Greening Divisions 15 & 16

Gail Vittori
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Co-Director, Center for Maximum Potential Building Systems • 8604 F.M. 969, Austin, TX 78724 USA • Telephone 512/928-4786 • Fax 512/926-4418 • Email gvittori@cmpbs.org

1. INTRODUCTION

Significant progress has been made to identify environmentally preferable materials and products for most of the CSI divisions, with the notable exception of Divisions 15 and 16, specifically relating to plumbing and electrical materials. Indeed, a review of BuildingGreen's GreenSpec for Division 15 – *Mechanical* lists nine manufacturers, six representing vitrified clay pipe manufacturers, and three cast-iron soil pipe manufacturers; interestingly, no listings for potable water delivery (supply) are identified. For Division 16, *Electrical*, no manufacturers are listed for wiring, cabling and other electrical materials such as switches. These materials are intimately associated with safety considerations associated with building operations and represent significant cost and volume. Due to the nature of conventional materials used in these applications, they also represent a window of opportunity for market transformation towards substantial improvement relative to environmental health performance over their respective life cycles.

This paper focuses on specific applications of plumbing and electrical materials, code and performance considerations, and a framework to guide the market towards enhanced environmental health performance, with some examples of industry innovators and public policy initiatives.

2. CONTEXT

In a 2000 report, *BaselineGreen™ -- GreenBalance™: Balancing Environment and Employment Inputs to the Seattle Justice Center*, co-authored by Center for Maximum Potential Building Systems and Sylvatica, Uniformat Level 2 Building Group Elements were ranked based on upstream environmental burden indicators associated with total air pollution, global warming (CO_2 emissions), and toxic releases, with D50, Electrical and D20, Plumbing, ranked in the top eight (out of 11) categories:

Uniformat Level 2 Building Group Elements	Air Pollution	Global Warming	Toxic Releases	Combined Ranking	Final Ranking
C30 Interior Finishes	2	2	1	5	1
B10 Superstructure	1	1	4	6	2
D50 Electrical	**4**	**3**	**3**	**10**	**3**
A10 Foundations	4	5	2	11	4
D30 HVAC	7	6	5	18	6
C10 Interior Construction	6	7	6	19	7
D20 Plumbing	**8**	**8**	**7**	**23**	**8**

Additionally, several of the U.S. EPA-listed persistent bioaccumulative toxins (PBTs) are associated with electrical and plumbing materials. The U.S. EPA identifies PBT chemicals as of concern because they are highly toxic, do not break down easily in the environment, and accumulate in living tissues. Among the PBTs linked to Divisions 15 and 16 are: mercury used in electrical switches, lead used as a stabilizer in PVC electrical jacketing and plumbing pipe, cadmium used as a stabilizer in PVC electrical jacketing, and dioxins released as a byproduct of vinyl chloride monomer (VCM) manufacture, a feedstock of PVC, and released as a consequence of accidental or intentional combustion of PVC. Because of the significant and prolonged environmental and human health burdens associated with PBTs, they represent priority chemicals to eliminate as feedstocks or by-products associated with building materials and products, particularly when substitutes of comparable or superior performance are available and competitively priced.

3. PLUMBING MATERIALS

The pipes used to transport potable water (supply) and wastewater (drain, waste and vent) to and from buildings are assumed to be safe, particularly supply pipes carrying drinking water. However, an evaluation of plumbing pipe options and materials associated with their installation distinguishes their respective characteristics, and reveals opportunities to enhance the environmental health profile of these products.

Supply pipes transport potable water from the water source into the building. Copper remains the principal material for this application, with ductile iron, high density polyethylene (HDPE), cross-linked polyethylene (PEX), and polyvinyl chloride (PVC) options. (In the latter case, chlorinated polyvinyl chloride (CPVC) is often used for both hot and cold supply as it can withstand domestic hot water temperatures beyond PVC's tolerances.) For drain, waste and vent (DWV) applications, options are concrete, HDPE, PVC, cast and ductile iron, and vitrified clay.

Using a lifecycle framework, several stages are worth noting. For raw material feedstock, recycled content as a single attribute reveals a range of 100% recycled content for polyethylene drainage pipe and cast and ductile iron, about 64 percent recycled content for copper pipe, and undetermined percentages for PVC pipe. Because recycling processes can be energy-intensive and release toxic chemicals, further analysis is required to determine the relative environmental health burdens and costs associated with recycling the respective materials. Using virgin feedstock, PVC is distinguished as being the only chlorinated compound, representing unique environmental and health exposures including the unavoidable dioxin releases during manufacture of the raw material feedstocks and in the event of combustion.

Installation of the various piping materials is another life cycle stage with clear distinctions. For example, several environmentally-preferred options for joining copper pipe are available. Copper pipe is generally joined using solder and flux; some products are still manufactured with lead. Indeed, as of June 19, 1986, the Safe Drinking Water Act (SDWA), Section 1417(a) states that only “lead free” pipe, solder or flux may be used in the installation and repair of public water systems or any plumbing in residential or non-residential facility providing water for human consumption, connected to the public water system. In the SDWA, “lead free” is defined as solders and flux containing no more than 0.2 percent lead, and pipes, pipe fittings and well pumps containing no more than 8 percent lead. Even small exposures to lead creates hazards to workers during installation and can have long term indoor and outdoor air quality impacts, especially considering lead's persistent and bioaccumulative properties. At least one U.S. manufacturer of 100% lead free solder exists: Tarcorp, Inc. located in Winston-Salem, NC selling products under the names Taramet Sterling Premium Lead-Free solid wire solder, Sterling Premium Lead-Free water soluble flux, and Dutch Boy Lead-Free solder and flux.

A second option is to use flux formulated to reduce copper corrosion associated with exposure to acidic air and/or water. This is a concern because copper pipe corrosion can release high levels of copper into aquatic ecosystems via wastewater, creating potentially toxic conditions for aquatic species. To retard copper corrosion, an ASTM B813 flux is recommended, and is available through most flux manufacturers.

A third option is avoiding the use of solder and flux altogether. A mechanical joining technique for copper pipe, marketed as ProPress fittings, uses an O-ring gasket and crimping tool for jointing, similar to that used for polyethylene pipe. This method eliminates fumes associated with soldering, and enhances the cleanliness of the pipe, thus significantly limiting the potential toxic exposure to installers. According to the manufacturer, Ridgid, ProPress fittings carry a 50-year warranty against defects, claimed to be equivalent or better than warranties offered on copper tubing sold in the U.S..

Circumventing the need for solder and flux is an inherent attribute of polyethylene pipe, and serves as a principal distinction from PVC pipe which requires a cement to connect pipe lengths. A survey of PVC cements reveal many products have high flammability (3 on the HMIS scale), VOCs greater than 600 g/l (the LEED IEQc4.1 maximum threshold for PVC cement is 510 g/l, based on the South Coast Air Quality Management District standards), and formulations including Tetrahydrofuran. According to OSHA, Tetrahydrofuran has the following health hazards:

> *Tetrahydrofuran is a central nervous system depressant in humans; based on effects seen in animals, it may also cause irritation of the mucous membranes and upper respiratory tract and liver and kidney damage. There are no reports of chronic effects in humans [Hathaway, Proctor, Hughes, and Fischman 1991, p. 537]. However, investigators exposed to unknown concentrations while testing tetrahydrofuran's pharmacological properties developed severe occipital headaches [Gosselin 1984, p. II-408]. Researchers engaged in the experimental spinning of synthetic fibers showed a marked decrease in white blood cell count that is believed to have been caused by exposure to tetrahydrofuran, which was used as a solvent; these individuals recovered after 2 years of treatment [HSDB 1989].*

A few PVC cement products are formulated to reduce toxic exposures, including Gorilla PVC cement, which the manufacturer describes as non-toxic, non-flammable, and low odor.

4. ELECTRICAL WIRE & CABLE

Wire and cable represent a $20.5 billion industry in the US, with demand for wire and cable used in buildings anticipated to increase by 3.4% per year through 2006. Wire is an individual strand of material of a certain gauge size, or a single conductor, generally made of bare or tinned copper, and covered with insulation. Cable is a product made of two or more wires, covered with an insulated jacket. Halogenated refers to products made with chlorine- or fluorine-based compounds, which emit hydrogen chloride, hydrogen fluoride, and carbon monoxide gases when burning. Due to fire-related health concerns, there has been a shift in the European market in the public and private sectors towards non-halogenated products, though a similar shift has not occurred in the US market.

According to an industry manufacturer, Jayflex Plasticizer, plasticized PVC is the single largest volume electrical insulating material in current use, with estimates of 55 percent to 60 percent of all wire and cabling manufactured with vinyl. As an insulated jacketing, PVC is noted for its good electrical properties, abrasion and moisture resistance, and potential for custom formulations to meet specific performance requirements. How PVC has historically achieved these performance feats involves the addition of plasticizers and stabilizers (generally heavy metals) that represent concern.

Beginning in September 2003, the State of California, through Proposition 65 legislation, will require cable suppliers to label as hazardous cabling containing lead. PVC is the only plastic material that uses lead as a stabilizer. This legislation is anticipated to be a catalyst for the development of non-lead jacketing products, some of which are beginning to enter the marketplace. The U.S. EPA classifies lead and lead compounds as persistent bioaccumulative toxins, and has reduced thresholds for lead in federal reporting requirements, as have many states, as part of a nationwide initiative to reduce risks to human health and the environment associated with PBT pollutant exposure. To their credit, several PVC cable jacketing manufacturers including Solvay, Gitto-Global Corporation, and AlphaGary Corporation have introduced PVC compounds free of heavy metals; some of these are claimed to come without a pricing premium. However, other concerns about PVC persist including plasticizers used to achieve flexibility, and dioxin releases through the PVC life cycle.

Complicating the lead substitution strategy is the emergence of fluoropolymer jackets (commonly referred to as Teflon® or NEOFLON FEP) as a lead-free alternative to PVC. Frank Bisbee, editor of the cabling industry newsletter Wireville.com, states: “FEP is a long-lasting, highly stable material that contains no lead and no phthalates. From a fire hazard perspective, PVC has a fuel load similar to gasoline, whereas FEP has a fuel load similar to concrete.” However, due to health and safety concerns raised about Teflon-based cable, Bisbee and others are withdrawing their endorsement. Cross-linked polyethylene (XLPE) is emerging as a more benign alternative, with Environment Canada reporting its use in the NMD-90 residential building wire niche. In Canada, PVC is used in 60 percent of all wire and cable, polyethylene in 34 percent, and other resins fulfill the balance.

Lead also emerges as a concern associated with the aging of installed wiring and cabling in buildings, especially in light of recent regulations requiring the removal of disconnected products when replaced with upgraded ones as now required by the National Electrical Code’s (NEC) 2002 edition. The new code requires the removal of accessible, abandoned cable as a fire safety measure, unless it is identified for future use. This requirement will go a long way to achieve enhanced building health and air quality. But the removal raises concerns about the management of PVC jacketing stabilized with lead and plasticized with phthalates, which has been the prominent voice and data cabling material over the past two decades. According to Frank Peri in *Cabling Business Magazine*, “…there is no cost-effective way to remove lead from the PVC in recycling. … some environmental studies indicate that the discarded cables disposed of in C and

D (construction and demolition) unlined landfills are leaching toxic substances into the groundwater. The downstream costs for handling HAZMAT may be much higher than current disposal fees." Mr. Peri also voices concern about the growing awareness of the consequences of PVC jacketing materials disintegrating over time, and the associated release of lead dust that could compromise the building air quality, and notes "…a broad-based, worldwide movement where the goal is to reduce or completely eliminate PVC and these harmful (lead and phthalate) chemicals."

Low smoke, zero halogenated (LSZH) wire and cable products, principally made of polyethylene and polyolefin, are available in the U.S. for most, if not all, large commercial and industrial wire and cable specifications. Generally, the LSZH are considered more mechanically rugged, and are more expensive, than their halogenated counterparts, though volume discounts may reduce the cost premium. Current U.S. manufacturers include Belden Wire of Richmond, Indiana, Service Wire Co. of Culloden, West Virginia, and Southwire Company of Carrollton, GA. Interestingly, Romex produced an LSZH product but withdrew it from the market due to low demand.

Copper continues to be a dominant wiring material, especially in power applications. Scrap copper represents about 55% of total copper consumed in the US on an annual basis. Because of the performance requirements for high conductivity wiring, the use of recycled copper can introduce trace impurities that negatively impact its qualities. For this reason, copper wiring requires newly mined, or primary copper or scrap copper that has been re-refined, re-smelted and re-refined. The former option – newly mined copper – introduces significant environmental burdens associated with the primary mining and processing of virgin ore.

The Massachusetts Toxics Use Reduction Institute (TURI) based at the University of Massachusetts – Lowell, convened a Wire and Cable Focus Group, *Environmental Challenges in the Coated Wire and Cable Industry,* in June 2001, with approximately 30 representatives from the wire and cable supply chain participating. The purpose of the gathering was to discuss research and technology options to help industry respond to increasingly stringent international environmental, health and safety standards, European initiatives to phase-out PVC and some halogenated flame-retardants, California's Proposition 65, and increasing focus on lead and PBTs in the United States. Among the recommendations are to: provide information on California's Proposition 65 requirements and court cases associated with coated wire and cable, especially concerning the 'safety factors' for the different chemicals used in these products; assist industry to understand and prioritize relative hazards of different lead compounds and alternatives; assist industry estimate the total cost of using lead, PVC, and brominated flame retardants (BFRs). Currently disposal and OSHA costs are not accounted for when considering alternatives.

5. ELECTRICAL SWITCHES & THERMOSTATS

Approximately 60 percent of mercury releases to the environment are from anthropogenic sources, with 40 percent resulting from naturally occurring phenomena such as volcanoes and wind blown dust. Although the use of mercury in manufactured products is dropping, U.S. EPA estimates about 4 percent of mercury-containing devices in the municipal solid waste stream are thermostats (3.3 percent) and electrical switches (0.77 percent), representing approximately 10 tons per year. (Household batteries are the largest contributor at about 72 percent, with electric bulbs estimated at about 14 percent. While of obvious importance to a mercury elimination strategy, these products are not included in this paper's scope.) Accidental exposure to mercury can result during the maintenance and repair of these devices, when the devices break; in addition, workplace exposure during manufacturing represents an additional risk.

The following chart identifies mercury-containing electrical devices and suggested alternatives:

Mercury-Containing Electrical Device	**Estimated Amount of Mercury**	**Suggested Alternatives**
Thermostats	~ 3 grams Hg / tilt switch	Programmable electronic thermostats
Silent Wall Switches	~ 2 grams Hg	Hard-contact wall switches
Temperature Sensitive & Mechanical Tilt Switches	~ 3.5 grams Hg in small electrical switches; industrial switches can contain as much as 8 lbs.	Hard-contact switches, solid-state switches, capacitive sensors, photoelectric sensors, and ultrasonic sensors.
Float Switches	unknown	New float switches are mercury free

6. CONCLUSION

Heightened awareness about persistent bioaccumulative toxins and their long-term environmental and health consequences is a catalyst for re-engineering product development to eliminate these worst in class chemicals. Recent policies in the City of Seattle and City of San Francisco have established plans to reduce PBT emissions associated with building material life cycles, while the U.S. EPA and Washington State's Department of Ecology have identified prioritized PBT lists. In the case of Washington State, dioxins, cadmium, lead and mercury, among others, are targeted for virtual elimination from Washington sources. Because of the materials and products used in CSI Divisions 15 and 16, they are prime candidates to come into alignment with these environmental health based policies. Clearly, momentum has begun. A broad and heightened awareness of PBTs in plumbing and electrical equipment can catalyze swift market transformation towards a generation of products that fulfill the environmental and human health considerations consistent with green building objectives.

7. REFERENCES

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