Appendix G.

[47] Access and more information can be found at http://www.mindfulmaterials.com/

Many of the tools described above steer project teams towards binary decision-making: either a material contains a substance on a chemical avoidance list or not, either a product has a transparency document or not. Sometimes, it is useful to see choices on a more detailed spectrum of material contents, which makes it easier to evaluate trade-offs when multiple factors are involved. This allows the team to take into account multiple attributes such as performance, cost, availability, and ease of installation. The example in Figure 9 compares several plastics.[48]

The Healthy Building Network (HBN) recently developed the HomeFree Database,[49] an online resource that creates hazard spectra within various product categories. The tool assigns a relative ranking to product options within a given category based on the hazards associated with the chemicals those products commonly contain (see the "Additional resources" for more information).

Of course, any mapping is based on certain assumptions, generalizations, and the value set defining what is preferred versus necessary to avoid, so it is important that the team understands and agrees to those factors when adopting third-party evaluations.

This approach can also be implemented using benchmark scoring methods included in some tools, which assign an overall hazard score to specific chemicals or products. Rather than mapping out a variety of alternatives along a spectrum, these systems use a consistent, predefined methodology to score chemicals or whole products on a hazard spectrum. The project team could use the score to compare the product against the score of an alternative product—in essence, generating the spectrum described above for a more discrete and specific set of choices already deemed suitable for the project. GreenScreen, Pharos Lens, UL Product Lens, and C2C provide benchmark scoring methods.

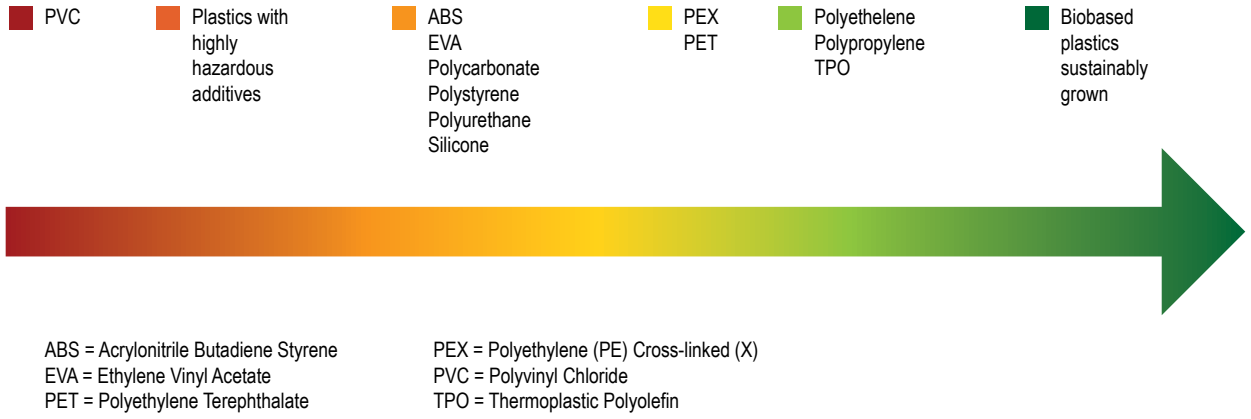


FIGURE 9
A mapping of various types of plastic based on their hazard profiles.

SOURCE
Healthy Building Network.

[48] Rossi, M. & T. Lent. (2006). "Creating Safe and Healthy Spaces: Selecting Materials that Support Healing." in *Designing the 21st Century Hospital*. Center for Health Design & Health Care Without Harm.

[49] Access and more information can be found at http://homefree.healthybuilding.net.

Understanding and utilizing product disclosure and optimization tools

SECTION HIGHLIGHTS:

- Understanding popular product-level tools, and how they can help you reach your HM goals.
- Related information about Volatile Organic Compound (VOC) content and emissions certifications.

04

As should be clear from the approaches presented in the previous section, the building industry has a growing number of product declarations and certifications that manufacturers may use to address transparency and health goals. Table 5 summarizes some of the key aspects of the most popular product-level tools in use at the time of this writing.

SCHEME	Cradle to Cradle v3	GreenScreen full assessment	UL Product Lens	HPD v2	Declare
INTENT	Multi-attribute assessment, of which material health is part, based on C2C design principles.	Hazard benchmark derived from hazard evaluation for 18 health/ environmental endpoints.	Hazard disclosure and exposure indicators across four phases of the product lifecycle.	Ingredient disclosure and hazard screening. Open standard shaped by an inclusive group.	Ingredient disclosure, hazard screening against LBC red list, material sourcing info, end-of-life fate.
SCOPE	Product level	Chemical level	Product level	Product level	Product level
CHEMICAL INVENTORY					
LIST-BASED SCREENING					LBC Red List only
ASSESSMENT					
OPTIMIZATION					
RISK					
HAZARD ASSESSMENT					LBC Red List only
EXPOSURE PREDICTION					
ADOPTION					
LEED					
WELL					
LBC					
LIFECYCLE PHASES					
INPUTS + OUTPUTS					
DISCLOSURE LEVEL	100 ppm	100 ppm	100 to 1,000 ppm	100 to 10,000 ppm	100 ppm
PUBLIC DATA AVAILABILITY	Intellectual property protected by C2C.	When used for LEED, parallel to HPD.	Intellectual property protected by UL.	Role, amt, and hazard must be disclosed	Two exception paths for intellectual property.
REPORTING FORMAT					
VERIFICATION	Third-party verified	Third-party verified	Third-party verified	Third-party optional	Self-declared
KEY	 MANUFACTURING UNINTENDED USE PRODUCT LABEL BENCHMARK SCORE INTENDED USE END OF LIFE DATA SHEET				

TABLE 5
Key aspects of the most popular product disclosure and optimization tools in use.

The scope categories in the matrix were developed by the LEED Material Health Harmonization Task Group[50] and are defined as follows:

- **Chemical inventory.** Inventory of chemicals contained within a given product or material. Disclosure levels for chemical inventories are variable across the tools considered in the matrix, from 100 ppm (0.01%) to 10,000 ppm (1%).
- **List-based screening.** Screening a given product or material's constituent chemicals against lists of known chemicals of concern. Lists included in this analysis vary across the tools considered in the matrix.
- **Assessment.** A detailed assessment of impacts to human and environmental health, using a range of endpoints (i.e., health effects). There is variation in the number and specific endpoints included in the tools that assess these impacts. For example, GreenScreen includes 18 human/environmental health endpoints, while C2C includes 24.[51,52]
- **Optimization.** The process of redesigning or reformulating a product to eliminate chemicals known to pose a hazard to human and/or environmental health or to replace them with more benign alternatives.

[50] Heine, L., et al. (2015). *Material Health Evaluation Programs Harmonization Opportunities Report*. Washington D.C.: USGBC. Accessed 7 August 2016.

[51] Clean Production Action. (2013). *GreenScreen for Safer Chemicals Chemical Hazard Assessment Procedure v.1.2*. Somerville, MA: Clean Production Action .Accessed 21 May 2016.

[52] Michael Braungart Design Chemistry (MBDC). (2012). *Material Health Assessment Methodology: Cradle to Cradle Certified Product Standard Version 3.0*. Charlottesville, VA: MBDC. Accessed 21 May 2016.

COMMON TOOLS FOR CONSIDERATION

The following subsections describe, in more detail, the tools from the matrix. With the exception of C2C, the scope of these tools is limited to information related to human health impacts. That said, all of these assessment methods are useful supplements to broader analyses of environmental impacts.

GreenScreen Assessment

The GreenScreen for Safer Chemicals is a comparative chemical hazard assessment methodology used to derive hazard benchmarks for individual chemicals, rather than products as a whole. The GreenScreen is designed to assist its users in the identification of the most benign chemical and material options that provide the needed functionality.[53]

The GreenScreen methodology[54] assigns a chemical a benchmark score based on 18 human and environmental hazard endpoints. This method considers impurities and intentionally added chemicals to a reporting threshold of 100 ppm, as well as chemicals' potential transformation products.[55] A full GreenScreen assessment relies on manufacturer-supplied chemical content data, authoritative lists, and the primary literature to derive benchmark scores.[56] A less rigorous, automated GreenScreen evaluation, called the GreenScreen List Translator (GSLT or LT), relies solely on authoritative lists to identify worst-in-class chemicals (Benchmark 1 chemicals). The majority of available HPDs rely on the list translator for hazard screening.

Within the building industry, the GreenScreen has been most broadly adopted among product manufacturers and material suppliers. This is, in part, due to its scope—while GreenScreen operates at the chemical level, project team members more often conduct material research at the product level. Only because the GreenScreen benchmark score is embedded in many product-level tools, like the Health Product Declaration, can specifiers use the GreenScreen benchmark score to help evaluate a given substance in a product.

Health Product Declarations

The Health Product Declaration (HPD) is a market-generated standardized reporting format for materials and products, which aims to promote the disclosure of comparable chemical content data. Reporting thresholds for an HPD may vary from 100 to 10,000 ppm, and the chosen threshold(s) must be disclosed. Depending on the manufacturer's own understanding of residual chemicals and impurities, HPDs may not report health impacts of process chemicals, combined exposures, or chemicals' potential transformation products. The accuracy of an HPD relies on manufacturers' self-policing as well as feedback from the rest of the product sector. A third-party verification protocol is in development as of 2017, so that verification will be an option for any manufacturer creating an HPD.

The HPD is designed for use at different points along the product supply chain: manufacturers report product contents, emissions, and known hazards associated with those contents using their own data or data from an independent lab; designers, specifiers, and builders then use the HPD to inform their product selections. In this way, this scheme can be used more broadly than others.

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[53] Heine, L., et al. (2015). *Material Health evaluation Programs Harmonization Opportunities Report*. US Green Building Council: Washington D.C. Accessed 7 August 2016.

[54] Heine, Lauren G., and Shari A. Franjevic. Chemical Hazard Assessment and the GreenScreen for Safer Chemicals. *Chemical Alternatives Assessments* 36 (2013): 129.

[55] Atlee, J., et al. (2012). Avoiding Toxic Chemicals in Commercial Building Products. Brattleboro, VT: BuildingGreen. Accessed 10 August 2016.

[56] Clean Production Action. (2013). *GreenScreen for Safer Chemicals Chemical Hazard Assessment Procedure v.1.2*. Somerville, MA: Clean Production Action. Accessed 21 May 2016.

Declare Product Certification

The Declare Product Certification is a chemical disclosure label for materials and products that indicates Living Building Challenge (LBC) Red List compliance. It is administered by the International Living Future Institute (ILFI) and promoted in that organization's LBC rating system.[57] For a given product, a Declare label includes a list of disclosed constituent chemicals, sourcing data for those chemicals, a statement regarding extent of compliance with the LBC Red List, estimated life expectancy, and end-of-life options for the product. Chemicals are required to be disclosed to 100 ppm. Unlike other programs, it does not report health impacts of process chemicals, combined exposures, or chemicals' potential transformation products as they degrade and react over their life cycles. Like the HPD, data presented in a Declare label are not currently assessed and validated by a third-party; therefore, the accuracy of the Declare label relies on manufacturer self-policing. Like the HPD, third-party verification is anticipated to come to the Declare label in 2017.

UL Product Lens

UL Product Lens is a third-party verified material certification and declaration tool that was derived from the C2C methodology. The certification aims to provide a user-friendly report of chemical content data for hazard and exposure over four phases of a product's life cycle. Unlike C2C, UL Product Lens does not require chemical content optimization, and, consequently, it provides C2C a larger audience and an expanded entry point for its platform. Consistent with the C2C approach, Product Lens requires disclosure to UL of each chemical present at concentrations greater than 100 ppm in the final product. In publicly reporting these chemicals, however, disclosure thresholds range from 100 to 1,000 ppm. Additionally, UL Product Lens considers reaction chemistry at every phase, including residuals and process chemicals.

It is unique in that it assesses and reports materials based on each product's life cycle phase, rather than in aggregate for the material. For each life cycle phase, UL Product Lens reports hazard using the a four-point rating system that is consistent with C2C's and provides exposure indicators in each phase where an exposure is predicted to occur.

C2C Certification

The C2C certification for materials and products assesses material health as one of its five quality categories. Other categories consider material reutilization, energy and carbon management, water impacts, and social fairness. In addressing social and environmental impacts in more detail, C2C certification is set apart from the other methodologies considered in this document. In part because of its expanded scope, this methodology can be more resource-intensive for manufacturers seeking product certifications.

In its material health quality category, C2C assessment uses manufacturer-supplied chemical content information to characterize the hazards of chemicals present in a material or product using 24 human and environmental health endpoints. The methodology then generates a benchmark score similar to the GreenScreen assessment methodology. Unlike GreenScreen, however, C2C considers relative routes of exposure during use and end-of-life phases of a given product, in addition to hazard.[58] Also unique to C2C is a non-disclosure agreement that holds chemical content data confidential, which eases manufacturers' concerns about revealing sensitive intellectual property

The score generated by a C2C material health assessment is reported in a product label, along with scores from the four other assessed quality categories. The overall product score is determined by the lowest-scoring category. Because the full C2C assessment is resource- and data-intensive, manufacturers may opt for a Material Health Certificate, which is conducted by third-party trained assessors and does not include full assessments of the other four categories. Both types of certification provide designers with the final certification level (and the C2C program methodology is also publicly accessible), but neither discloses the data that informed those scores.

[57] International Living Future Institute (ILFI). (2014). *Living Building Challenge 3.0*. Seattle, WA: ILFI. Accessed 22 November 2016.

[58] Michael Braungart Design Chemistry (MBDC). (2012). *Material Health Assessment Methodology: Cradle to Cradle Certified Product Standard Version 3.0*. Charlottesville, VA: MBDC. Accessed 21 May 2016.

Considering VOC content and emissions standards

While VOC content and emissions criteria are built into some of the tools described above, many other certifications can help designers identify low-emitting materials. VOC emissions from building materials significantly affect the indoor air quality within a space, and source control is essential. Certifications like these, therefore, are central to the conversation about material impacts on human health.

With many such certifications available, the landscape can be confusing. Some certifications assess VOC content, others address emissions, and some address both. As an aid, Figure 10 lists the more prevalent VOC content and emissions certifications, and which are accepted for six materials categories within the LEEDv4 Low-Emitting Materials credit.

MATERIAL	REQUIREMENTS	COMPLIANCE PATH
Paints + coatings, Adhesives + sealants	VOC content limits + air emissions testing	Any 3 content + emissions certifications or Any 3 emissions only certs + SDS
Ceilings + walls insulation	Air emissions testing	Any of the 4 starred (*) certifications
Flooring	Air emissions testing	Any of the 4 starred (*) certifications or FloorScore, NSF-332, CRI Green Label+
Composite wood (veneer or substrate)	CARB ULEF label or CARB exempt	Manufacturer information
Furniture	Air emissions testing	SCS Indoor Advantage with/without Gold UL GreenGuard with/without Gold MAS Certified Green BIFMA Level 7.6.1 and/or 7.6.2 Intertek ETL Environmental VOC

FIGURE 10
Low-Emitting Materials certifications recognized by LEEDv4.

The comparative discussion describes the broad and complex landscape of documentation and assessment tools that exists. It is the team's responsibility to determine which of these tools is most appropriate to guide material selection for their projects.

As this document's sections show, it is just as important to consider how the team will use the tools as it is to consider which tool, or tools, to use.

Why can't I use a Safety Data Sheet?

Designers and specifiers have historically turned to Material Safety Data sheets (MSDSs) and Safety Data Sheets (SDSs) to better understand their materials' chemical contents and any known hazards those chemicals may pose. Why do we need anything new?

As many of users have found, MSDSs can come in many different formats and, consequently, there are inconsistencies in the data they contain.[59,60,61] In 2012, the Occupational Safety and Health Administration (OSHA), transitioned to SDSs and the Global Harmonized System. SDSs provide more consistency than MSDSs do. While an MSDS could follow many different formats, contain very different information, and use different levels of detail, the SDS is organized into 16 required sections, which require specific information and use a standardized classification system.

In the US, SDSs are designed and required by OSHA, and are focused specifically on the safety of workers directly handling the material. The hazards found on SDSs tend to focus on emergency scenarios around accidental spills or potential for fire and do not reach the level of disclosure necessary to understand their complete life cycle impacts. The consideration of "healthier materials" in the context of this guidebook goes beyond occupational hazards to span the full product life cycle, from manufacture to disposal. Furthermore, the newer VOC certifications account for actual emissions, not just VOC content. Overall, MSDSs and SDSs serve an entirely different need and are therefore less useful for designers' purposes.

[59] Atlee, J., et al. (2012). Avoiding Toxic Chemicals in Commercial Building Products. Brattleboro, VT: BuildingGreen. Accessed 10 August 2016.

[60] Frazier, L.M., et al. (2001). Health Information in Material Safety Data Sheets for a Chemical that Causes Asthma. *Journal of General Internal Medicine*, 16: 89-93.

[61] Blair, A.S. (2007). Dust explosion incidents and regulations in the United States. *Journal of Loss Prevention in the Process Industries, 20*: 523-529.

Overcoming common barriers

SECTION HIGHLIGHTS:

- Addressing difficulties in obtaining buy-in from peers, clients, and the market.
- Understanding the risks involved with materials selection and claiming “healthy” buildings.
- Opportunities to learn and share best practices.

05

LIMITED KNOWLEDGE ABOUT HEALTHIER MATERIALS

There are many sources of resistance to integrating HM considerations on projects. While specific strategies to overcome some of these barriers are addressed below, developing an HM plan will deal with issues underlying most of these challenges. Additionally, we should acknowledge that each small step a project makes to selecting healthier materials contributes to the availability of material content information and, eventually, increases the number of safer building materials available.

Few knowledgeable practitioners

Though the building industry has made significant strides in generating awareness and resources around HM assessment and selection, practitioner knowledge about the topics remains fairly low and limited to the architectural design community.

The number of knowledgeable practitioners is anticipated to grow and diversify as more projects pursue LEEDv4 certification and as more building owners integrate HM criteria into their sustainability policies. This protocol provides beginners from multiple sides of the table with a place to start. Ideally, readers will be able to use the steps in this document to define and implement an achievable plan, while expanding their knowledge and expertise around the topic.

> "Our innovative clients who have either investors or university regulations to conform to have been developing protocols and specification guidelines that all their projects must adhere to. We never used to see this level of detail in our specifications; however, we now realize the importance for our clients and need to be able to train our subcontractors to procure the materials appropriately."
>
> – *Natalie Wheating, Webcor [sustainability analyst, BD engineer/coordinator]*

Complexity and nuance of the topic

HM selection has a steep learning curve. Often, due to limitations and ambiguities in the data, drawing actionable conclusions from disclosed material content information relies on expert judgment and a more nuanced understanding of fundamental topics in chemistry and toxicology. Few firms have such knowledge internally; however, many are beginning to grow this knowledge.

> "Through our standards program we help educate our design teams. We also count on our vendors to help educate our consultants. Once project teams hear the 'why' behind our mission, they want to do the right thing, and it becomes part of their 'DNA' to choose healthier products."
>
> – *Jennifer MacDaniel, Kaiser Permanente [project principal, facilities planning and design]*

To fill knowledge gaps on the project team, an owner and/or the design team themselves may enlist a consultant to support the project team on some or all HM tasks that are not part of the direct responsibility of the architect or Engineer of Record.

Additionally, teams can establish HM goals that are appropriate to the team's level of expertise. For example, setting a goal to obtain material content information from manufacturers does not require a high level of expertise, but it does go a long way to promote increased transparency in the industry. Project goals can grow increasingly sophisticated as practitioners develop their understanding of this complex topic.

> "Everyone is trying to figure it out, and if you start talking to peers, they might have better best practices for some things, and we might have better practices for others, but if we don't talk about it, then we'll be spinning our wheels. We need to collaborate."
>
> – *Vince Digneo, Adobe [sustainability strategist]*

Misconception that life cycle assessments provide ample health information

Environmental Product Declarations (EPDs) can be easily construed to also cover health impacts, but they do not. Typical EPDs focus on the broad environmental impacts of the major constituents of a product and ignore trace components, but even trace levels of toxic substances may be of great concern. This focus of life cycle assessment has made room for health-specific disclosure and optimization tools, like the Health Product Declaration and the GreenScreen for Safer Chemicals method, which evaluate a material's human health impacts in a more comprehensive way. It can be daunting to navigate the suite of health-specific disclosure and optimization tools on top of the life cycle assessment information, but these analyses are complementary and are best conducted in parallel (see "Understanding and utilizing product disclosure and optimization tools" for a comparative review).

CONFLICTING ASSESSMENT TOOLS AND CRITERIA

Each of the currently available third-party assessment tools has slightly different requirements and characteristics (see "Implementing a Healthier Materials plan"). Additionally, owner- and project-specific assessment criteria and tools are often different from the third-party tools. These variations pose significant resource challenges to manufacturers, who are asked to accommodate many similar but different requests for information, and dilutes the market signal. As third-party assessment tools continue to evolve, Project teams can help by aligning their project goals to existing frameworks and product-level tools as much as possible.

harmonization remains a high priority. Harmonization efforts should continue to minimize these differences and reduce the barrier to entry for more manufacturers.

> "Each owner has their own scheme. It needs to be addressed differently, and you can't get to that point of getting products specified and arranging pricing to meet construction requirements if you're spending all your time trying to figure out exactly what it is that is problematic and that is unique to each owner's framework."
>
> – *Architectural Sales Manager, global ceilings manufacturer*

LACK OF ALTERNATIVE PRODUCTS

We are at the early stages of a long process toward comprehensive suites of safer product options. It is currently difficult to identify healthier building products, in part because these alternatives are simply not yet available on the market.

Pervasiveness of toxic substances in building products

Substances of concern can be difficult to avoid in the products we use to make buildings. Table 6 lists product categories, organized by CSI division, and some of the major chemicals of concern commonly found in them. The chemicals listed are only those found on the LBC Red List, which is not a comprehensive list of substances of concern, but provides sufficient representation of the ubiquity of toxic chemicals in building products. The data in Table 6 was provided by the International Living Future Institute in conjunction with the Quartz Common Products Database.

This list may appear daunting, but each year a few manufacturers break through long-standing formulations and introduce products that are free of traditionally used Red List substances. ILFI and other green building program operators attribute this in large part to "the ask."

Red list violations found in common products		
CSI Division	Products Included	LBC Red List Violation
06	Particleboard	Phenol and melamine formaldehyde
	Steel door	Polychloroprene, phenol formaldehyde
	Medium Density Fiberboard (MDF)	Urea formaldehyde
	Glass fiber reinforced polymer decking	Dimethyl phthalate
07	Concrete cork expansion joint	Phenol and melamine formaldehyde
	Polyurethane foam window/ door seal	Halogenated flame retardants
	Elastic facade joint sealant	Butyl benzyl phthalate
	IGU silicone sealant	Octamethylcyclotetrasiloxane (d4)
	Drywall acoustical sealant	Phenol and melamine formaldehyde
	Intumescent firestop sealant	Melamine
	EPS foam insulation	Halogenated flame retardants
	Spray polyurethane foam insulation	Halogenated flame retardants
	Mineral fiber batt insulation	Urea phenol formaldehyde
	PVC membrane roofing	PVC, diisononyl phthalate
08	Double pane IGU	PVC
	Exterior door with IGU	Chlorinated paraffin, halogenated flame retardants, diisononyl phthalate, PVC
	PVDF-coated Al curtainwall extrusion	BPA in coating
	Polycarbonate cladding	BPA
09	Thin film intumescent coating	Melamine
	Type X drywall	Trace metals
	Acoustical Ceiling Panels (FGD gypsum)	Sodium poly(naphthalene formaldehyde) sulfonate, PVC
	Acoustical Ceiling Panels (natural gypsum)	Sodium poly(naphthalene formaldehyde) sulfonate, PVC
	High performance coating (acrylic)	Nonylphenoxypolyethylenoxy ethanol sulfate
	Vinyl composition tile	PVC
	Carpet tile	Perfluorohexanoic acid
	Hardwood flooring (pre-finished)	Octamethylcyclotetrasiloxane (d4)
	Bamboo flooring (engineered)	Octamethylcyclotetrasiloxane, phenol formaldehyde
21	Carbon steel sprinkler pipe	BPA in epoxy coating
22	Solvent weld soil and waste pipe	PVC
	Pipe insulation adhesives	Polychloroprene
	Glass fiber reinforced polymer water storage tank	Dimethyl phthalate
23	Fiberglass board insulation	Urea phenol formaldehyde

TABLE 6
LBC Red List violations found in common products. Courtesy: International Living Futures Institute

"THE ASK"

The widely accepted hypothesis is that as healthier materials initiatives are more broadly implemented, the market signal for safer alternatives will grow stronger, and the palette of healthier options that are cost- and performance-competitive will grow. This process starts with the architecture, engineering, and construction community—including building owners—expanding its collective ask. As Figure 11 describes, "the ask" for content transparency begins a series of conversations that inspire the innovations needed to achieve the building industry's HM goals.

> "We have been lucky to work with other like-minded organizations to combine our purchasing power and move the market in a positive way."
>
> – *Jennifer MacDaniel, Kaiser Permanente [project principal, facilities planning and design]*

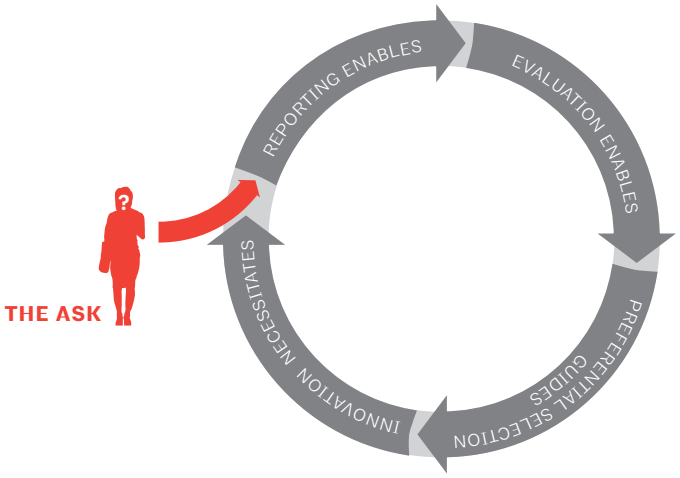


FIGURE 11
"The ask" for chemical reporting begins a series of conversations that can inspire the innovations needed for healthier building materials. Adapted from presentation by Brenden Owens given at Greenbuild, 2014.

Contractor-selected products

HM efforts have also primarily addressed interior finish products that are prescriptively specified by architects and interior designers. While the numbers of healthier products in these specification divisions have grown significantly, healthier options in product categories that are more typically selected by the contractor remain relatively limited. Similarly, contractor engagement with these issues remains low compared to the design community. This has the potential to improve if projects include performance-specified products within the scope of their HM requirements. Projects that achieved their HM goals on these product types attest that making a champion out of the general contractor and key trade partners was critical, as they were best placed to leverage existing relationships with manufacturers of their go-to products.

Whether selected by the design team or the construction team, a critical element to making "the ask" work towards increasing the availability of better building products is for manufacturers to see rewards for their actions. Without more widespread procurement of healthier, more transparent building products, it is hard to expect continued improvement from manufacturers.

> "A voice of one might be good, but a group of trusted brands with a unified voice is powerful."
>
> – *Vince Digneo, Adobe [sustainability strategist]*

RECOGNIZING THE VALUE OF HEALTHIER MATERIALS

For owners

There is a common perception that because cost-competitive, safer alternative materials are difficult to find, and very few property owners yet see its direct marketability, implementing HM criteria will cost more than the value it adds. However, several leading building owners have found that when considering the long-term importance of human and environmental health, adopting and implementing HM goals add clear value to their project, especially when the strategy is seen as supportive of the organization's stated values or mission. Additionally, as more projects implement HM plans, the industry's collective knowledge and the sophistication of the tools will improve, thereby increasing the value of healthier materials on future projects.

> "What you've seen on this project is the coming together of the stars. The Airport is fully supportive. The design-builders (representatives from both design and construction) are at the same table, as opposed to someone saying it's too expensive. Everyone has come together in a collaboration to achieve an exceptional project outcome."
>
> – *Anthony Bernheim, SFO [program sustainability manager]*

For design and construction teams

Similarly, some members of the building community are reluctant to invest in the research and resources necessary to establish and achieve HM goals. This lack of internal buy-in might make firm leadership reluctant to invest money in growing the knowledge and resources to address these issues internally. And if a firm does make the investment, HM work may be limited to the sustainability or interior design teams, rather than integrated across teams. Similar patterns characterized the early adoption of other sustainability efforts, such as LEED, but those that engaged early are now at an advantage because of growing adoption. The options presented in "Implementing a Healthier Materials plan" introduce a variety of frameworks—and applicable resources—for teams to choose, many with a low barrier to entry. The hope is that this will broaden adoption across a variety of firms.

> "I think it's possible for any firm to do this, but they absolutely need to have, at a leadership level, acknowledgement that it's a worthy effort. Time is money, so leadership needs to be willing to set aside time for the materials health champion, or group, to really focus on this."
>
> – *Suzanne Drake, Perkins+Will [Research Director, Senior Associate]*

For manufacturers

Finally, manufacturers will struggle to see value if there is no return for the effort. Producing transparency documentation and developing in reformulations most often require significant investment of time and resources. The strongest market signal project teams can send is to actually purchase products that support their HM goals.

> "The challenge internally is that there are certain people who look at the documentation format and say, 'this is fundamentally flawed' and they immediately want to disengage... If there's no customer pull, it makes all the change agents and champions at various levels have much harder jobs."
>
> – *Sustainability Director at a global carpet modular flooring manufacturer*

REAL AND PERCEIVED RISK

Liability

There is broad concern about risks, both real and perceived, that the adoption of materials disclosure and assessment may pose. One common concern is that an architect's awareness about a hazardous substance in a selected material may make the architect responsible to avoid specifying that material. There is also concern about overstating claims of "healthy" buildings. The *AIA's Materials Transparency and Risk for Architects* white paper aims to provide context and background to introduce architects to basic legal and practice questions within the realm of product content transparency.[62] Equally important, it cautions designers about attempts by the architect to interpret ingredient disclosure documents or assess the impacts of hazard warnings in those documents since design professionals aren't trained materials scientists equipped to evaluate the complex chemistry of building materials.

Manufacturers' risk around intellectual property

For manufacturers, chemical formulations can be the backbone of their business and revealing such information may put them at risk.

Some material health certification programs keep chemical inventory information confidential, such as Cradle to Cradle and UL Product Lens, in exchange for providing rigorous and independent evaluations; however, these can be cost-prohibitive when compared to HPDs and Declare, which encourage full disclosure. In some instances building professionals may not need the exact formulation for a given product if they have a proper understanding of its health impacts. For example, a designer could select among competing products, e.g. shade cloths, based on Cradle to Cradle scores or on hazards disclosed on HPDs without knowing the identities of the chemicals that pose those hazards. Striking a balance between full disclosure and intellectual property protection is one of the biggest challenges to overcome as the industry moves toward healthier building materials.

Performance concerns about new alternative or reformulated materials

When new products are introduced with reformulated materials or materials that are not typically used for the function at hand, questions about their performance naturally arise. Similarly, due to health concerns, a designer or builder may decide to leave a material out altogether where that material traditionally formed part of a familiar assembly. Due to the lack of a track record that is comparable to the typically-used product or assembly, manufacturers may not provide the same level of warranties

> "The available alternatives didn't have enough of a performance track record over time."
>
> – *Lauren Swezey, Facebook [sustainability manager].*

This is little different than other, more general innovations brought to the buildings industry. The construction sector is well-known to exercise more caution than other end users of manufactured products; it is already grappling with its slow pace of change while surrounded by faster-moving product and materials innovations. Healthier material innovations are most likely to be adopted when the value chain escalates this as a priority among other desired material attributes, and communicates successful experience with alternate products and systems. While in-house HM program operators like Kaiser Permanente and San Francisco Department of the Environment have been collecting performance information, and some databases for HM information have made mention of providing a platform for reviews, as of this writing there is no open, public platform recording the performance feedback of material health innovations. The notion of compiling and updating product information in a Building Materials Manual (within Step 7 of the HM Plan) at least offers owners and project teams a place to start.

[62] The American Institute of Architects. (2016). *Materials Transparency and Risk for Architects*. Washington D.C. Accessed 10 November 2016.

LIMITED PLATFORMS AND MECHANISMS FOR COLLABORATION

As project teams take on more ambitious healthier materials criteria, the industry is generating a large amount of collective data and expertise. Platforms or mechanisms to share this knowledge, however, remain fairly limited, despite evidence of the benefits of collaborative opportunities. For example, several groups have established "buyers' clubs," such as those organized by the Building Health Initiative of USGBC and GSPI. These clubs provide members with a common space to discuss challenges and successes in their development and implementation of HM criteria.

Whether in-person or online, more collaborative platforms like these are needed. This document aims to encourage more teams to take on HM criteria, with the hope that as the body of relevant knowledge grows, so too will the platforms and tools to share and learn from it.

> "One of the challenges of having all of these groups is that most of the organizations have so many different rules about confidentiality and the sharing of resources... We gather this information, and we haven't been able to share it. There's no central repository."
>
> – *Katie Bachman, Stōk [sustainability consultant]*

Considering healthier materials in practice

SECTION HIGHLIGHTS:

- How the healthier materials protocol can be used as a customizable framework in projects.
- Examples from practice in business, architecture, transportation, and healthcare.
- Inspiration for implementing healthier materials targets by content disclosure goals, hazard avoidance goals, or both.

06

This section offers four examples from practice that demonstrate how the HM protocol can be applied. These examples show the range of actors involved, from an owner developing healthier materials criteria and translating them into a tool for broader use to an architecture firm developing and implementing a chemical avoidance list and using it as the basis for both internal and external tools. Each provides a practical example of a slightly different portion of the protocol, as noted in Table 7.

Collectively, these case studies show how the HM protocol can be used as a customizable framework, rather than a prescriptive set of requirements. There are many ways to implement HM goals, both on individual projects and across multiple projects, and these may be driven by content disclosure goals, hazard avoidance goals, or both. Approaches can be customized from one project to the next to most appropriately deliver outcomes that are consistent with the owner's values and are beneficial for the project and its occupants.

Portions of protocol highlighted in case study

Case Study	Focus	Goal + Scope	Method + metrics	Prioritization criteria	Targets	Roles + responsibilities	Tracking + documentation	Operations + maintenance
Kaiser Permanente: Environmentally Preferable Purchasing Criteria		■	■					
Google: Portico		■	■	■	■	■	■	
SFO Airport: Pursuing ingredient transparency				■	■	■	■	
Perkins+Will: The Precautionary List			■	■			■	

A step that is not highlighted simply means it is not addressed in the case study. It is not an indication that the project did not complete that step.

CONTENT DISCLOSURE

HAZARD AVOIDANCE

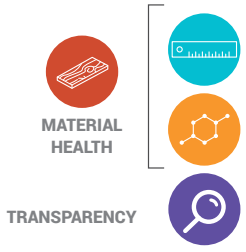
TABLE 7
Portions of protocol highlighted in case study.

CASE STUDY: GOOGLE: ADVANCING HEALTHIER MATERIALS IMPLEMENTATION AT SCALE USING PORTICO

To respond to the increasing demand for transparency and materials optimized for human and environmental health, Google, in partnership with HBN, created Portico, an online HM evaluation and selection tool. It is designed for use by a range of stakeholders related to a project—including manufacturers and suppliers, owners, architects and designers, and contractors and project managers—and combines an extensive product database, backed by the 40,000+ Pharos Chemical and Material Library, with project management related functionalities to support information gathering, product evaluation analysis, and decision-making based on project-specific requirements. The tool also provides manufacturers visibility into the specific selection criteria that may be set differently for each project. In the two years of using Portico on projects, Google has driven manufacturers to add 4,500 products in its library globally.

The criteria used to evaluate products in Portico is built on science-based, established industry standards, such as the HPD, GreenScreen for Safer Chemicals, and C2C, and aligns with industry third-party ratings systems, such as LEED, LBC, and WELL Building. Based on the data shared by manufacturers using these industry standards, the products are evaluated based on material health and transparency and scored between 0-16. Portico is dynamic and information is updated in real time, which allows for flexibility and setting project-specific targets based on scope and scale.

Launched in 2015, Portico was initially only used by Google. In October 2016, Google and HBN announced the launch of the Portico Early Access Program with four other industry leaders—P+W, Harvard University, The Durst Organization, and HomeFree Affordable Housing Initiative (led by HBN). The vision is to scale and make the tool available for anyone involved in the design, construction, and operation of projects seeking to provide healthier spaces.



Scoring system for Material Health and Transparency Levels	Scoring Ranges Max Score: 16
Ingredient Inventory + Characterization (aka Associated Hazards) Identification and disclosure of ingredients and all hazards associated with ingredient components in product/material formulation.	0 - 8
Disclosure Threshold Disclosure level for all intentionally added ingredients and residuals. (dependent on standard addressed)	0 - 4
Transparency Level of product/material formulation shared with end users by manufacturer (includes ingredient names and associated hazards).	0 - 8

FIGURE 12

Portico utilizes the inventory, screening, assessment, and optimization framework as the foundation for its criteria and includes HPD, GreenScreen for Safer Chemicals, and Cradle to Cradle for manufacturers to provide product information. Image courtesy of Google, Inc.

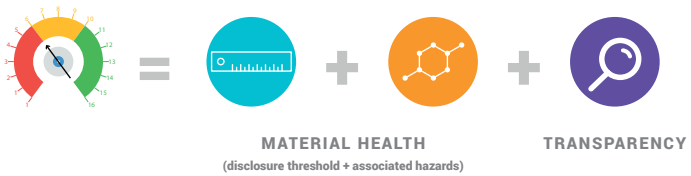


FIGURE 13

Portico scores are based on aspects of material health, including associated hazard and disclosure threshold, and transparency. Image courtesy of Google, Inc.

CASE STUDY: PERKINS+WILL: IMPLEMENTING THE PRECAUTIONARY LIST

Perkins+Will created the Precautionary, Asthmagen, and Flame Retardant Lists, and the accompanying Transparency website, as a set of informational tools for interior designers, architects, owners, and the larger building community. The Precautionary List includes substances commonly found in the built environment that are known or suspected to be harmful to humans and/or the environment. For each listed substance, the Transparency site presents suspected health effects, as well as the products and specification divisions in which that substance or substance group most often occurs.

Internally, the firm translated the Precautionary List into an evaluation tool for design projects. The tool guides designers as they are developing specifications for products, materials, and finishes in a given project and flags where Precautionary List substances may be found. In conjunction with the Transparency site, designers and owners can then better understand how certain products may negatively affect human and environmental health, creating an opportunity to make a different choice. As specifications are confirmed, the tool tracks how many Precautionary List substances are present compared to the total number of products on the project, both overall and by specification division.

Results are compiled into a report provided to the owner upon the completion of each milestone phase. For future projects, this report provides a roadmap for products to consider, or reconsider. For example, in a recently completed review the project reported out at 99 percent free of Precautionary List substances. As part of the report, the design team highlighted additional items in the project that usually escape scrutiny: finger guards at door hardware (this childcare center included "finger pinch guards" at all doors in areas where children would be present) and insulating pipe socks at lavatories.

Because this reporting tool has been in use on three consecutive projects with this client, the project team was able to spend some extra effort to address those items: finding and working with a supplier of bio-based plastic willing to extrude a new shape (in budget), in order to replace PVC plastic hardware guards, and finding a few options to cover the exposed under-sink pipes with materials other than plastic.

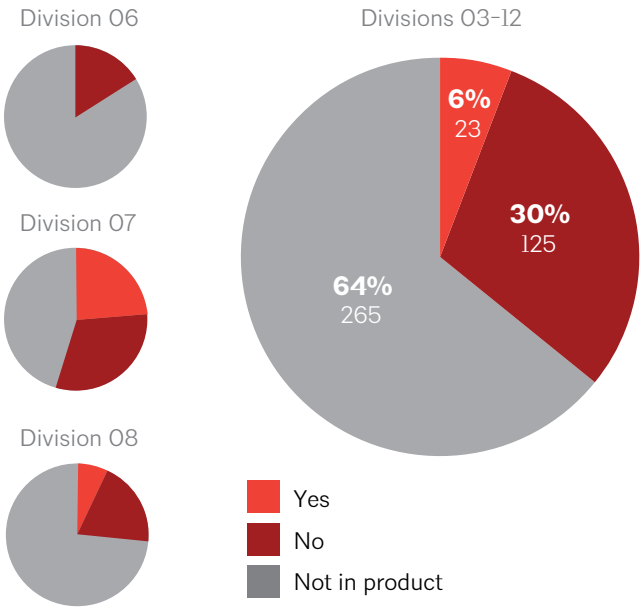


FIGURE 14
Graphical results of Perkins+Will application of the Perkins+Will Precautionary List on a project

CASE STUDY: SAN FRANCISCO INTERNATIONAL AIRPORT: ACHIEVING LEEDV4 GOLD CERTIFICATION

As it targets the newest LEED Gold certification, the Terminal 1 project at San Francisco International Airport (SFO) is pursuing the Material Ingredient Reporting credit (MRc4 Option 1), which rewards the use of 20 products that submit disclosure/transparency documents, and the Low Emitting Materials credit (IEQc2). SFO has prioritized air quality impacts and material content transparency in its product selection and specification process to align with the goals of these credits.

To achieve this credit, architects are using the Mindful MATERIALS[63] system to collect information from manufacturers, and an Arup-designed tracking tool (shown in Figure 15) to ensure that a sufficient number of qualifying products are in the project specifications.

Additionally, firms Austin-Webcor, Arup, and Urban Fabrick collaborated to create a submittal cover smartsheet that simultaneously guides subcontractors through the documentation requirements for the applicable materials credits and auto-populates a shared materials tracking spreadsheet using the data from these sheets. The clippings in Figures 16 and 17 show part of this cover sheet for the material ingredient and low-emitting materials credits and a portion of the tracking matrix that it auto-populates.

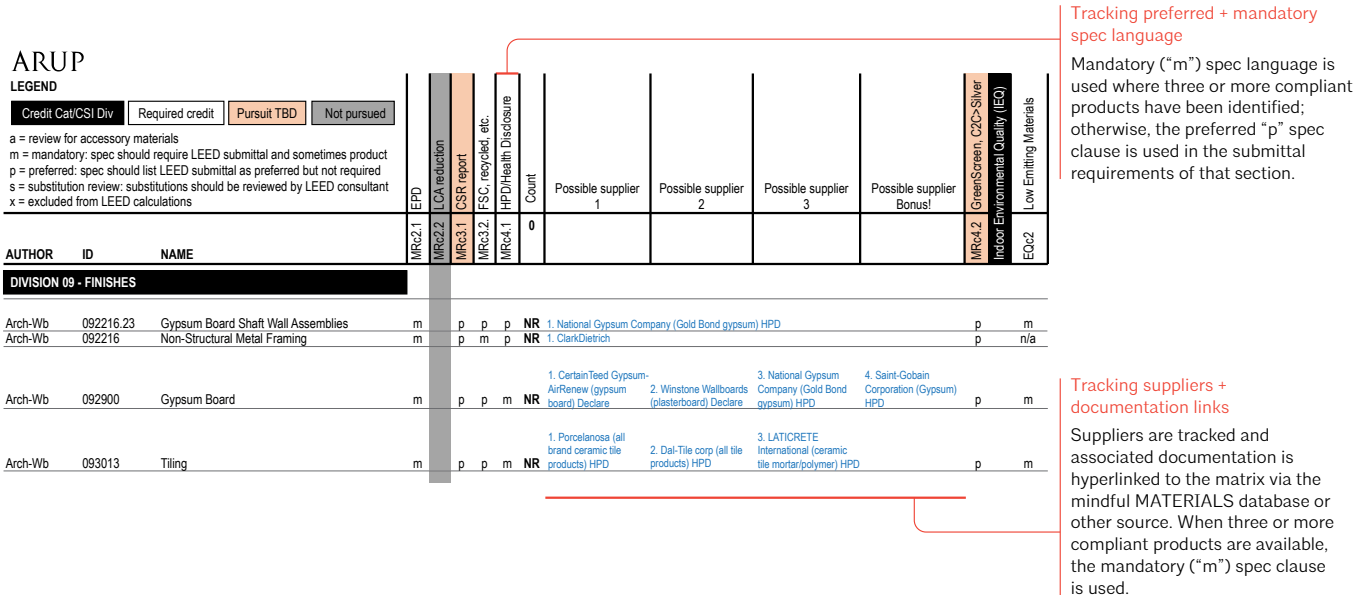


FIGURE 15
Arup tracking tool.

[63] *HKS, Inc. (2017). Mindful Materials.*

FIGURE 16

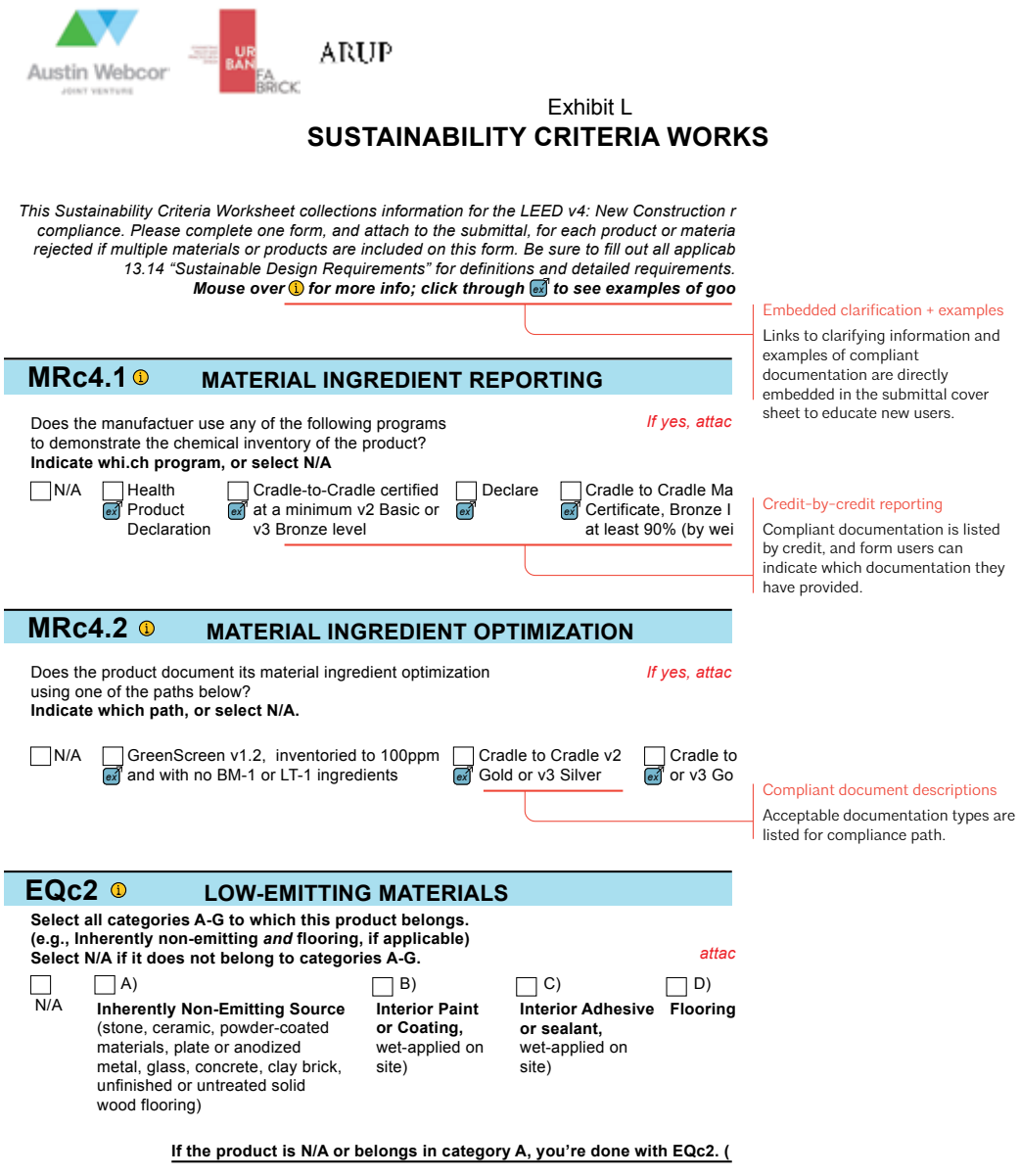


FIGURE 16
Sustainability Criteria Worksheet example.

FIGURE 17

Austin Webcor JOINT VENTURE | URBAN FABRICK | ARUP

SUSTAINABILITY CRITERIA TRACKING SHEET

BID Package/ Contract	CSI Division	Scope	EPDs?	Material Sourcing?	HPDs?	Emitting Material? (Adhesives, Paints, Sealants, Coatings, Flooring, Agrifiber)	InitiaLEED Exhibit Received?	FinaLEED Exhibit Received?
BP 1	32 3111	TP-02.00 - Temporary AOA fencing & barricadaes	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	31 2514	TP-03.10 - Stage 1 SWPPP & Maintenance	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	02 8000	TP-04.10 - Stage 1 structure abatement (east rotunda)	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	02 4116	TP-05.10 - Stage 1 structure demolition	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	21 0000	TP-05.30 - Stage 1 demolition, fire protection make ready	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	33 0001	TP-06.10 - Make ready, site utilities	Possible	YES	N/A	N/A	YES	NO
BP 1	01 4301	TP-43.01 - Waste management / trash disposal	N/A	N/A	N/A	N/A	N/A	N/A
	01 4302	TP-43.02 - Photography (DELETED)	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	01 4303	TP-43.03 - Watchman / security	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	01 0002	TP-43.04 - General requirements / field services	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	01 4307	TP-43.07 - Field engineering (stage 1 ONLY)	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	22 0001	CT-01.10 - Make ready, SSLS-3 temporary forced main (COR-005)				N/A	N/A	N/A
BP 1	23 0001	CT-01.10 - Stage 1 demolition HVAC make ready (COR-002 & 003)	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	26 0001	CT-03.10 - Stage 1 demolition electrical investigation (COR-003)	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	26 0001	CT-03.10 - Stage 1 demolition electrical make ready (COR-004)	N/A	N/A	N/A	N/A	N/A	N/A
BP 1	26 0001	CT-03.10 - Stage 1 demolition electrical temporary power (COR-005)	N/A	N/A	N/A	N/A	N/A	N/A
BP 2	31 2300	TP-03.20 - PCC/AC demo & excavation & backfilling	N/A	N/A	N/A	N/A	N/A	N/A
BP 2	03 3000	TP-07.00 - Structural Concrete	YES	Possible	N/A	Review for accessory mtls	YES	NO
BP 2	03 3000	TP-07.00 - Structural concrete (Scope creep)	YES	Possible	N/A	Review for accessory mtls	YES	NO
BP 2	03 3000	TP-07.30 - Structural concrete (Common Use Lounge)	YES	Possible	N/A	Review for accessory mtls	YES	NO
BP 2	03 0000	TP-07.60 - Structural concrete (added elevator pits)	YES	Possible	N/A	Review for accessory mtls	YES	NO
BP 2	31 621	TP-08.00 - Tubex steel piles	Possible	YES	N/A	N/A	YES	NO
BP 2A	05 1200	TP-11.00 - Structural steel & metal decking	YES	YES	N/A	Review for accessory mtls	YES	NO
BP 2A	21 0000	TP-36.00 - Fire suppression systems	N/A	N/A	N/A	Review for accessory mtls	NO	NO

FIGURE 17
Sustainability Criteria Worksheet example.

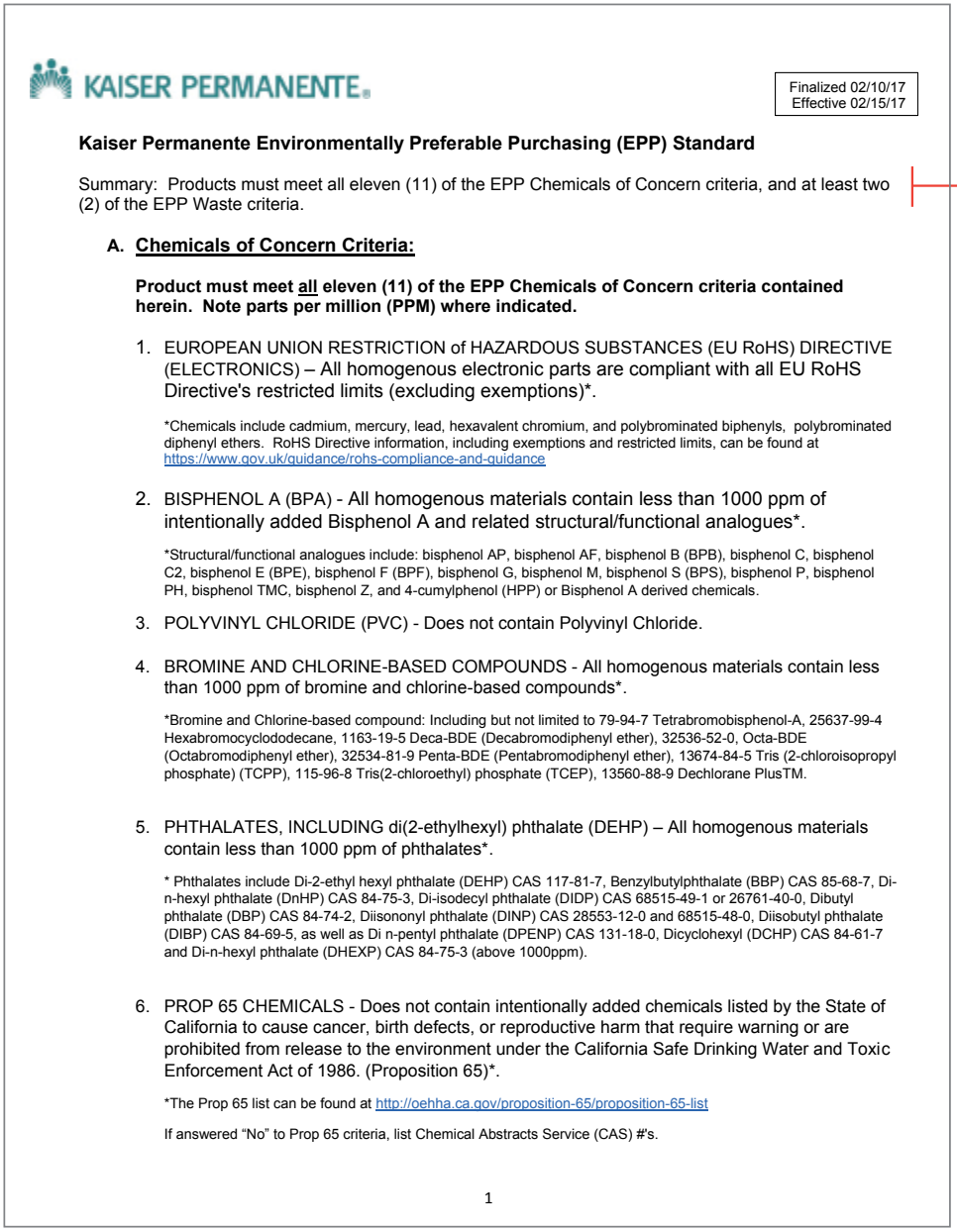
CASE STUDY: KAISER PERMANENTE: ENVIRONMENTAL PURCHASING PROGRAM CRITERIA

As part of its mission to provide high quality, affordable health care services and improve the health of the communities it serves, Kaiser Permanente (KP) announced ambitious new environmental goals to increase their purchase of products and materials that meet environmental standards to 50 percent by 2025. KP's Environmentally Preferable Purchasing (EPP) Program includes specific purchasing criteria in the areas of chemicals and waste, and this criteria is known as the KP Environmentally Preferable Purchasing overarching Standard. This Standard was collaboratively developed by Kaiser Permanente internal experts, as well as industry experts in the organizations of Healthcare Without Harm, Practice Greenhealth, Clean Production Action, Center for Environmental Health, Ecology Center, and the Science and Environmental Health Network. Other key environmental purchasing criteria in the areas of Energy and Water have been identified as criteria pertaining to product-specific EPP Standards in development now. KP's EPP overarching Standard has been summarized in an online document made available to manufacturers and suppliers involved in all major, strategic, and critical purchasing decisions. A excerpt from the standard appears in Figure 18.

> "Healthy buildings are a demonstration of Kaiser Permanente's commitment to healthy communities in which everyone can thrive."
>
> *– Kathy Gerwig, vice president, employee safety, health, and wellness; environmental stewardship officer, Kaiser Permanente*

In outlining these criteria, KP acknowledges the existing limitations of chemicals policy at both the state and federal levels, and provided a list of sustainable product design guidelines, as well as a list of chemicals and materials to avoid in purchased products. The next KP EPP Standard to be released later this year will be for furnishings and fabrics. KP leverages its significant purchasing power to make compliance a contractual requirement for suppliers and manufacturers of these products. As a result, manufacturers working directly with KP have expanded the palette of compliant materials available to designers on KP projects, as well as to the general public.

FIGURE 18



KAISER PERMANENTE®

Finalized 02/10/17
Effective 02/15/17

Kaiser Permanente Environmentally Preferable Purchasing (EPP) Standard

Summary: Products must meet all eleven (11) of the EPP Chemicals of Concern criteria, and at least two (2) of the EPP Waste criteria.

A. Chemicals of Concern Criteria:

Product must meet all eleven (11) of the EPP Chemicals of Concern criteria contained herein. Note parts per million (PPM) where indicated.

1. EUROPEAN UNION RESTRICTION of HAZARDOUS SUBSTANCES (EU RoHS) DIRECTIVE (ELECTRONICS) – All homogenous electronic parts are compliant with all EU RoHS Directive's restricted limits (excluding exemptions)*.

   *Chemicals include cadmium, mercury, lead, hexavalent chromium, and polybrominated biphenyls, polybrominated diphenyl ethers. RoHS Directive information, including exemptions and restricted limits, can be found at https://www.gov.uk/guidance/rohs-compliance-and-guidance

2. BISPHENOL A (BPA) - All homogenous materials contain less than 1000 ppm of intentionally added Bisphenol A and related structural/functional analogues*.

   *Structural/functional analogues include: bisphenol AP, bisphenol AF, bisphenol B (BPB), bisphenol C, bisphenol C2, bisphenol E (BPE), bisphenol F (BPF), bisphenol G, bisphenol M, bisphenol S (BPS), bisphenol P, bisphenol PH, bisphenol TMC, bisphenol Z, and 4-cumylphenol (HPP) or Bisphenol A derived chemicals.

3. POLYVINYL CHLORIDE (PVC) - Does not contain Polyvinyl Chloride.

4. BROMINE AND CHLORINE-BASED COMPOUNDS - All homogenous materials contain less than 1000 ppm of bromine and chlorine-based compounds*.

   *Bromine and Chlorine-based compound: Including but not limited to 79-94-7 Tetrabromobisphenol-A, 25637-99-4 Hexabromocyclododecane, 1163-19-5 Deca-BDE (Decabromodiphenyl ether), 32536-52-0, Octa-BDE (Octabromodiphenyl ether), 32534-81-9 Penta-BDE (Pentabromodiphenyl ether), 13674-84-5 Tris (2-chloroisopropyl phosphate) (TCPP), 115-96-8 Tris(2-chloroethyl) phosphate (TCEP), 13560-88-9 Dechlorane PlusTM.

5. PHTHALATES, INCLUDING di(2-ethylhexyl) phthalate (DEHP) – All homogenous materials contain less than 1000 ppm of phthalates*.

   * Phthalates include Di-2-ethyl hexyl phthalate (DEHP) CAS 117-81-7, Benzylbutylphthalate (BBP) CAS 85-68-7, Di-n-hexyl phthalate (DnHP) CAS 84-75-3, Di-isodecyl phthalate (DIDP) CAS 68515-49-1 or 26761-40-0, Dibutyl phthalate (DBP) CAS 84-74-2, Diisononyl phthalate (DINP) CAS 28553-12-0 and 68515-48-0, Diisobutyl phthalate (DIBP) CAS 84-69-5, as well as Di n-pentyl phthalate (DPENP) CAS 131-18-0, Dicyclohexyl (DCHP) CAS 84-61-7 and Di-n-hexyl phthalate (DHEXP) CAS 84-75-3 (above 1000ppm).

6. PROP 65 CHEMICALS - Does not contain intentionally added chemicals listed by the State of California to cause cancer, birth defects, or reproductive harm that require warning or are prohibited from release to the environment under the California Safe Drinking Water and Toxic Enforcement Act of 1986. (Proposition 65)*.

   *The Prop 65 list can be found at http://oehha.ca.gov/proposition-65/proposition-65-list

   If answered "No" to Prop 65 criteria, list Chemical Abstracts Service (CAS) #'s.

1

Environmentally Preferable Purachasing criteria summary

Products must meet all eleven (11) of the Environmentally Preferable Purchasing (EPP) Chemicals of Concern criteria, and at least two (2) of the EPP Waste criteria.

FIGURE 18

Excerpt of the KP's Environmentally Preferable Purchasing Program criteria. The full standard may be viewed at <http://supplier.kp.org/formsreqs/KPEPPStandards.pdf>

Appendix A

Simplified target setting worksheets

This section describes a target-setting worksheet, or Acceptability Table, that is designed to assist project teams in working through steps 2-4 of the Protocol (priority setting, developing measurable targets, and defining methodology and metrics). The section includes instructions for use, example mark-ups for three established building rating systems (LEED, LBC, and WELL), and example mark-ups to show how a team might use the worksheet independent of any existing rating system. Appendix C includes complete sample plans that use this worksheet to establish methodology, metrics, and targets.

ACCEPTABILITY TABLE INSTRUCTIONS

The Acceptability Table presents the currently available frameworks for materials transparency and disclosure in parallel to facilitate the use of these frameworks in the project. A blank worksheet is shown below.

It is important to note that this is not an equivalence table: while higher points in each column indicate products with reduced hazard, the table is not intended to suggest that equal vertical positions on the chart share a similar level of hazard. The Acceptability Table allows the project team to record goals for including HM and/or excluding other materials by indicating which certifications are acceptable at which levels and in which amounts.

Multiple Acceptability Tables can be used to distinguish criteria for different scopes of work on a given project. For instance, in order to reduce occupant exposure to hazards, interior materials—especially interior finish materials—can be held to a higher standard than exterior materials. Or, as indicated in the sample plans in Appendix C, areas serving occupants who may be more vulnerable or experience higher exposures can be held to a higher standard.

Prepare as many copies of the Acceptability Tables as needed for the various concerns of the project, and clearly state which portion of the Scope of Work each applies to. Masterformat divisions and specification numbers can be used for clarity.

The following step-by-step instructions are intended to clarify how to complete an Acceptability Table for inclusion in an HM plan.

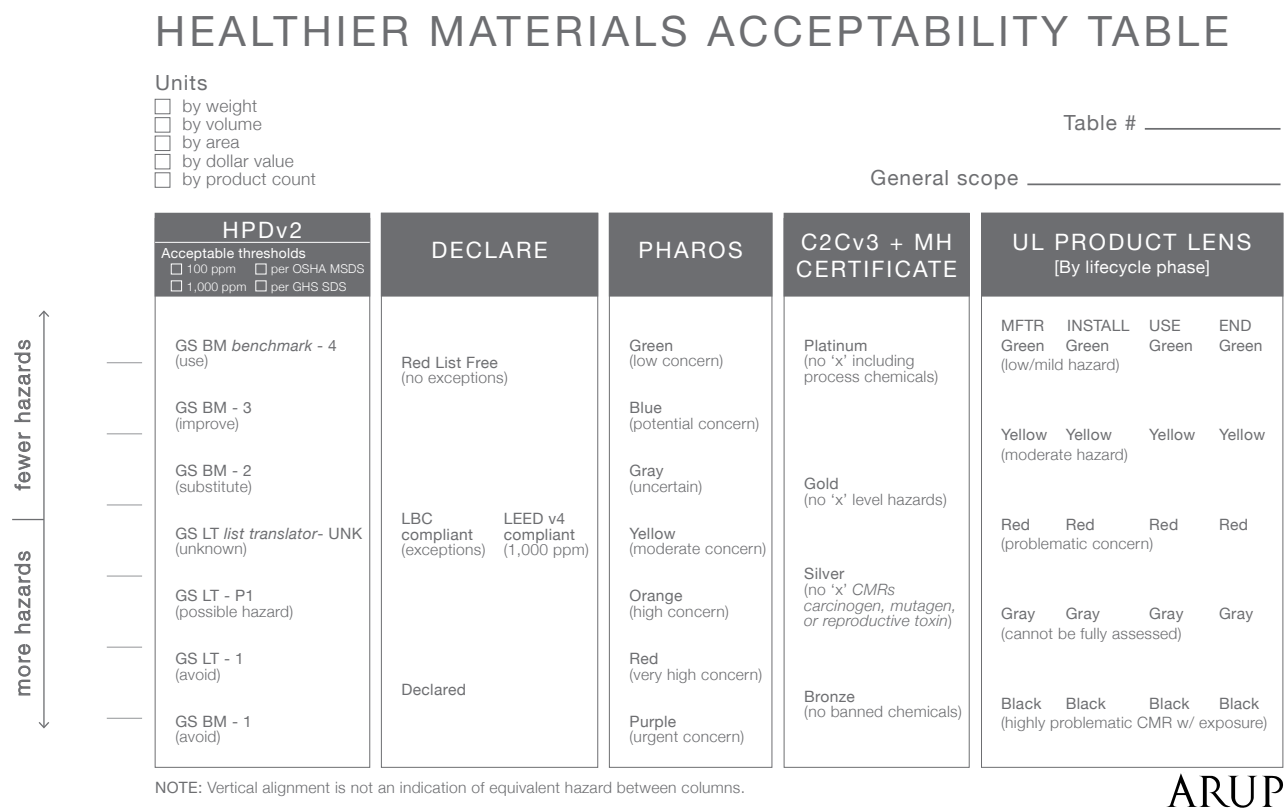


FIGURE A1
Blank worksheet example of a Healthier Materials Acceptability Table

POPULATING THE TABLE

1. Indicate which portion of the scope the table will cover (e.g. interior materials, exterior materials, sensitive areas, etc.), and number the table for reference.

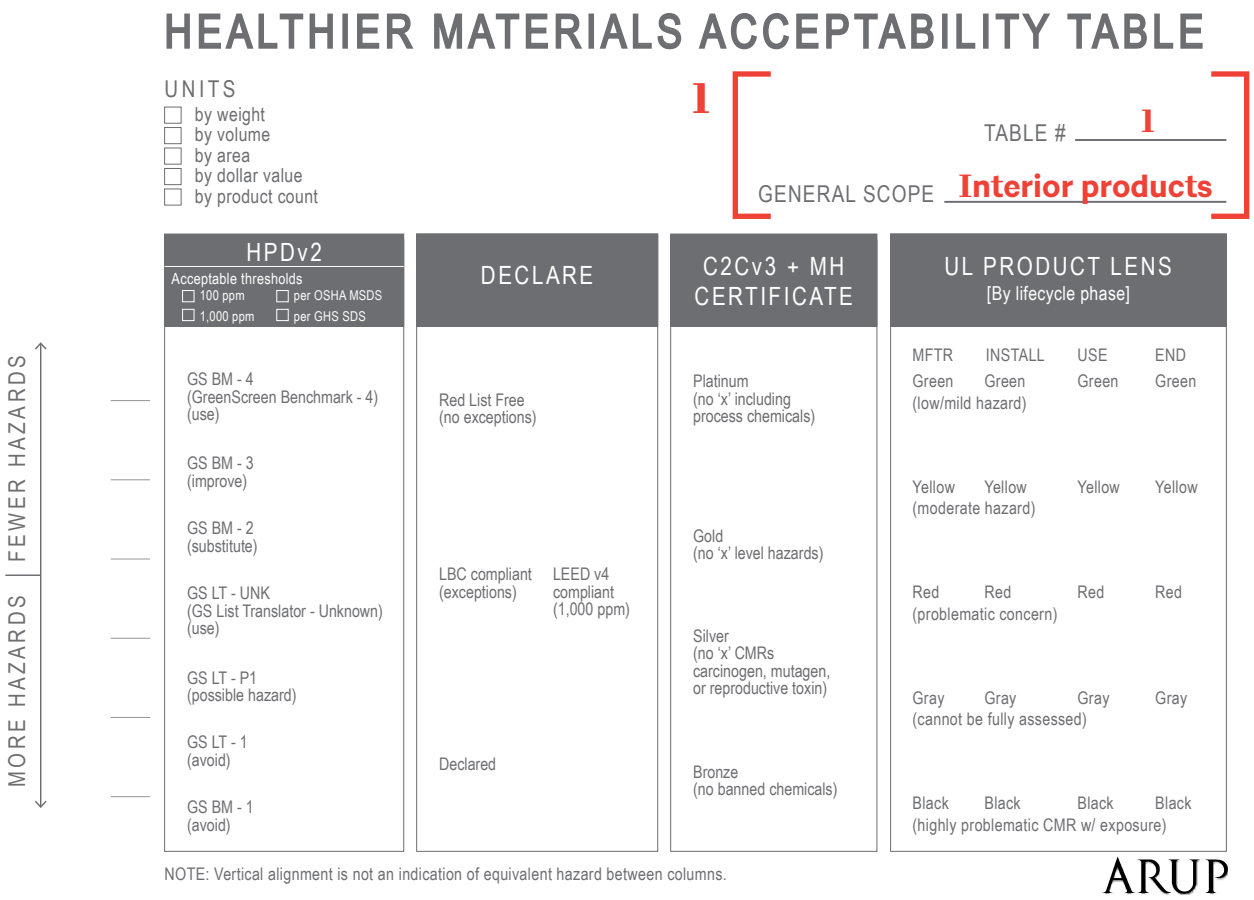


FIGURE A2
Designating the table number and scope.

POPULATING THE TABLE

2. Decide which units will be used for the table (e.g. weight, volume, area, dollar value, or product count). This will later serve as a unit of comparison to state target percentages of materials.

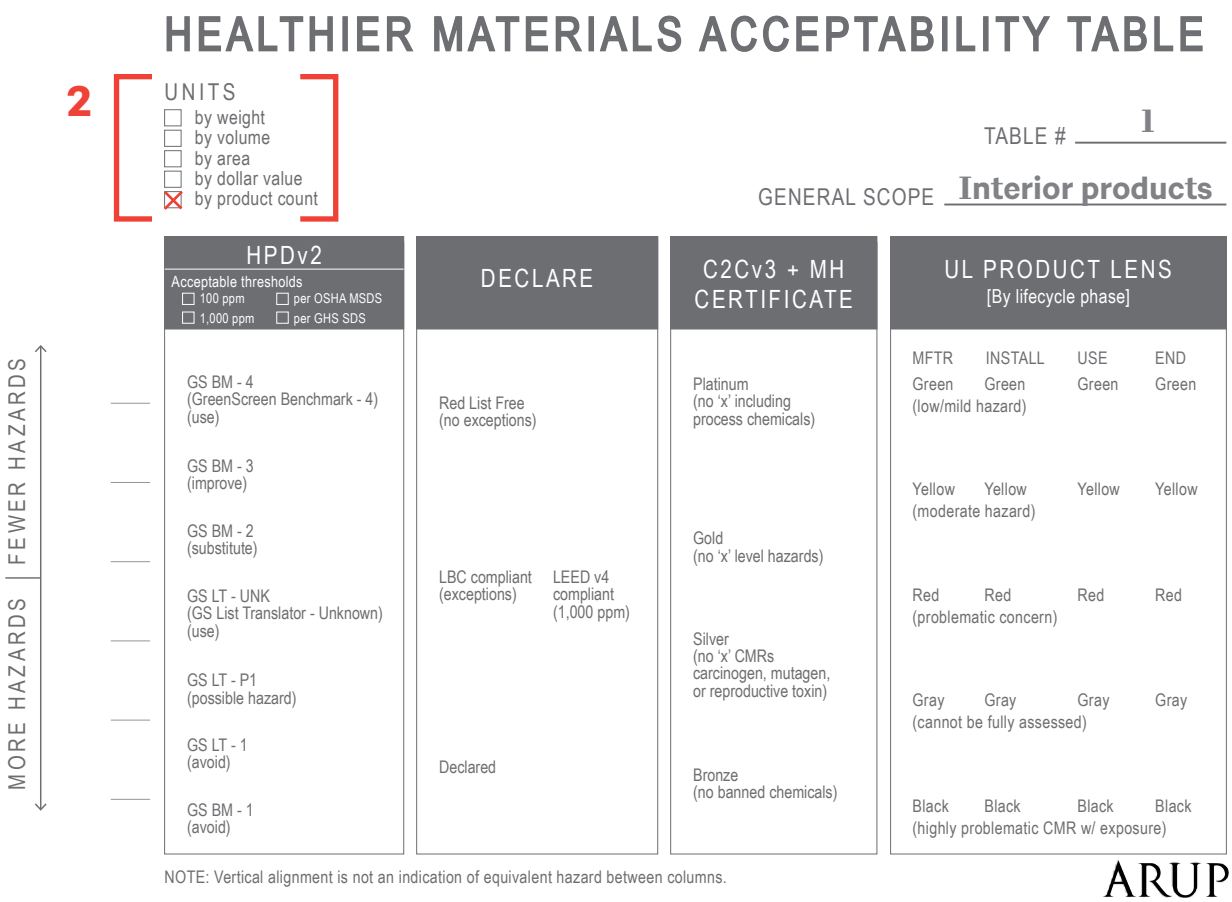


FIGURE A3
Designating the table number and scope.

POPULATING THE TABLE

3. Indicate target percentages on the left side of the table. The top percentage is the level at which products are considered acceptable and not restricted. You can create as many levels of acceptability as needed to explain project goals.

HEALTHIER MATERIALS ACCEPTABILITY TABLE

UNITS
- ☐ by weight
- ☐ by volume
- ☐ by area
- ☐ by dollar value
- ☒ by product count

TABLE # 1

GENERAL SCOPE Interior products

3

MORE HAZARDS | FEWER HAZARDS

	HPDv2 Acceptable thresholds ☐ 100 ppm ☐ per OSHA MSDS ☐ 1,000 ppm ☐ per GHS SDS	DECLARE	C2Cv3 + MH CERTIFICATE	UL PRODUCT LENS [By lifecycle phase]
Level A >15% required	GS BM - 4 (GreenScreen Benchmark - 4) (use)	Red List Free (no exceptions)	Platinum (no 'x' including process chemicals)	MFTR INSTALL USE END Green Green Green Green (low/mild hazard)
	GS BM - 3 (improve)			Yellow Yellow Yellow Yellow (moderate hazard)
	GS BM - 2 (substitute)	LBC compliant (exceptions) LEED v4 compliant (1,000 ppm)	Gold (no 'x' level hazards)	
	GS LT - UNK (GS List Translator - Unknown) (use)			Red Red Red Red (problematic concern)
Level B <85% required	GS LT - P1 (possible hazard)		Silver (no 'x' CMRs carcinogen, mutagen, or reproductive toxin)	
	GS LT - 1 (avoid)	Declared		Gray Gray Gray Gray (cannot be fully assessed)
Level C <10% allowed	GS BM - 1 (avoid)		Bronze (no banned chemicals)	Black Black Black Black (highly problematic CMR w/ exposure)

NOTE: Vertical alignment is not an indication of equivalent hazard between columns.

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FIGURE A4
Indicate target percentages.

POPULATING THE TABLE

4. Draw lines indicating which level of certification fall into each band. For example:
   a. For LBC compliance, materials marked Red List Free or LBC compliant are 100 percent acceptable (by product count), and everything below the line is not.
   b. For LEEDv4 BPDO Materials Ingredients Reporting Option 1, 20 products (by product count) must fall above a line showing the reporting requirements accepted by LEED.
   c. An owner might aim for generally high performance but be prepared to accept a small amount, such as one percent by weight, of non-compliant materials to expedite project management. In areas serving more vulnerable populations, these exception levels could be lower relative to other areas.

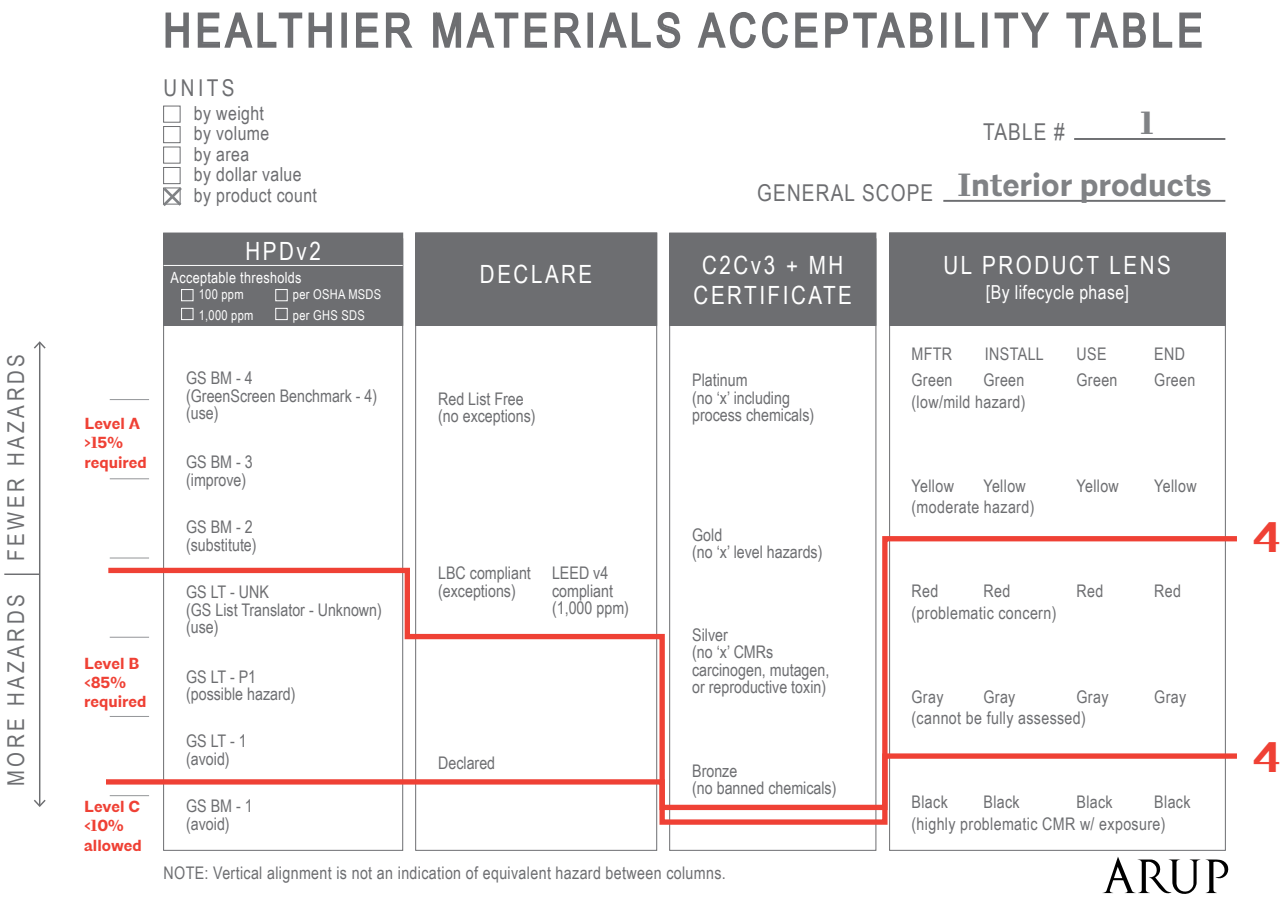

FIGURE A5
Draw lines to indicate which level of certification fall into each band.

POPULATING THE TABLE

5. Indicate which threshold of reporting is acceptable for HPDs. Note that 100 ppm is a finer screen than 1,000 ppm, so selecting a higher level of screening will exclude more trace materials. This information, however, may be harder to obtain.

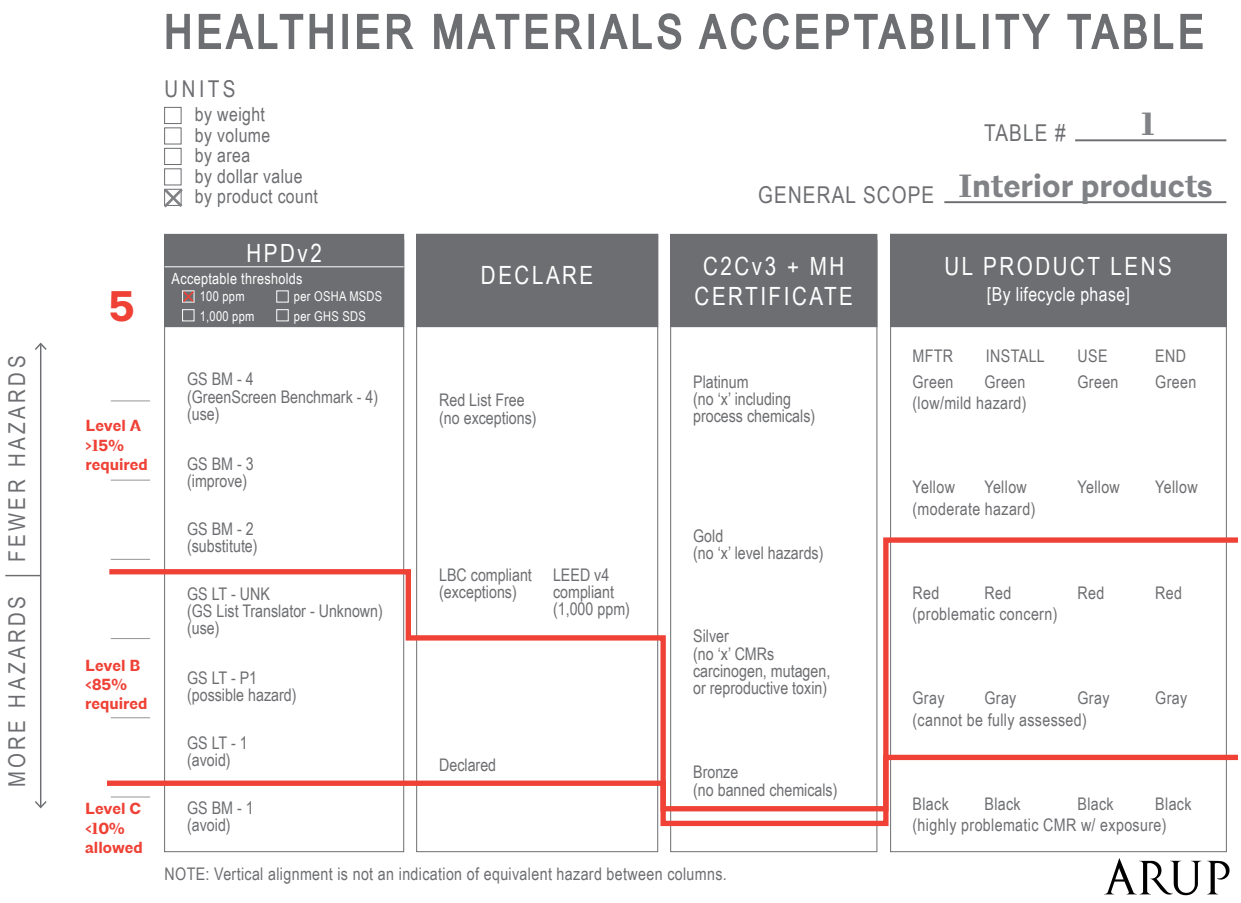

FIGURE A6
Indicate which threshold of reporting is acceptable for HPDs.

EXAMPLE MARK-UPS: THIRD-PARTY RATING SYSTEMS

This section includes three worksheets, each of which has been marked up for alignment with LBC, LEEDv4, or WELL criteria. These examples show how the worksheet may support project teams who have defined HM criteria and targets based on those published in one or more rating systems.

LIVING BUILDING CHALLENGE

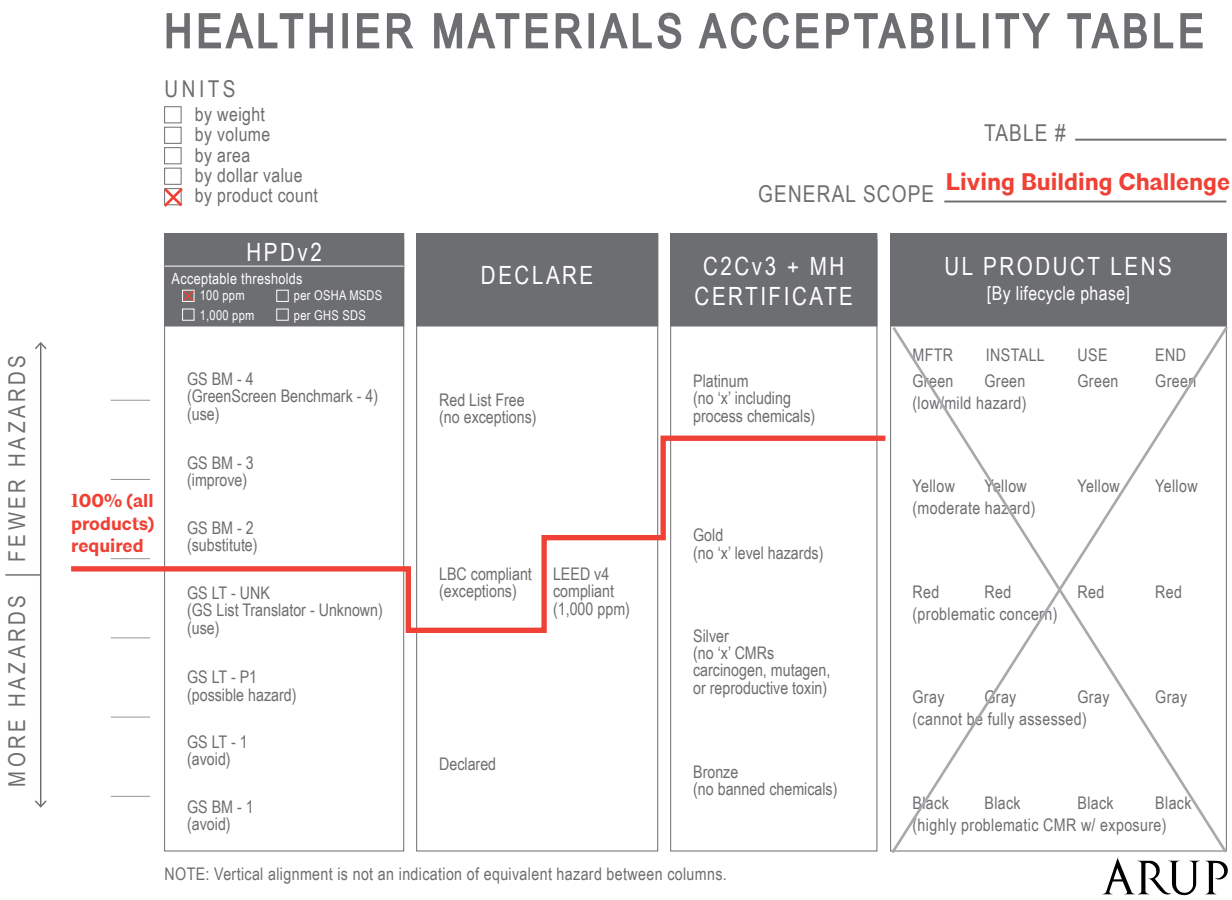

FIGURE A7
Worksheet marked up for alignment with the Living Building Challenge Red List Imperative.

LEED V4

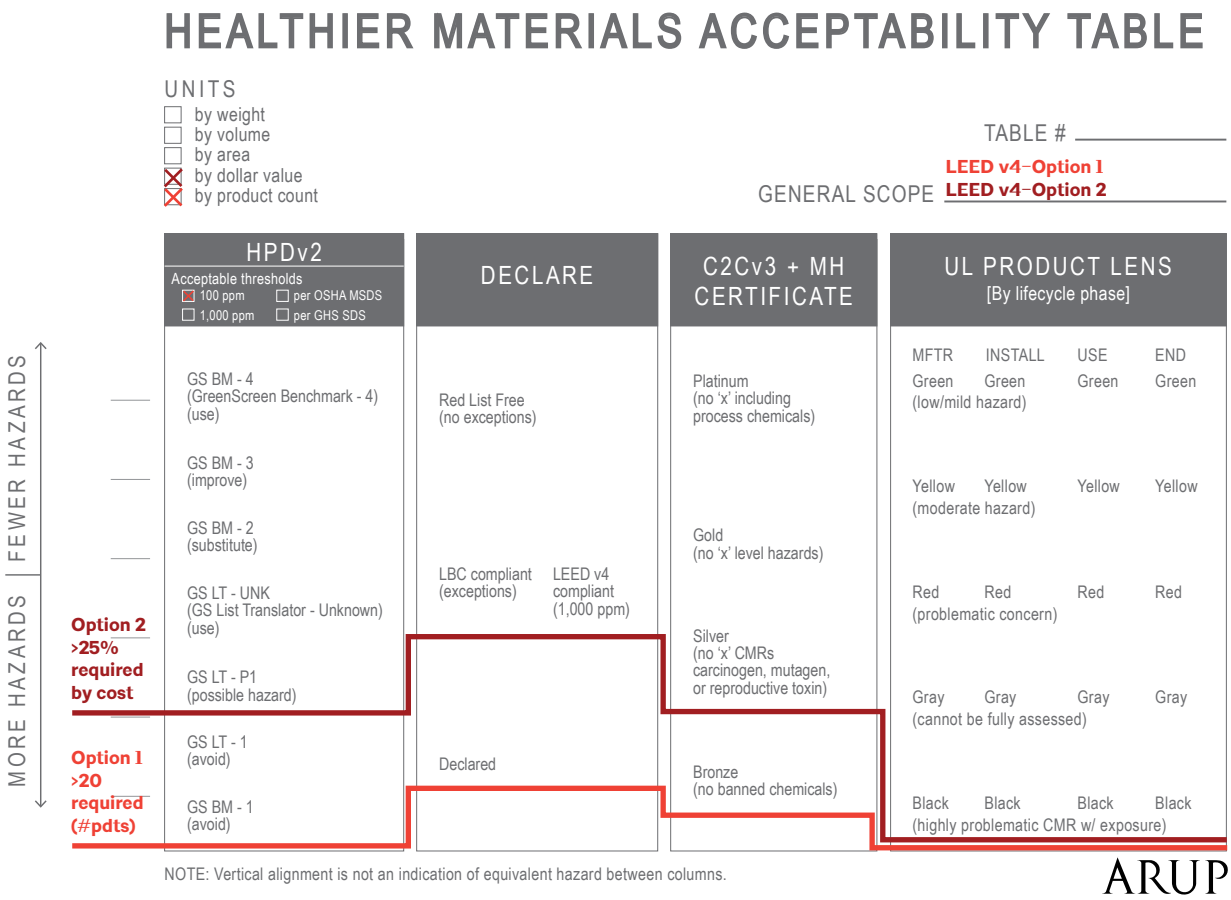

FIGURE A8
Worksheet marked up for alignment with LEEDv4.

WELL

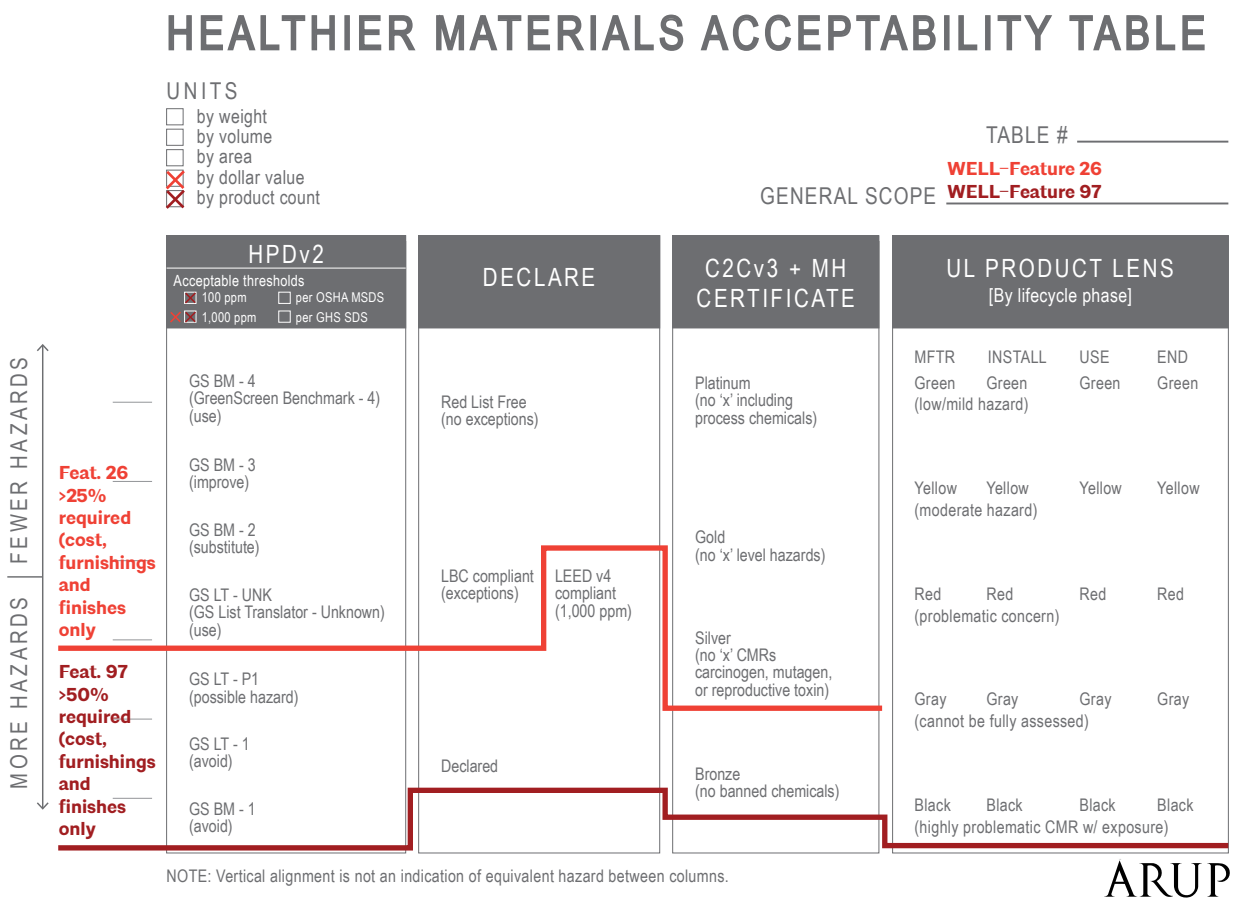

FIGURE A9
Worksheet marked up for alignment with WELL.

EXAMPLE MARK-UPS: PROJECT-SPECIFIC TARGETS

This section provides two marked-up examples reflecting what might be generated on a project prioritizing chemical transparency. The two charts both focus on the generation of product documentation and do not reject products on the basis of hazard score. However, they differ in how they define transparency. Figure A11 accepts only those documentation types that make chemical content data fully public, while Figure A12 accepts documentation types that protect chemical content data under a non-disclosure agreement with the third-party assessor.

CHEMICAL TRANSPARENCY: PUBLIC DISCLOSURE

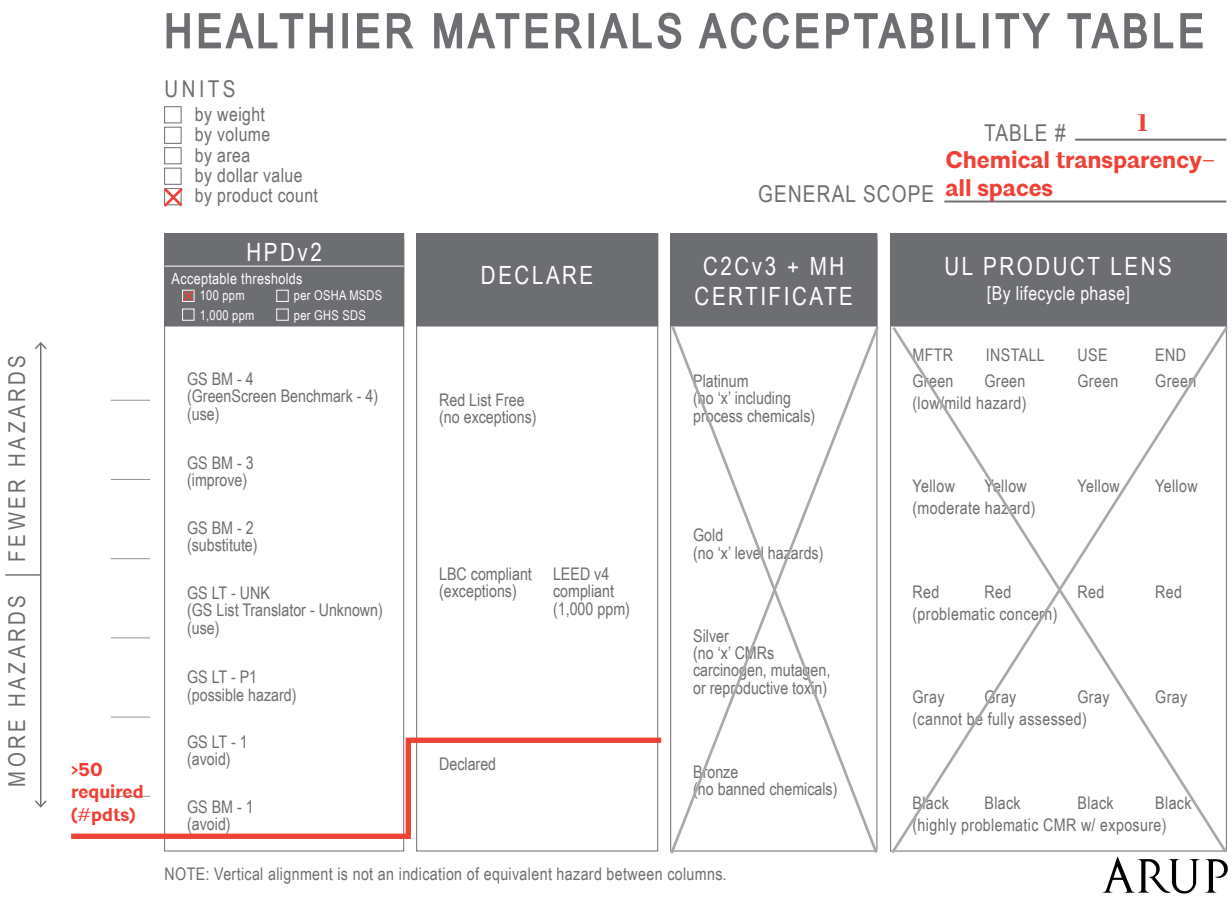

FIGURE A10
Worksheet marked up to reflect what might be generated on a project prioritizing chemical transparency, when chemical content data is fully public.

CHEMICAL TRANSPARENCY: PROTECTED DATA

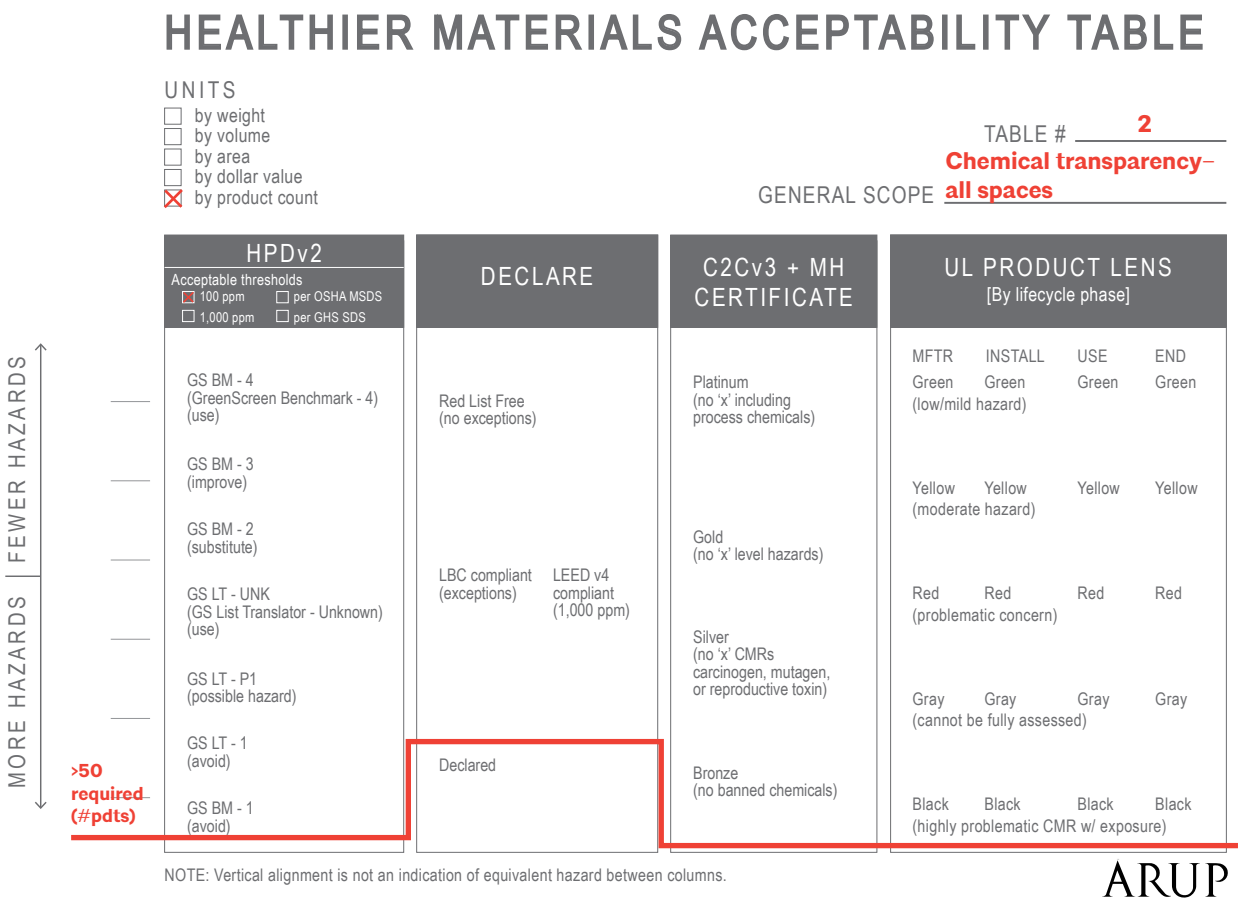

FIGURE A11

Worksheet marked up to reflect what might be generated on a project prioritizing chemical transparency, when chemical content data is protected under a non-disclosure agreement with the third-party assessor.

Appendix B

Sample tracking spreadsheets

The tracking spreadsheet in Table B1, developed by Arup, enables teams to track the elimination of specific chemicals of concern from specific product categories over the course of a project. Within each product category, the available options are tracked and evaluated against several criteria:

- chemical contents
- volume of product used on the project
- locations where products are installed
- qualitative level of occupant exposure

Users are able to weigh these considerations differently from project to project, or within different spaces in the project, to reflect project-specific values and priorities. Criteria can be added, removed, or weighted differently as project values vary.

- This tool was developed for a mixed-use housing project at a major university, which used the following weightings:
- occupant exposure (qualitatively evaluated)
- percentage of construction cost
- prevalence of the product or material in the building

Used in Project?	Product Name	Category	Exposure	Cost	Prevalence of material in the Building	Space Type
yes	Sample Adhesive 1 option a	Adhesives	high	low	moderate	Daycare
no	Sample Adhesive 1 option b	Adhesives	high	low	moderate	Daycare
no	Sample Adhesive 1 option c	Adhesives	moderate	low	moderate	Daycare
no	Sample Adhesive 1 option d	Adhesives	moderate	low	moderate	Daycare
no	Sample Adhesive 2 option a	Adhesives	low	low	moderate	Daycare
yes	Sample Adhesive 2 option b	Adhesives	low	low	moderate	Daycare
yes	Sample Adhesive 3 option a	Adhesives	moderate	low	moderate	Daycare
no	Sample Adhesive 4 option a	Adhesives	high	low	moderate	Apartment
no	Sample Adhesive 4 option b	Adhesives	moderate	low	moderate	Apartment
yes	Sample Adhesive 4 option c	Adhesives	moderate	low	moderate	Apartment
no	Sample Adhesive 5 option a	Adhesives	low	low	moderate	Apartment
no	Sample Adhesive 5 option b	Adhesives	low	low	low	Apartment
yes	Sample Adhesive 5 option c	Adhesives	high	low	low	Apartment
no	Sample Adhesive 5 option d	Adhesives	high	low	low	Apartment
yes	Sample Adhesive 6 option a	Adhesives	high	low	low	Apartment
no	Sample Adhesive 6 option b	Adhesives	high	low	low	Apartment
no	Sample Adhesive 7 option a	Adhesives	high	low	low	Innovation
yes	Sample Adhesive 7 option b	Adhesives	high	low	low	Innovation
no	Sample Adhesive 7 option c	Adhesives	high	low	low	Innovation
no	Sample Adhesive 7 option d	Adhesives	high	low	low	Innovation
yes	Sample Adhesive 8 option a	Adhesives	high	low	low	Innovation
no	Sample Adhesive 8 option b	Adhesives	low	low	low	Innovation
no	Sample Adhesive 9 option a	Adhesives	low	low	low	Retail
yes	Sample Adhesive 9 option b	Adhesives	moderate	low	low	Retail
yes	Sample Adhesive 10 option a	Adhesives	high	low	low	Retail
no	Sample Adhesive 10 option b	Adhesives	moderate	low	low	Retail

Flexible weightings

The tracking tool links products to the spaces in which they are used and to qualitative estimates of their prevalence within the building, their percentage of the project cost, and the potential that occupants are exposed to them. Weighting factors can be applied to each of these aspects to align with the project goals.

Comparing alternatives

The tool can track and compare different product options for the same product category.

FIGURE B1
Sample of the tracking spreadsheet.

SOURCE

In addition to tracking this information and evaluating criteria within product categories, the tool provides graphical outputs, which provide easily interpreted feedback to the project team. The final output includes charts that show total reduction of specific hazardous chemicals compared to an assumption that all products commonly containing the substances have them. Various graphs display output organized by chemical, space type, and for the project overall, and separated by interior and exterior exposures. The tracking spreadsheet produces a series of graphs like the one below in Figure B2, which collectively compare the prevalence of chemicals of concern in different spaces.

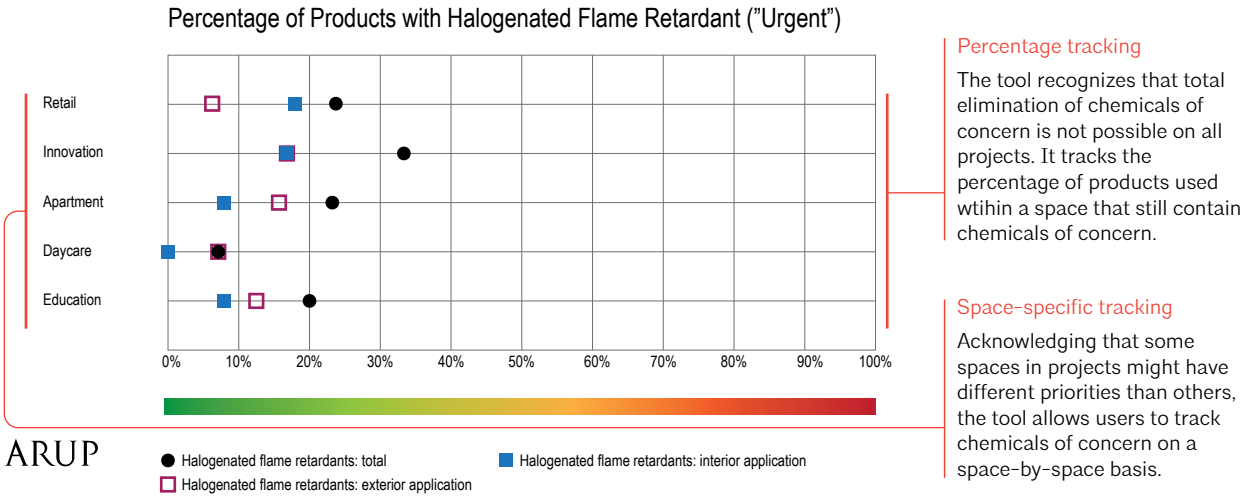

FIGURE B2
An example of a graph output from the tracking spreadsheet.

SOURCE
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Appendix C

Sample HM plans

This section contains three sample HM plans that serve as a starting point for project teams to select and specify healthier materials. They may be helpful as you prepare your own plans, after appropriate consultation with your own advisors, including attorneys and subject matter specialists.

Each plan has a slightly different goal:

- chemical transparency aims to meet product transparency goals specific to the project
- established frameworks aims to meet product transparency and optimization goals based on established frameworks like LEED
- chemical avoidance aims to meet chemical avoidance goals specific to the project

These sample plans also employ different methodologies. The first two plans use the target-setting acceptability tables described in Appendix A, while the third plan uses the tracking matrix described in Appendix B.

PROJECT 1

[PROJECT NAME] HM PLAN: CHEMICAL TRANSPARENCY

1.1 Goal and scope

Goal

The purpose of this HM plan is to gather accurate and comprehensive chemical content information for the building materials used in this project.

The goal is to collect product content and hazard data using established documentation frameworks to increase the amount of material content information in the public domain and to advocate for standardized chemical content reporting from building product manufacturers.

This plan serves as a component of the OPR for the project and can be referenced throughout the design, construction, use, and end-of-life of the building by the building owner and his/her representatives; architects, engineers, and other designers and specifiers; the general contractor, subcontractors, and other builders; and eventually building operators and facility managers.

Scope

This plan shall apply to all products used on the project, with specific criteria assigned to specific portions of work, as outlined in methodology and metrics.

1.2 Criteria for prioritization

Chemical content documentation is most widely available in interior architectural finish and furnishing materials. Because this HM plan aims to promote chemical transparency, the project team has opted to prioritize those product categories for which chemical content data is more limited. More specifically, this prioritizes the collection of documentation for core and shell building materials (CSI divisions 03-08, and 31-33).

1.3 Project targets

Project targets have been set using the Acceptability Table below, which uses several third-party frameworks (e.g., HPD, C2C certificate, etc.) to establish acceptability criteria for different portions of the project. More specifically, this includes existing frameworks that require content disclosure to a minimum of 1,000 ppm. While some of these frameworks produce a product-specific document on which the 1,000 ppm level of disclosure is clearly displayed, other programs meet the disclosure threshold through the standard requirements of their program. Furthermore, since current availability of qualifying products is still limited, the project will accept those with or without third-party verification. Additionally, disclosure to a third-party assessor, in contrast to disclosure to the public, as in the C2C and UL Product Lens programs, is acceptable (see the disclosure and optimization tools section for more detail).

As part of the project targets, the acceptability limits shown in Figure C1 outline the acceptable thresholds for interior and exterior portions of the work separately.

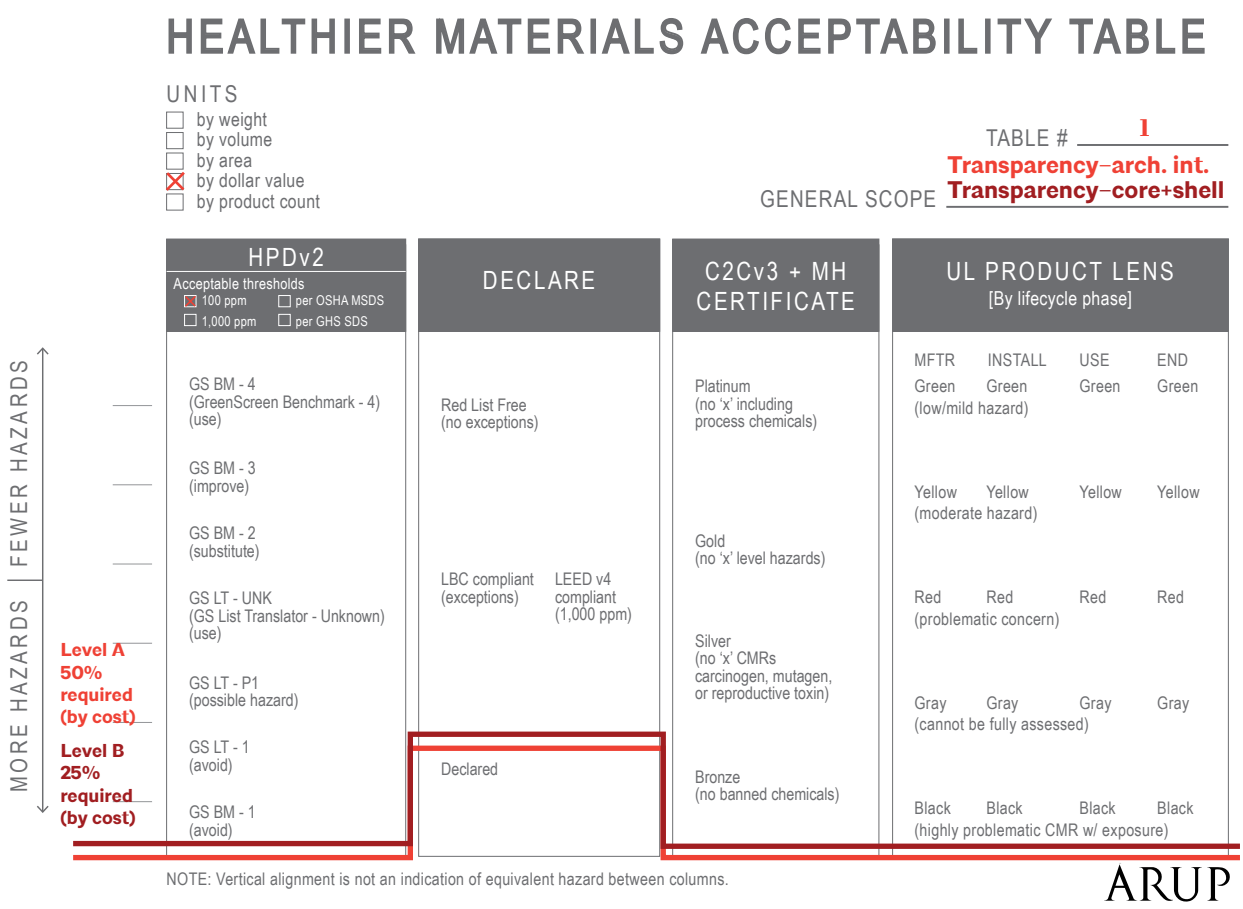


FIGURE C1
The darker line corresponds to interior architectural materials (Divisions 09-10, 12), while the lighter line corresponds to core and shell materials (Divisions 03-08, 31-33).

1.4 Methodology and metrics

For products for which any of these reports has been published, the team can use the Acceptability Table to determine if the product meets the 1,000 ppm chemical disclosure threshold. More specifically:

- **HPD.** The project team should check that HPD document shows reporting to at least 1,000 ppm.
- **Declare.** The project team only needs to check that the Declare label states that the product is either "LBC Compliant" or "Red List Free," as only these two levels ensure disclosure to at least 1,000 ppm.
- **C2C.** Materials must be inventoried to 100 ppm, so a C2C certificate automatically qualifies the product.
- **UL Product Lens.** Materials must be inventoried to 100 ppm, so a UL Product Lens certificate automatically qualifies the product.

The following provisions are established for the many products that do not currently have compliant documents available:

A. A.In the event that a product does not currently have compliant documentation, a project team member should contact the manufacturer of that product and encourage their engagement with one or more compliant programs (sample phone scripts and letters are available in Appendix F).

B. Products for which a published report cannot be obtained should not be used. However, manufacturers' claims outside of a public reporting format (e.g., an email or letter claiming that the product meets the criteria in this plan) may be accepted on a case-by-case basis depending on the role of the product, available alternatives, and other factors. These decisions shall be made by the owner or architect, with the owner having the final say in case of disagreement.

C. Products used in quantities below 1 lb (0.5 kg) of solid material or 16 ounces (500 mL) of liquid may use a Safety Data Sheet (SDS) formatted according to the Globally Harmonized System to screen hazard content. Material Safety Data Sheets (MSDS), which do not meet Globally Harmonized System formatting requirements, should not be used.

1.5 Roles and responsibilities

Owner

The owner is responsible for either generating or requesting the creation of this Plan, for communicating project priorities to the design team, and for accepting the Plan. Their contribution may include helping the design team set priorities or coordinate goals from end users. The owner shall approve the goals and sensitivities described in this Plan.

Materials Specifiers

Architects and other designers whose role includes specifying materials and products that will be installed on the project (e.g., civil and structural engineers, interior designers, etc.) are responsible for selecting materials that meet the project standards. Their responsibilities include:

- **Research.** Looking for or requesting product information from manufacturers that provides the necessary information about product content to the level of detail necessary to meet the project's disclosure targets.
- **Materials selection.** When particular products are listed by name or manufacturer in the specifications, choosing products that meet the HM goals.
- **Specification.** Including the HM requirements from sections 1.3 and 1.4 in product specifications.
- **Tracking.** Providing a tracking tool for reporting on progress towards meeting the HM goals during design phases of the project, in partnership with the builders per section 1.6.
- **Submittal review.** Reviewing contractor submittals for compliance with the project HM goals.
- **Building materials manual.** Collaborating with the construction team to develop a manual that documents any product selections that may need special maintenance, cleaning, care, repair, or replacement by a party on the owner- or design-side.
- **Training.** Providing a review and explanation of product selections using the Building Materials Manual to a party on the operations-side, per section 1.7.
- **Final report.** Compiling a final materials tracking report for the owner. This report may also include the building materials manual.

Builders

The general contractor, subcontractors, and other project participants who purchase materials and products for the project are responsible for following the guidance of the project specifications. However, these participants should also be aware of the project's HM goals and participate in helping to meet the goals, particularly in cases where they might otherwise be missed. Currently, teams most frequently overlook accessory products, such as sealants, or products that are specified based on performance, such as firestopping and insulation.

Specifically, builders' responsibilities include:

- **Tracking.** Working with the specifiers to develop and agree to a tracking tool for reporting progress towards meeting the HM goals.
- **Procurement.** Ensure that the products purchased and used on the project are as specified.
- **Submittals.** Tracking progress towards meeting the HM goals (and any exceptions) as described below:
  - » Do not forward substitution requests for products that do not meet the HM goals. (When no acceptable substitute can be found, non-compliant substitutions may be proposed, but the issue must be flagged for review).
  - » Train subcontractors not to bring accessory materials (i.e., materials that may not have been specifically identified in specifications, such as incidental adhesives, sealants, or touch-up paints) to the project that do not meet HM goals. Even de minimis uses should meet the HM goals unless no acceptable alternative can be found. In the case that no alternative is available, the use of the non-compliant product should be documented, as detailed in the Tracking section.

- Collaborating with the design team to develop a **building materials manual** that documents any product selections that may need special maintenance, cleaning, care, repair, or replacement by a party on the owner- or design-side and reviewing this building materials manual by a party on the operations-side.
- **Operations and maintenance documentation and training** should include two sections: (1) instructions to facilities maintenance for any materials requiring special maintenance and (2) instructions to purchasers listing those products that should be replaced with compliant materials. Training should involve installers and/or manufacturers as necessary to review warranty and care procedures with the operations and maintenance team.

Builders should note that meeting the project's HM goals is also intended to help protect the health of construction workers on the job site and those producing construction materials. Contractors should help educate their subcontractors on this note.

Building Operators

At the end of the project, the building operators or facility managers will receive information and training from the material specifiers and builders about many aspects of operating and maintaining the building, including the HM plan. It is the responsibility of the operator to maintain the integrity of the HM environment in the use phase. This specifically includes:

Completion. When receiving the building materials manual, reviewing and clarifying any questions with the specifiers and/or builders before they leave the project.

- **Purchasing.** For products that met HM criteria, continuing to purchase and use only materials that meet the HM criteria for renovations, repainting, and other maintenance and repairs. They should also periodically review the availability of other product categories to also meet the HM criteria.
- **Maintenance.** Being aware of and respecting the maintenance requirements of the HM used on the project, as detailed in the building materials manual.

1.6 Tracking and documentation

Compliance tracking

The project team shall maintain an HM tracking chart that identifies, by MasterFormat Code, the materials to be used on the project and the report/certification that meets the criteria in the Acceptability Tables, or an explanation for why a non-compliant product was selected. Within each MasterFormat code, all products and accessory materials being considered shall be separately identified and reviewed for plan compliance.

At each design milestone (100 percent schematic design, 100 percent design development, and 100 percent construction documents) the design team shall provide the owner with a report on compliance with this plan and updated Tracking Chart. The report should identify:

- percentage of specified products that successfully meet the goals
- any significant departures from plan requirements that cannot be avoided
- reasons for any departures from the requirements

At quarterly (or monthly) intervals during the construction process, the contractor shall provide the owner with a report on compliance with this plan and updated Tracking Chart. The report should identify:

- percentage of reviewed submittals that successfully meet the goals
- percentage of purchased products that successfully meet the goals
- any significant departures from plan goals that cannot be avoided
- reasons for any departures from the plan

Upon the completion of the project, the contractor shall provide the owner a final report on the materials used in the project as part of the building materials manual.

Substitution procedures

Because HM information is new to the construction industry and can be difficult to obtain within a short time frame, specifiers should check that the substitution procedures in the General Conditions (Division 01) are practical for all project participants to adhere to. In the event that a submittal is delayed or rejected solely due to difficulty of compliance with HM criteria, the owner, with the advice of the specifiers, may grant a waiver for use of a non-compliant product through the submittal review process. That waiver should be tracked in the HM Selection Tracking Chart.

Additional verification on site

If materials are found that are not in compliance or where additional data indicates a failure to match the project's HM goals, the products shall be removed from the

completed work and replaced with compliant products. At the owner's option, the materials may be left in place, and the builder shall record changes to the HM Selection Tracking Chart and building materials manual. The owner may choose to conduct periodic spot checks of construction materials present on site to verify that they match product specifications (or hire a special inspector for this purpose).

FINAL REPORT

At the end of the construction process (i.e., substantial completion or final completion), all participants should attend a meeting to review the draft building materials manual prior to its handover to the owner and operator.The agenda should include a review of lessons learned in the design and construction process, such as code restrictions on certain materials, lead times, product performance, and cost. Materials maintenance requirements should also be reviewed.

1.7 Building materials manual for operations and maintenance

At the conclusion of the project, the design and construction team will deliver a building materials manual to the owner for use by the building operators. This may be part of a larger building manual that describes operations and maintenance requirements. The manual should include:

A. A final version of the HM Selection Chart, indicating the materials used, manufacturers, distributors, product names, types, colors, and other properties needed to re-order the same product. Each product's certification as a verified HM (or status as an exception) should also be included.

B. A list of any materials with special maintenance needs or concerns (e.g., do not get wet, clean with a specific type of product, etc.)

C. An inventory of any replacement materials stored at the end of construction (e.g., additional carpet tiles, furniture pieces, etc.)

PROJECT 2

[PROJECT NAME] HM PLAN: ESTABLISHED FRAMEWORKS

2.1 Goal and scope

Goal

The purpose of this Healthier Materials (HM) plan is to limit harm to human and environmental health from the production, fabrication, installation, use, maintenance, and eventual disposal of the building materials used in this project.

The goal is to eliminate or reduce the presence of very dangerous substances within building materials, whether or not there is a known exposure path for building occupants.

This plan serves as a component of the Owner's Performance Requirements for the project and can be referenced throughout the design, construction, use, and end-of-life of the building by the building owner and his/her representatives; architects, engineers and other designers and specifiers; the general contractor, subcontractors, and other builders; and building operators or facility managers.

Caveat: This plan recognizes that most, if not all, building materials cause some level of human health and/or ecosystem impact. It also recognizes that risks can be minimized, but not all risks can be eliminated, and that there is a significant amount of unknown information about the long-term effects of the various substances used as bulk, minor, or trace components of building products. Users of this plan must accept that some level of risk is inherent in the activities of manufacturing products and constructing, occupying, altering, and demolishing buildings; and that the state of knowledge of these risks is incomplete and constantly changing. Reasonable judgment in light of currently available information is essential in use of this plan.

Scope

This plan shall apply to all products used on the project, with specific criteria assigned to specific portions of work.

2.2 Criteria for prioritization

Broadly, the elimination of hazardous chemicals shall be prioritized based on the expected frequency, intensity, and duration of exposure to the occupant. In practice, this prioritizes high-touch materials in areas occupied by the greatest number of people for the greatest length of time (both per day and over the years). Other exposures shall also be considered, including those to workers who manufacture building products, construction workers who install products, and workers processing materials during demolition and disposal.

2.3 Project targets

Project targets have been set using the Acceptability Tables below, which align with targets from established third-party frameworks, such as LEED (see "established frameworks from rating systems" for more details). Each acceptability table corresponds to a different portion of work. This approach allows more stringent criteria to be defined for higher priority product categories. Each portion of work listed below has been assigned a different acceptability table.

Portion of work	Acceptability Table
Exterior and structural materials Divisions 03-08, 31-33	1
Interior architectural materials except in daycare center Divisions 09-12	2
Interior architectural materials in daycare center Divisions 09-10, 12	3
Interior mechanical, electrical, plumbing, fire protection, communications, and other equipment Divisions 11, 13-29	4

TABLE C1

A list of what Acceptability Table to use for specific portions of work on a hypothetical project.

The corresponding acceptability tables shown below outline the acceptable thresholds for each of these four portions of the work.

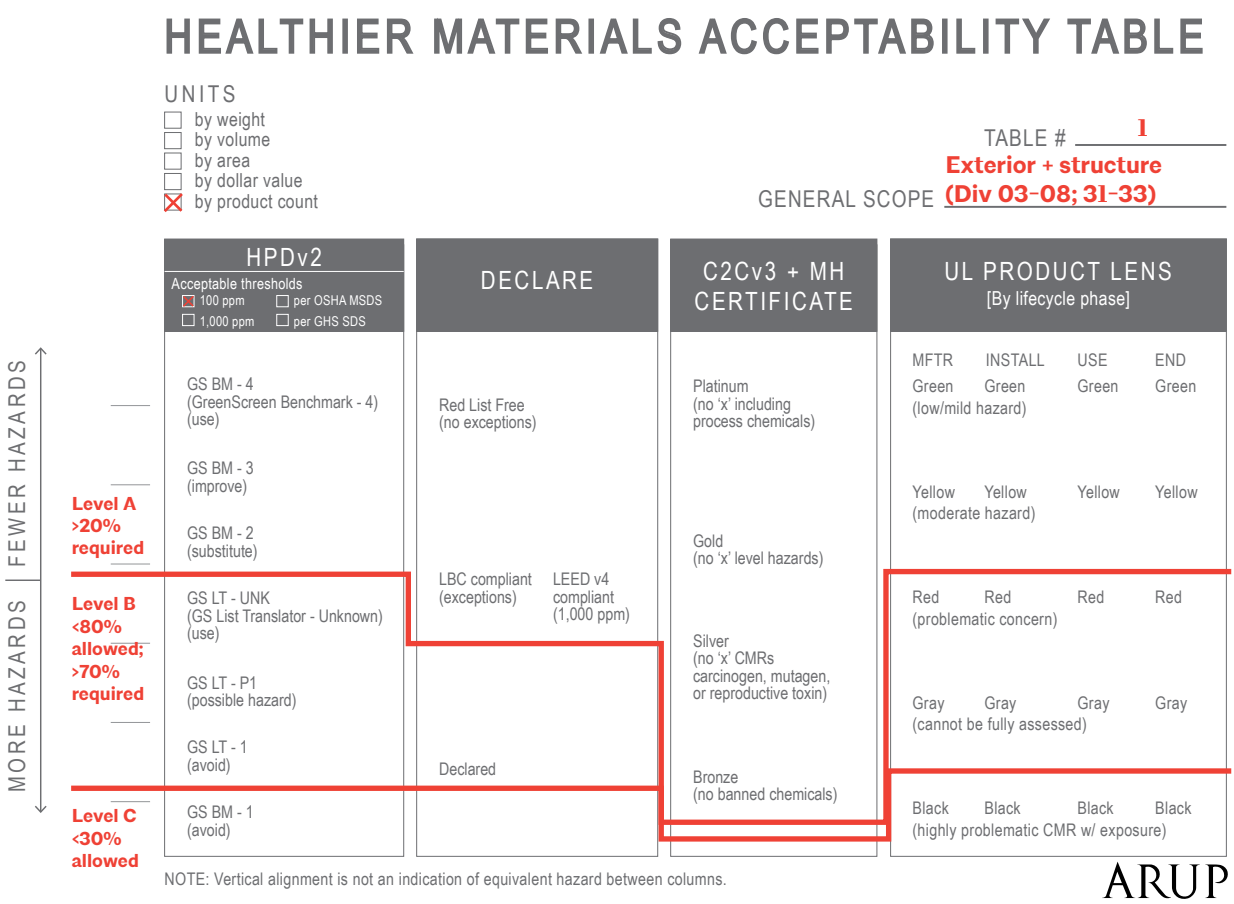


FIGURE C2
Sample Acceptability Table for exterior and structure materials.

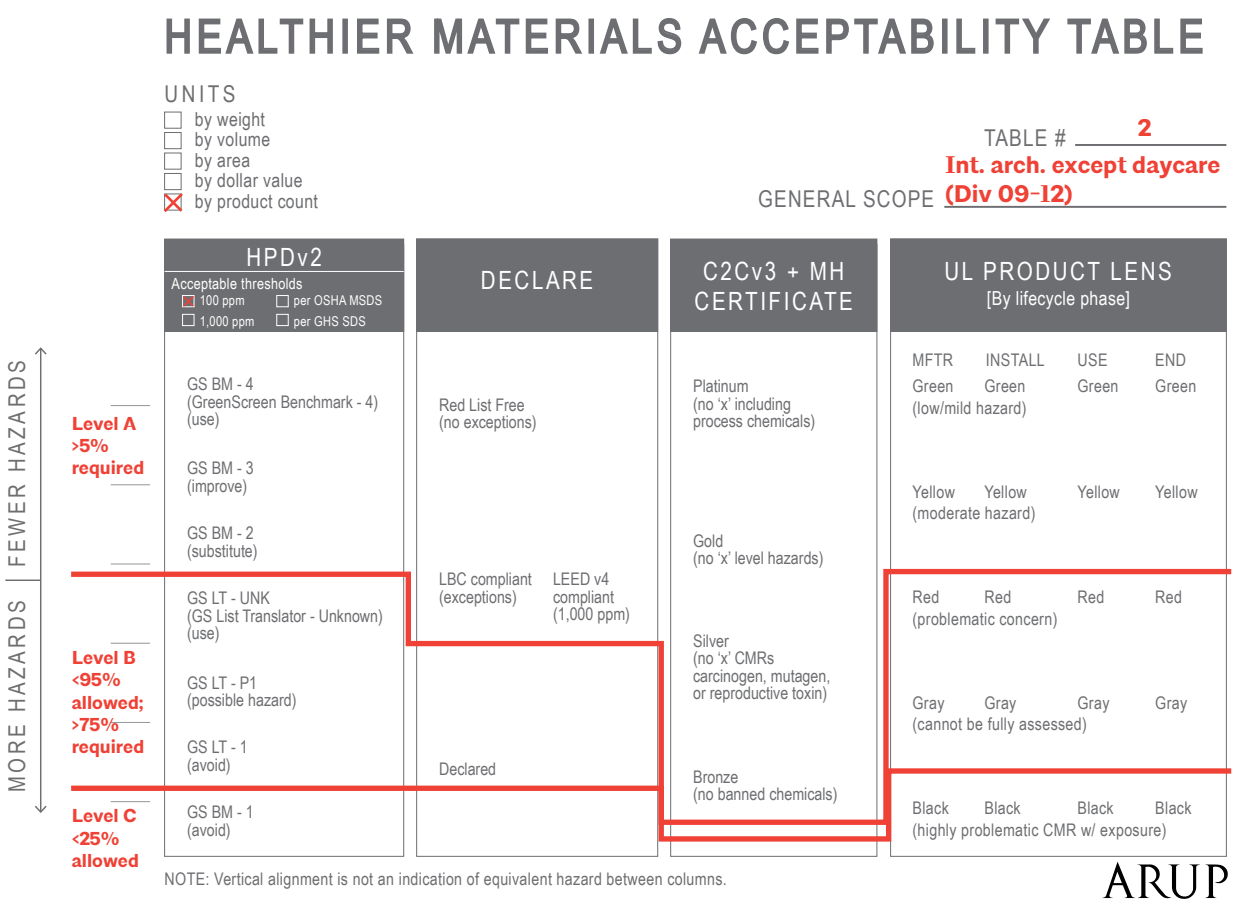


FIGURE C3
Sample Acceptability Table for interior architectural materials, except in daycare center.

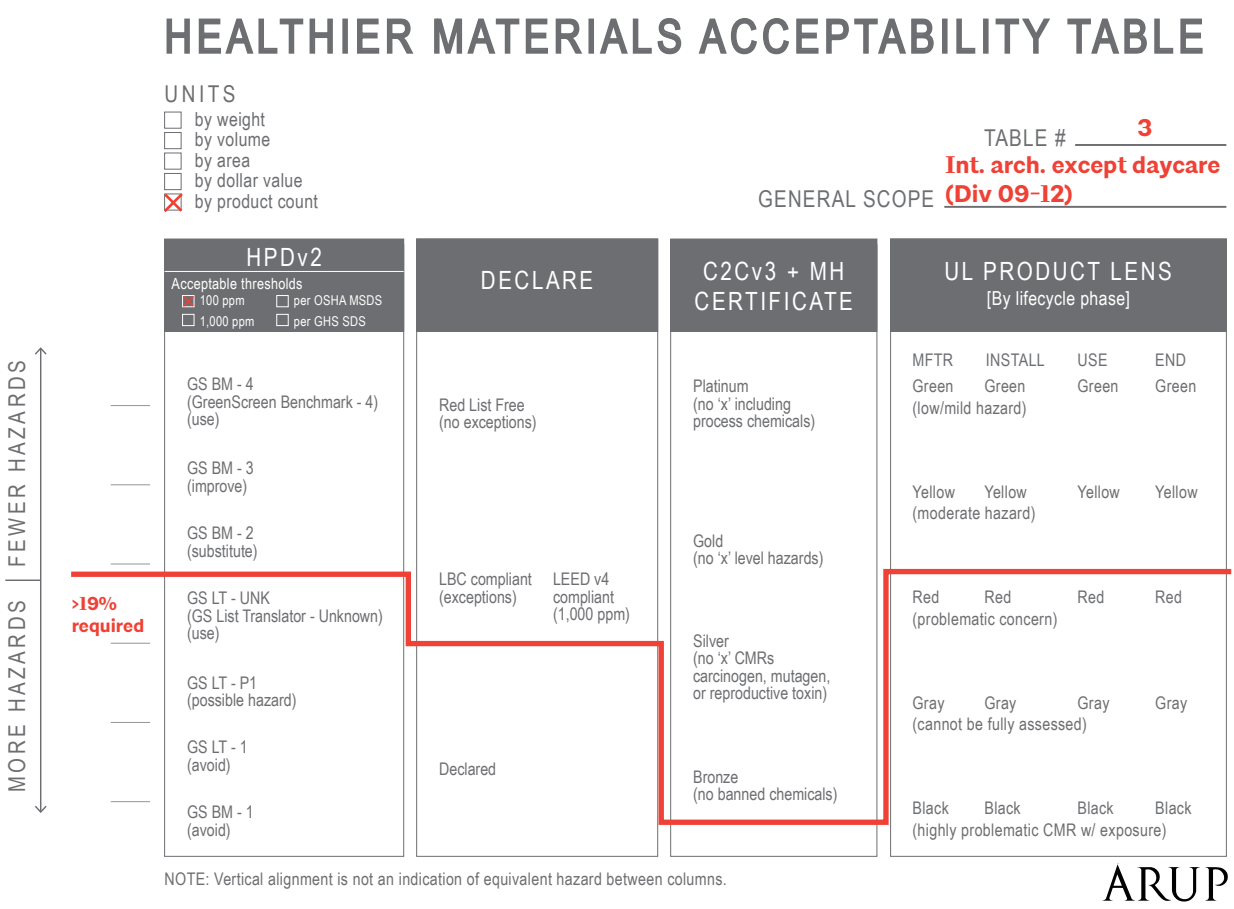


FIGURE C4
Sample Acceptability Table for interior architectural materials in a daycare center.

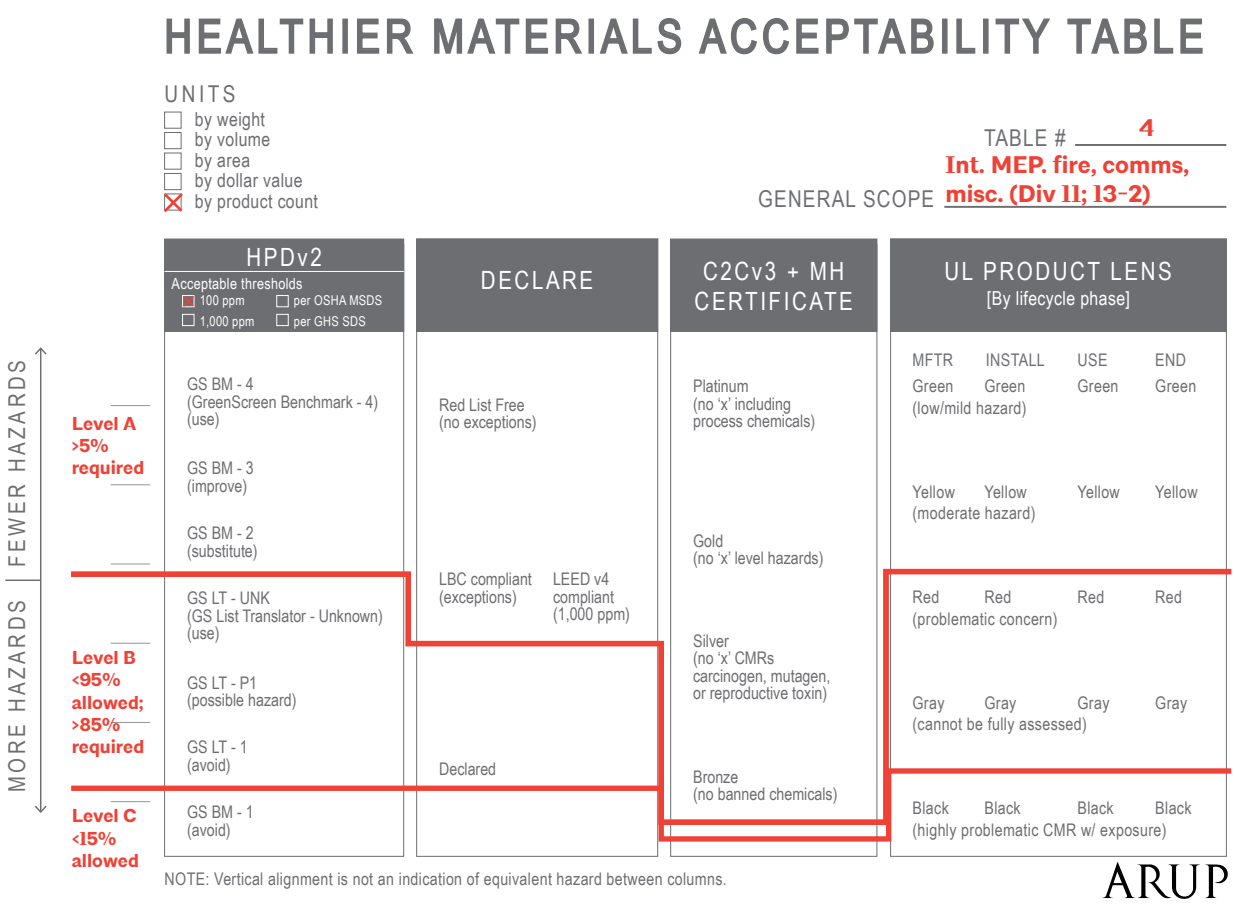


FIGURE C5
Sample Acceptability Table for interior mechanical, electrical, plumbing, fire protection, communications, and other equipment.

2.4 Methodology and metrics

For products that have been included in any of these reports, the team can use the Acceptability Table to determine if the product meets the targets. More specifically:

- **HPD.** The project team should check that HPD document shows reporting to at least 100 ppm and meets the established GreenScreen benchmark targets for the given portion of work (e.g., GreenScreen Benchmark 2 or better for the interior finishes in the daycare space).
- **Declare.** Under the Declare program, the team must confirm that the product achieves the target specified for the given portion of work.
- **C2C.** Any product with a C2C certification or Material Health Certificate meets the targets for this project.
- **UL Product Lens.** The team must confirm that the product achieves the target specified for the given portion of work.

The following provisions are established for the many products that do not currently have compliant documents available:

- A project team member should contact the manufacturer of that product and encourage their engagement with one or more compliant programs (sample phone scripts and letters are available in Appendix F).
- Products for which a published report cannot be obtained should not be used. However, manufacturers' claims outside of a public reporting format (e.g., an email or letter claiming that the product meets the criteria in this plan) may be accepted on a case-by-case basis depending on the role of the product, available alternatives, and other factors. These decisions shall be made by the owner or architect, with the owner having the final say in case of disagreement.
- Products used in quantities below 1 lb (0.5 kg) of solid material or 16 ounces (500 mL) of liquid may use a Safety Data Sheet (SDS) formatted according to the Globally Harmonized System to screen hazard content. Material Safety Data Sheets (MSDS), which do not meet Globally Harmonized System formatting requirements, should not be used.

2.5 Roles and responsibilities

Refer to Section 1.5.

2.6 Tracking and documentation

Refer to Section 1.6.

2.7 Building materials manual for operations and maintenance

Refer to Section 1.7.

PROJECT 3

[PROJECT NAME] HM PLAN: CHEMICAL AVOIDANCE

3.1 Goal and scope

Goal

The purpose of this Healthier Materials (HM) Plan is to limit potential health impacts to building occupants by reducing toxic substances typically found in common building products, as well as to limit harm to human and environmental health from the production, fabrication, installation, use, maintenance, and eventual disposal of the building materials used in this project.

The goal is to eliminate or reduce the presence of very dangerous substances within building materials, particularly products to which occupants are frequently directly exposed and on products used in areas serving occupants who tend to be more vulnerable to the associated health risks.

This plan serves as a component of the Owner's Performance Requirements for the project and can be referenced throughout the design, construction, use, and end-of-life of the building by the building owner and his/her representatives; architects, engineers and other designers and specifiers; the general contractor, subcontractors, and other builders; and eventually building operators and facility managers.

Caveat: This plan recognizes that most, if not all, building materials cause some level of human health and/or ecosystem impact. It also recognizes that while risks can be minimized, not all risks can be eliminated, and that there is a significant amount of unknown information about the long-term effects of the various substances used as bulk, minor, or trace components of building products. Users of this plan must accept that some level of risk is inherent in the activities of manufacturing products and constructing, occupying, altering, and demolishing buildings, and that the state of knowledge of these risks is incomplete and constantly changing. Reasonable judgment in light of currently available information is essential to use of this plan.

Scope

This plan shall apply to all Construction Specification Institute (CSI) Divisions 3-12, plus select portions of other CSI divisions that are known to contain problematic substances for which alternatives are available. At a minimum, it shall include the following categories of building materials

- Paints
- Epoxy & Resins
- Sealants
- Insulation
- Adhesives
- Roofing
- Carpets and backing
- Polycarbonate plastics
- Resilient flooring
- Waterproofing
- Flooring and backing
- Siding
- Furniture
- Doors and windows
- Textiles and upholstery
- Conduits
- Window treatments
- Piping
- Composite wood products
- Wire and cable sheathing
- Wood treatment
- Electrical devices
- Protective coatings
- Refrigerants

3.2 Criteria for prioritization

Prioritization is necessary due to cost targets. The project team should more heavily weigh products with which occupants are most frequently in contact, product types that are prevalent throughout the building, and products that represent the highest anticipated percentage of the construction cost. These prioritization criteria translate into a weighting system for the project team to rate product alternates on a low/medium/high scale in the areas of contact, prevalence, and cost.

These product alternates will also be tracked according to the space in which they will be used. Areas serving occupants who tend to be more vulnerable, like daycare centers, can be tracked separately (and more stringently) from the other spaces.

This scoring system calls attention to the product types that carry the highest weighting factors. Cost premiums should be recorded during product research so that benefit-to-cost information can be presented to the owner if decisions need to be made about products because of other trade-offs, such as performance or schedule impacts.

3.3 Project targets

The project aims to add less than a 1 percent of overall construction cost premium to eliminate hazardous substances from at least 90 percent of the weighted volume of products in the daycare space and 75 percent of the weighted volume of products in all other spaces.

3.4 Methodology and metrics

Methodology

The methodology is based on the avoidance of specific chemicals of concern. The project will track the following substances by the level of concern listed below. The list is derived from an analysis of commonalities among building industry chemical avoidance lists and of hazard classifications from the Pharos Chemical and Material Library.

Level of concern	Chemical substances
"Urgent"	arsenic, cadmium, halogenated flame retardants, lead, mercury, PFCs
"High"	BPA, creosote, hexavalent chromium, formaldehyde
"Moderate"	phthalates, PVC and chlorinated plastics, VOCs

The project will assume that these chemicals are used in the following product categories unless documentation demonstrates otherwise:

Paints	cadmium, BPA, VOCs
Sealants	BPA, formaldehyde, phthalates, VOCs
Adhesives	formaldehyde, phthalates, VOCs
Carpets and backing	formaldehyde, phthalates, VOCs
Resilient flooring	formaldehyde, phthalates, PVC, VOCs
Flooring and backing	PFCs, formaldehyde, phthalates, PVC, VOCs
Furniture	PFCs, formaldehyde, phthalates, PVC, VOCs
Textiles and upholstery	PFCs, VOCs
Window treatments	PFCs, VOCs
Composite wood products	formaldehyde
Wood treatment	arsenic, creosote
Protective coatings	PFCs, BPA, hexavalent chromium, VOCs
Epoxy and resins	BPA, formaldehyde, VOCs
Insulation	halogenated flame retardants, formaldehyde, VOCs
Roofing	PFCs, phthalates, PVC
Polycarbonate plastics	BPA
Waterproofing	phthalates, PVC, VOCs
Paints	cadmium, BPA, VOCs
Siding	arsenic, creosote, PVC
Doors and windows	lead, hexavalent chromium, PVC
Conduits	hexavalent chromium, PVC
Piping	lead, hexavalent chromium, PVC
Wire and cable sheathing	halogenated flame retardants, PVC
Electrical devices	halogenated flame retardants, lead, mercury
Refrigerants	CFC/HCFCs

The following disclosure and optimization tools will be used to determine if a given product includes these substances:

- **HPD.** The project will use products when HPD discloses contents to 1,000 ppm or below.
- **Declare.** The project will use when substances are disclosed to 10,000ppm (99%).
- **GreenScreen Full Assessment.** The project will use the results of any published GreenScreen Full Assessment of the product.
- **C2C product certifications or the C2C Material Health Certificate.** The project will use products that have attained Bronze level or higher under the Material Health category, which requires the elimination of the above substances, as shown through an inventory of materials to 100ppm (because the substances included on the list above are also on the C2C Banned List).
- **UL Product Lens.** The project will use a product when the Product Lens materials health assessment shows only low (green) or moderate (yellow) hazard identified. High hazard (red) is only acceptable in supply chain/ manufacturing, installation, and end of use life cycle stages.

For products for which any one of these reports has been published, the team can clearly determine whether or not the product is acceptable. Not all products, however, currently have these documents readily available. In these cases, the following provisions are established for the many products that do not currently have compliant documents available:

- A project team member should contact the manufacturer of that product and encourage their engagement with one or more compliant programs (sample phone scripts and letters are available in Appendix F).

- Products for which a published report cannot be obtained should not be used. However, manufacturers' claims outside of a public reporting format (e.g. an email or letter claiming that the product meets the criteria in this plan) may be accepted on a case-by-case basis depending on the role of the product, available alternatives, and other factors. These decisions shall be made by the owner or architect, with the owner having the final say in case of disagreement.
- Products used in quantities below 1 lb (0.5 kg) of solid material or 16 ounces (500 mL) of liquid may use a Safety Data Sheet (SDS) formatted according to the Globally Harmonized System to screen hazard content. Material Safety Data Sheets (MSDS), which do not meet Globally Harmonized System formatting requirements, should not be used.

Metrics

Measurement for tracking will use a binary system where the substance is either assumed to be in the product or proven to be eliminated from the product. Results will be rolled up into a total amount using a weighted sum. Product counts will be weighted based on exposure, cost, and prevalence of the material in the building. These will first be set at low, medium and high levels by the project team during vetting and selection of materials. Once cost and prevalence information is better known for all tracked products, these estimates will be changed to actual dollar values and volume/area, respectively.

3.5 Roles and responsibilities

Refer to Section 1.5.

3.6 Tracking and documentation

Refer to Section 1.6.

3.7 Building materials manual for operations and maintenance

Refer to Section 1.7.

Appendix D

Sample specification clauses

Sample Division 01 specifications

Sample Division 01 specifications for compliance with the LEEDv4 Building Product Disclosure and Optimization - Material Ingredients and Low-Emitting Materials credits are not covered here but should be provided to support the specification language provided in this section.

Sample Division 3+ specifications

To maintain consistency, the same clauses will ideally be used to place requirements for meeting LEED credits (or other goals) related to materials transparency, substance avoidance, and/or air emissions throughout all the Div 03+ specification sections. However, the same clauses can not simply be inserted into all specifications: for instance, air emissions limits in LEEDv4 apply only to products used inside the building waterproofing membrane, while HM goals may vary based on likelihood of exposure, marketplace availability, or other owner concerns.

Drawing on the case study of SFO Terminal 1, the specification chart approach is a way to identify which LEED credits or HM criteria apply to each specification section. In addition, requirements may be more or less stringent within each section. For instance, architects working on SFO chose to request materials ingredient disclosure in virtually all specification sections (marked "p" for preferred in the chart), but only to require it (marked "m" for mandatory in the chart) where the project team could identify a minimum of three manufacturers who could comply with the requirement.

The table of specification clauses then guided the specifications writers on the project to include the appropriate language for the "p" or "m" mark by each credit. Depending on the LEED credit, clauses are added to the Part I submittal requirements or to both Part I and Part II product requirements of relevant specification sections. For instance, material ingredient disclosure is purely a submittal issue, but low-emitting products must not only have the appropriate materials documentation but are also specified to meet the emissions limits as a product requirement.

The examples in Figure D1 and D2 illustrate how the specification matrix and table of clauses can be used to meet LEEDv4 credit MRc4, option 1 - Building Product Disclosure and Optimization - Material Ingredients, and credit IEQc2 - Low Emitting Materials.

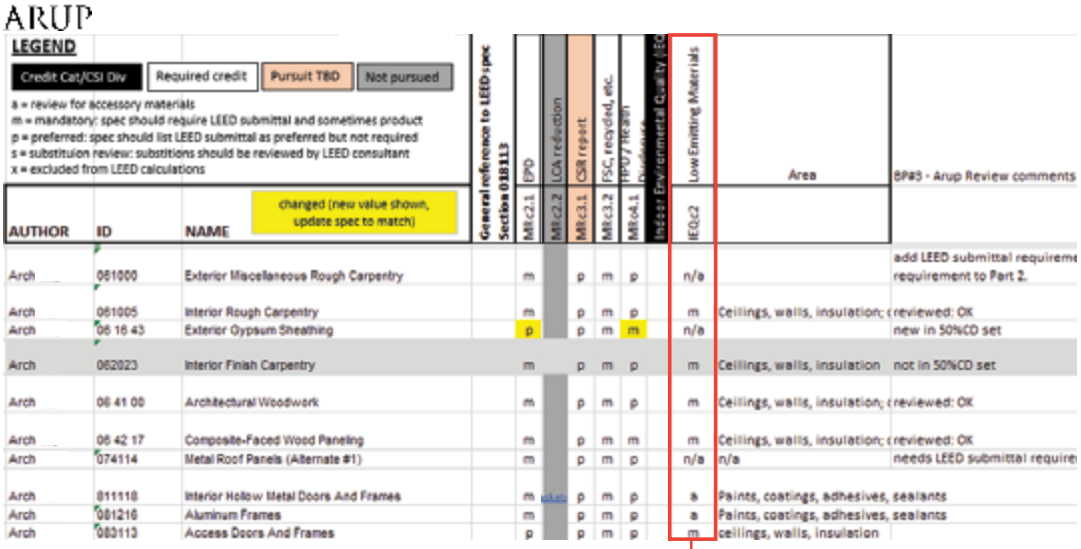
Tracking preferred + mandatory spec language

The specification matrix above tracks compliant products for the project. Where 3+ compliant products have been identified, mandatory ("m") spec language is used; otherwise, the preferred "p" spec clause is used in the submittal requirements of that section. Spec language for both cases is given in the table below.

LEED CREDIT	REQ'D/ PREFRD	TEXT FOR PART 1 - SUBMITTAL REQUIREMENTS	TEXT FOR PART 2 - PRODUCT REQUIREMENTS
MRc4.1	m	MRc4.1: Material Ingredient Inventories: A material ingredient inventory is required; submit a Health Product Declaration (HPD), Cradle2Cradle (C2C) certificate at Bronze level or above, C2C Material Health Certificate, Declare product label, or other acceptable material ingredient inventory in accordance with 01 81 13, LEED Submittals.	none
MRc4.1	p	MRc4.1, Material Ingredient Inventories: A material ingredient inventory is preferred; if available, submit a Health Product Declaration (HPD), Cradle2Cradle (C2C) certificate, Declare product label, or other acceptable material ingredient inventory in accordance with 01 81 13, LEED Submittals.	none
MRc4.2	p	MRc4.2, Material Ingredient Optimization: If available, provide a Cradle2Cradle (C2C) certificate at Silver level or above, or documentation (e.g. HPD, Declare label, etc.) that product contains no Benchmark 1 hazards above the 100 ppm level using GreenScreen List Translator or a full GreenScreen Assessment, in accordance with 01 81 13, LEED Submittals.	none

LEED CREDIT	REQ'D/ PREFRD	TEXT FOR PART 1 - SUBMITTAL REQUIREMENTS	TEXT FOR PART 2 - PRODUCT REQUIREMENTS
IEQc2 – Paints, Coatings	m	IEQc2, Interior Paints and Coatings: For products applied wet on site inside of the waterproofing membrane, submit air emissions testing reports documenting compliance with California Dept. of Public Health (CDPH) standards in accordance with 01 81 13, LEED Submittals. Submit documentation that product meets applicable VOC limits of the CARB SCM for Architectural Coatings or SCAQMD Rule 1113 in accordance with 01 81 13, LEED Submittals.	IEQc2, Interior Paints and Coatings: Products applied wet on site, inside of the waterproofing membrane, shall not emit more than the allowable concentrations of VOCs when tested in accordance with the CDPH Standard Method v1.1-2010. Products applied wet on site, inside of the waterproofing membrane, shall not contain more than the allowable concentrations listed in CARB SCM for Architectural Coatings 2007 or SCAQMD Rule 1113, June 3, 2011.

FIGURE D1
Specification matrix and table of clauses can be used to meet LEEDv4 credit MRc4, option 1 – Building Product Disclosure and Optimization – Material Ingredients.



ARUP

LEGEND

Credit Cat/CSI Div	Required credit	Pursuit TBD	Not pursued

a = review for accessory materials
m = mandatory: spec should require LEED submittal and sometimes product
p = preferred: spec should list LEED submittal as preferred but not required
s = substitution review: substitions should be reviewed by LEED consultant
x = excluded from LEED calculations

AUTHOR	ID	NAME (changed (new value shown, update spec to match))	General reference to LEED spec Section 018113	MRc2.1 EPD	MRc2.2 LCA reduction	MRc3.1 CSR report	MRc3.2 FSC, recycled, etc.	MRc4.1 HPD / Health Product Declaration	Indoor Environmental Quality (EQ)	IEQc2 Low Emitting Materials	Area	BP#3 - Arup Review comments
Arch	061000	Exterior Miscellaneous Rough Carpentry		m		p	m	p		n/a		add LEED submittal requirem requirement to Part 2.
Arch	061005	Interior Rough Carpentry		m		p	m	p		m	Ceilings, walls, insulation;	reviewed: OK
Arch	06 16 43	Exterior Gypsum Sheathing		p		p	m	m		n/a		new in 50%CD set
Arch	062023	Interior Finish Carpentry		m		p	m	p		m	Ceilings, walls, insulation	not in 50%CD set
Arch	06 41 00	Architectural Woodwork		m		p	m	p		m	Ceilings, walls, insulation;	reviewed: OK
Arch	06 42 17	Composite-Faced Wood Paneling		m		p	m	m		m	Ceilings, walls, insulation;	reviewed: OK
Arch	074114	Metal Roof Panels (Alternate #1)		m		p	m	p		n/a	n/a	needs LEED submittal require
Arch	081110	Interior Hollow Metal Doors And Frames		m		p	m	p		a	Paints, coatings, adhesives, sealants	
Arch	081216	Aluminum Frames		m		p	m	p		a	Paints, coatings, adhesives, sealants	
Arch	083113	Access Doors And Frames		p		p	m	p		m	ceilings, walls, insulation	

Tracking applicable materials for Low-Emitting Materials Credit

The specification matrix above tracks applicable materials for the Low Emitting Materials Credit. All applicable materials are assigned the same mandatory specification language. In contrast to the MRc4 specification language, no "preferred" language was created for these materials.

LEED CREDIT	REQ'D/ PREFRD	TEXT FOR PART 1 - SUBMITTAL REQUIREMENTS	TEXT FOR PART 2 - PRODUCT REQUIREMENTS
IEQc2-Paints, Coatings	m	IEQc2, Interior Paints and Coatings: For products applied wet on site inside of the waterproofing membrane, submit air emissions testing reports documenting compliance with California Dept of Public Health (CDPH) standards in accordance with 01 81 13, LEED Submittals Submit documentation that product meets applicable VOC limits of the CARB SCM for Architectural Coatings or SCAQMD Rule 1113 in accordance with 01 81 13, LEED Submittals.	IEQc2, Interior Paints and Coatings: Products applied wet on site, inside of the waterproofing membrane, shall not emit more than the allowable concentrations of VOCs when tested in accordance with the CDPH Standard Method v1.1-2010. Products applied wet on site, inside of the waterproofing membrane, shall not contain more than the allowable concentrations listed in CARB SCM for Architectural Coatings 2007 or SCAQMD Rule 1113, June 3, 2011.

FIGURE D2
Specification matrix and table of clauses can be used to meet LEEDv4 credit IEQc2 – Low Emitting Materials.

Other Resources for Sample Specifications

Sample specification language for Living Building Challenge projects is available on the ILFI website. Sample specifications for carpet and furniture developed in conjunction with GSPI can be found on the Center for Environmental Health website. Specification tools for sustainable purchasing, including ecolabels that address human health, are also on the federal General Services Administration website.

Appendix E

Substances of concern by functional class

The GSPI has identified six chemical classes of concern (known as the Six Classes) that contain many of the harmful chemicals found in everyday products, including building materials. The GSPI framework is unique in that it groups chemicals based on their molecular structure and/or functional uses. This function-driven approach is similar to how designers think about materials, and therefore a more relatable resource for further information. In identifying these groups, GSPI hopes to raise questions about whether these chemicals are needed at all and, if so, how they can be replaced with safer alternatives. Each class is described briefly below, summarized directly from GSPI's website.[64]

Highly Fluorinated Chemicals (HFCs)

In the built environment, HFCs are often used in finish products like carpeting to provide stain- and water-resistance. Because these chemicals are inert to most natural chemical degradation processes, they do not break down and accumulate in the environment. In fact, these chemicals have been detected in humans and biota globally. In humans, they have been associated with kidney and testicular cancer, thyroid disease, decreased fertility, elevated cholesterol, and changes in hormone function. These chemicals have become the norm in many finish products, where stain- and water-repellency has become the conventional expectation. The big question is: is it essential in this context, and is it worth the potential for harm?

Antimicrobials

Antimicrobial chemicals are frequently used in the built environment in products such as countertops, paints, and furniture to prevent microbial growth. These compounds, which can be ingested through the skin, have been detected in most Americans. In humans, they can disrupt hormone functioning, and may cause adverse reproductive and developmental effects, and increased allergen sensitivities. Additionally, they are prevalent in the environment, which raises concerns about their potential impacts on aquatic systems. Further, there are concerns that the excessive and unnecessary application of antimicrobials promotes the growth of resistant bacteria.

Flame retardants

Flame retardants are ubiquitous in the built environment. They can be found in furniture, insulation, and electronics, among many other product types. They have been detected in most Americans, with the highest levels found in children. Research has revealed associations with lower IQ and hyperactivity in children, and hormone disruption, decreased fertility, and cancer in adults. Simultaneously, additional research has shown that as currently used in furniture and building insulation, these chemicals do not improve fire safety. GSPI and BuildingGreen have compiled a summary of known alternatives to flame retardant-containing insulation products.[65]

Bisphenols and phthalates

Bisphenols and phthalates are found in plastics and pesticides, among other products. In the built environment, Bisphenol A (BPA) is a component of epoxy resins, which are found in high performance coatings and fluid-applied flooring, fillers, some solid-surface countertops, and sealants. Phthalates are often used as plasticizers in plastic products. They are the chemical additives used to make PVC soft in applications like electrical cable jacketing. Many bisphenols and phthalates are endocrine disrupting chemicals, with strong effects even in low concentrations, and have been detected in nearly 100 percent of tested humans. They are most harmful during critical windows of fetal development.

Some solvents

Solvents are used to dissolve or disperse other substances. In the built environment, solvents are used in paints, adhesives, coatings, and in the manufacturing processes for many other products. In paint, for example, a solvent would act as a carrier to allow dissolved pigments and resins to be spread. Once the paint is spread, the carrier solvent evaporates off, leaving the paint behind. These solvents, therefore, are highly volatile and, once vaporized, inhaled and absorbed by humans. Some are associated with neurotoxicity, reproductive toxicity, and carcinogenic effects during both short-term, high-level exposure and long-term, low-level exposure. It is assumed that the functional performance of these solvents relies on their high volatility; however, the availability and performance characteristics of water-based paint, coating, and adhesive products have increased in recent years.

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[64] Six Classes. Green Science Policy Institute. (2016).

[65] Levitt, B., and A. Wilson. (2012). *Halogenated Flame Retardants (HFR) and Board Insulation*. Green Science Policy Institute and BuildingGreen. Accessed 29 November 2016.

Metallic additives

In the built environment, metals of concern (such as cadmium, lead, mercury, and arsenic) are often used in pigments, coatings, electrical components, and in some cases, as antimicrobial additives in treated lumber. Many metals have the potential to bioaccumulate, and, consequently, once they migrate from products into the food chain, certain metals can bioaccumulate in humans and animals. While many metals are essential nutrients of the human diet, they can be toxic to humans in higher levels. Other metals have been found harmful to humans, even in very low concentrations. Both types of metals may interact with human biochemistry in concerning ways. Such interactions can cause a variety of nervous system disorders and cancers.

Appendix F

Sample phone scripts and template outreach letters

GENERIC PHONE SCRIPT

Hello, I am reaching out to obtain information about a product/products of yours that I would like to be able to specify on a {program} project in the {location} area.

The products I am interested in are {product list}.

In order to be able to include your products in our project specification, we need more information about your product's composition. We are specifically looking for information in the following formats:

- {Compliant documentation list}

Are you familiar with these programs?

[If yes]: Great. Has {company name} considered developing any material disclosure documentation for any of your products? If not, these documents are increasingly sought after for projects pursuing LEED version 4 and other green building certifications, so it can be very beneficial to begin to engage with this process.

[If no]: These material disclosure documents are part of a recent industry-wide effort to reduce the health and environmental impacts of building materials and, toward this goal, to promote chemical transparency within the supply chain. They require an inventory of the materials and chemicals that comprise a product, down to a level of detail beyond that of a typical Safety Data Sheet. These documents are increasingly sought after for projects pursuing LEED version 4 and other green building certifications, so it can be very beneficial to begin to engage with this process.

Would you be the right person to speak to about developing disclosure documentation for {company name's} products?

[If yes]: Great, thank you! Please look out for an email from me containing links to the websites where you can get started. Please let me know if you have any follow-up questions.

[If no]: Could you please help me find out who that person is? Could you tell me how soon you might be able to provide that contact information? Once you have it, could you please email me at: {email address}.

Thank you for your time and I look forward to hearing from you!

LBC RED LIST IMPERATIVE PHONE SCRIPT

Hello, I am reaching out to obtain information about a product/products of yours that I would like to be able to specify on a {program} project in the {location} area.

The products I am interested in are {product list}.

The project is pursuing the Living Building Challenge requirements for materials. In order to be considered for the project specification, we need more information about your product's composition.

Are you familiar with this program already? Do these products already have a Declare label, or is your company in the process of obtaining one?

[If yes to Declare:] Great. Can you help send me the URL to your Declare labels for these products?

[If no to Declare but yes to familiarity:] Great. So are you the right person to help me obtain this information?

[If no:] These programs require an inventory of the materials and chemicals that comprise the product, down to a level of detail beyond a typical Safety Data Sheet. So the best person to speak with would be someone with that type of knowledge, or who can access to that kind of data. Are you the right person to help us obtain that information?

[If yes:] Great. The first step is to let you see the full list of chemicals on the LBC Red List and let you internally screen your products so we know if it will be easy for you to comply with the Red List, or if we need to look into some of the special exceptions that the LBC program offers. I will send you a copy of the chemical list (listed by the chemical identifiers called CAS numbers), plus the specific documentation requirements

[If no:] Could you help me find out who that person is? Could you tell me how soon you might connect me with that person? You can call/email me at {contact info}.

Thank you for your time and I look forward to hearing from you!

GENERIC TEMPLATE OUTREACH LETTER

Dear {contact first name}:

I am reaching out to obtain information about a product/ products of yours that I would like to be able to specify on one of my projects. It is a {gross square footage and program} building in {project location}.

More specifically, I am interested in: {product List}

In order to be able to include your products in our project specification, we need more information about your product's composition. We are specifically looking for information in the following formats:

- {compliant documentation list, with hyperlinks to the corresponding websites}

Has {company name} considered developing any of these documents for any of your products? If you are unfamiliar with these types of documentation, they are part of a recent industry-wide effort to reduce the health and environmental impact of building materials and, toward this end, to promote chemical transparency within the supply chain.

These documents are increasingly sought after for projects pursuing LEED version 4 and other green building certifications, so it can be very beneficial for manufacturers to begin the process of engaging with this process.

If you have any questions about the programs, I would be happy to share more information.

If there is someone else within your company who is better suited to discuss this with, please provide their contact information so I can reach out to them.

Thank you so much, and I look forward to hearing from you,

{name}

Specific template outreach letters

Several templates for specific initiatives, such as mindful MATERIALS or the LBC Red List, are publicly available:

- mindful MATERIALS: available through the mindful MATERIALS website upon sign up.
- LBC manufacturers worksheet: available from Re:Vision Architecture

Appendix G

Ways to engage with healthier materials initiatives

While this document has focused on project-level roles, there are many ways that individuals and firms can support the industry movement toward healthier building products. The table below lists several opportunities for such engagement that exist within the industry. Note that the table includes volunteer committees that develop product-level assessments and databases. Separately, there are numerous volunteer committees that inform the development of building-scale certifications, but those are not captured here.

Engagement opportunities	
Group	**Overview**
mindful MATERIALS Collaborative Working Groups (mM Working Groups)	The mindful MATERIALS Collaborative is an industry-led group to foster and strengthen the resources available for informed material selection. Four Working Groups provide guidance, create content, and oversee and contribute to the growth of the initiative. These include the Outreach, Process, Content, Portal, Review, and Ambassador Working Groups. The Working Groups are collectively overseen by an Administrative Committee.
Health Product Declaration Collaborative (HPDC) Technical Sub-Groups	The HPD Collaborative uses a consensus-based, stakeholder process to create, support, and evolve the HPD Open Standard. Several Technical Sub-Groups complete this work, including the Content Inventory, Supply Chain, Special Conditions, Third-party Verification, and Harmonization Sub-Groups. The Sub-Groups are collectively overseen by the HPDC Technical Committee. Group members serve two-year terms.
Cradle to Cradle (C2C) Advisory Groups	Their C2C Certifications Board has created five advisory groups, one for each category of the C2C Product Standard, to provide expert guidance in the standard development process. The Certification Standards Board determines final revisions to the C2C Standard based on recommendations from the advisory groups.

Appendix H
Additional resources

The following documents provide a starting point to grow knowledge around healthier materials.

Engagement opportunities	
Group	**Overview**
FACT SHEET	
BPA, PFCs, Binders, PVC (HBN 2006-09)	These summaries introduce known health impacts and exposure routes for several classes of chemicals. Some also identify commercially available alternatives for materials containing these chemicals.
PFCs, antimicrobials, flame retardants, bisphenols and phthalates, solvents, metals (GSPI 2017)	These brief summary documents introduce each class, how it is defined, where its chemicals are commonly found, and the hazards those chemicals pose to human and environmental health.
REPORTS & GUIDES	
Avoiding Toxic Chemicals in Commercial Building Products (BuildingGreen 2012)	This guide provides rules-of-thumb for specification, case studies, information for navigating chemical avoidance lists, and guidance on specific chemicals of concern and their alternatives.
Post-Consumer Polyethylene in Building Products (HBN/ StopWaste 2016)	Polyethylene goes mostly unrecycled due to problems in supply chain controls and the relatively low cost of virgin materials. This report examines ways to optimize the use of post-consumer polyethylene in building materials.
Post-Consumer Flexible Polyurethane Foam Scrap Used In Building Products (HBN/ StopWaste 2016)	This report examines challenges related to flame retardant additives in the use of scrap flexible polyurethane foam in building products.
Healthy Environments: Understanding Antimicrobial Ingredients in Building Materials (HBN/P+W 2017)	This report presents current information about reported or potential health and environmental impacts of antimicrobial chemicals commonly used in the building industry.
Healthy Environments: What's New (and What's Not) With PVC (HBN/P+W 2015)	This report presents the human and environmental health hazards of PVC as currently understood through contemporary research.
Healthy Environments: Strategies for Avoiding Flame Retardants in the Built Environment. (P+W 2014)	This report reviews the state of science on flame retardants and their evolving market and regulatory contexts, and identifies opportunities to reduce the use of flame retardants without compromising fire safety or code compliance.
A Small Dose of Toxicology, 2nd Ed. (Steven Gilbert)	This e-book examines the health effects of common chemical agents and provides an introduction to the fundamentals of toxicology through the lens of our daily lives.

Engagement opportunities	
Group	**Overview**
PRODUCT REGISTRIES	
HPD, C2C, and Declare product registries	The HPD, C2C, and Declare database registries list products compliant with each of the three certification tools and include relevant documentation for each product.
mindful MATERIALS database	The mindful MATERIALS database is an open-source data platform that aggregates content from several product registries. The database engine, Origin, enables fluid data exchange among manufacturers, auditors, and A+D professionals.
Healthy Building Network HomeFree Database	HomeFree is a national initiative run by the Healthy Building Network, which supports professionals in the affordable housing sector in choosing less toxic building materials. Among its many resources, HomeFree offers simplified product category spectra, which rank different product options within a given category according to the toxicity of their chemical contents.
Healthy Urban Places	Maintained by the architecture firm Eskew+Dumez+Ripple, this resource collects information about building materials by CSI division, including a Regional Materials Map, to facilitate material selection for Living Building Challenge projects. The site additionally includes relevant research from several organizations in the building industry.

PRIMARY AUTHORS

Frances Yang, SE, LEED AP BD+C, WELL AP, specializes in healthier and environmentally preferable materials and structures in the Energy + Sustainability group of the San Francisco office of Arup. In leading Arup's Americas Sustainable Materials Consulting practice, Frances strives to bring healthy and low-carbon aims into the day-to-day consideration of materials alongside selection for their technical performance. She contributes to the HPDC Technical Committee, AIA Materials Knowledge Working Group, a Cradle-to-Cradle v4 advisory group, and the Carbon Leadership Forum. She also recently vice-chaired the USGBC Materials and Resources TAG and has consulted on numerous projects pursuing LEED v4, WELL, and/or Living Building Challenge.

Sara Tepfer is a Chemistry and Materials Sustainability Consultant in Arup's San Francisco office. Sara took a unique, cross-disciplinary path that included research, fellowships, and internships in the fields of building science, chemistry, and architecture while earning her Master of Science in architecture at UC Berkeley and BS in chemistry from University of Oregon. Her interests lie in using information on the life-cycle human and environmental health impacts of building materials to inform architectural decision making. She is active on the HPDC Special Conditions subgroup and the mindful Materials Outreach committee.

More info on **Arup Materials Consulting** can be found at http://www.arup.com/services/materials

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