The Role of Piping Systems in Green Buildings

When it comes to green buildings, much thought often goes into the building envelope, the HVAC systems, solar panels, daylighting, and other high-profile areas. But what about the components that aren't as visible? Though they remain largely unseen behind the walls, piping systems play an essential role in the day-to-day operation of a building—and an integral part in achieving green design goals. Choice of piping touches several aspects of sustainability, including occupant health, resource management, and even energy use.

Following is an overview of how CPVC piping systems influence the overall environmental and human health footprint of commercial buildings.

Life Cycle Assessment

Life cycle analysis provides a complete look at the environmental impacts of a product or system from raw material extraction through production, use, and, finally, end of life. By including the use phase of a product's life into this analysis, one can make specific comparisons based on a product's application. It is a time-consuming process for raw material producers and manufacturers, but it enables environmental impacts to be weighed among products of similar applications. In other words, it allows product specifiers to make apples-to-apples comparisons of products, weighing the environmental or human health attributes of one product clearly and legitimately against another in order to select the material most in line with chief project goals.

The onus of these analyses is on the material producers and product manufacturers. As end users demand a greater amount of environmental transparency in the products they are using, producers and manufacturers will respond with increasing amounts of information to enable informed decisions with respect to environmental impacts. The U.S. Green Building Council is encouraging this through LEED v4, where new credits and pilot credits reward product transparency.

Lubrizol recently completed a life cycle assessment for FlowGuard piping systems globally, including sister brands FlowGuard Gold pipe and fittings and Corzan piping systems for commercial plumbing applications in North America. The result is a baseline report that assesses the cradle-to-grave environmental impacts of the system, including the raw materials, manufacturing, transportation, use, and end of life stages. The evaluation was conducted by third-party agency ERM and peer reviewed by Dr. Walter Klöppfer, editor-in-chief of the International Journal of Life Cycle Assessment.

The LCA, which conforms to ISO 14040 and 14044 Standards, outlines the environmental impacts of the piping systems compared to other materials.

Based on the FlowGuard Gold LCA, Environmental Resource Management (ERM) wrote a report comparing FlowGuard environmental impacts to those of copper. The cradle-to-gate comparison, which analyzed impacts through the production of pipe, showed a significant benefit in choosing FlowGuard Gold products. For example, FlowGuard CPVC was found to have a lower global warming potential (carbon footprint) than copper.

Energy Efficiency

The manufacture of Lubrizol CPVC piping materials requires less energy and produces fewer greenhouse gas emissions than other piping materials, as reported in the "Life Cycle Inventory (LCI) of the Production of Plastic and Metal Pipes for Use in Three Piping Applications." Also, since Lubrizol plastic pipe and fittings do not corrode, they are likely to last longer, reducing the need for replacement materials.

Material Efficiency/Recycling
In consideration of the circular economy, a key factor in modern sustainability efforts, CPVC can be recycled at the end of its life, such as for drainage piping or window profiles. It can also be ground into pellets and granules for use in many products, such as floor fillings/coatings, speed bumps, and car mats.

LEED
For projects seeking LEED v4 BD+C certification, FlowGuard Gold and Corzan piping systems can contribute toward credits under several headings.

- Materials & Resources: Building Product Disclosure and Optimization, Environmental Product Disclosures (Option 1). Specifiers can earn 1 point for including at least 20 products from five different manufacturers with disclosure material consisting of a product-specific declaration, an EPD, or a USGBC-approved program.
- Materials & Resources: Building Product Disclosure and Optimization, Environmental Product Disclosures (Option 2). Specifiers can earn 1 point for using products that comply with one of several criteria for 50%, by cost, of the total value of permanently installed products in the project. Structure and enclosure materials may not constitute more than 30% of the value of compliant building products.
- Materials & Resources: Construction and Demolition Waste Management, Diversion. Specifiers can earn 1-2 points by using recycled and/or salvaged nonhazardous construction and demolition materials.
- Materials & Resources: Healthcare, BPT Source Reduction: Lead, Cadmium and Copper. Specifiers can earn 2 points by specifying substitutes for material manufactured with lead and cadmium.
- Innovation: Building Material Human Hazard and Exposure Assessment (Pilot Credit). Specifiers can earn 1 point by using at least 5 different permanently installed products from at least two different manufacturers with validated hazard assessment and exposure for each substance.
- Innovation: Integrative Analysis of Building Materials (Pilot Credit). Specifiers can earn 1 point by using at least three different permanently installed products that have a documented qualitative analysis of the potential health, safety, and environmental impacts of the product in five stages of the product's life cycle (product assembly/manufacturing, building product installation, product use, product maintenance, end of product life/reuse).

Water Quality
As material health gains greater attention in sustainability circles, it's important to note the relationship between pipe materials and the presence of harmful bacteria. Of particular note for sustainably built projects is that there is rising evidence that the lower flows from water-conserving fixtures may contribute to the formation of biofilm that provides opportunity for bacteria growth.

With water flow rates significantly lower than pre-conservation levels, water is staying in pipes longer. Longer residence times means opportunity for chlorine residuals to dissipate; without chlorine residuals, biofilm growth can occur, serving as a safe harbor for bacteria. Along with low flows, similar scenarios occur due to dead legs, stagnated water, and lower building water operating temperatures.

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Biofilm, a slimy glue-like substance that can harbor bacteria such as Legionella and E-coli, forms on piping materials when biomass adhere to surfaces in wet conditions and provides the bacteria protection from high temperatures and chlorine-based disinfection methods. These issues are in addition to other pipe-material factors that contribute to biofilm and bacteria growth, such as surface roughness, as well as characteristics that impact how a pipeline handles sanitization and temperature treatments once bacteria are detected.

Because biofilm is what provides a safe harbor for legionella growth, it's also vital to be aware of design and material options that create biofilm friendly environments. A 1999 study "Biofilm Formation Potential of Pipe Materials in internal installations, KIWA 1999" found that biofilm growth was highest in copper and PEX; stainless steel, CPVC, and polypropylene experience less growth by as much as half. In the same study, the number of legionella in the test water came in above 150 cfu/ml for polypropylene and polybutylene, above 100 cfu/ml for PEX and stainless steel, but less than 25 cfu/ml for CPVC.

A contributing factor to these results relates in part to the surface roughness: pipe materials with a smoother surface have less potential for biofilm growth. CPVC and PEX are two of the smoothest, with consistent surface roughness of 12.1 μm and 13.7 μm, respectively. Copper starts smooth at 7.9 μm but as it ages becomes rougher, to 2600 μm, dramatically increasing its biofilm growth potential.*

Treatments recommended for disinfection also can have an impact on pipe material. Disinfection calls for high levels of chlorination and super-heated temperatures of 158 degrees or higher, which not all pipe materials are rated to withstand.

CPVC is naturally chlorine-, chloramine-, and chlorine dioxide-resistant. In copper pipes, however, chloramines indirectly affect corrosion due to changing pH levels. Polyolefins (polypropylene, PEX, and polybutylene) require antioxidants to protect against chlorine and disinfection byproducts like hypochlorous acid. Polypropylene manufacturers strictly recommend against use with chlorine dioxide; per ASTM F2023, PEX is not recommended for service with chlorinated water above 140 degrees F.

When designing plumbing systems, considerations of biofilm growth potential, disinfection treatments, temperatures, and piping materials all need to be considered.

As water conservation issues continue to take center stage, it's vital to monitor how lower flows can contribute to biofilm formation and how that formation can be further exacerbated by design and material options. This, combined with leveraging the knowledge and product transparency opportunities brought by LCAs, can help specifiers make more informed decisions and ensure that piping systems play an integral role in achieving sustainability objectives.

**Source: Surface profile characterization of various pipes; P. Izquierdo/J. Michalenko; Lubrizol Advanced Materials; 2015*

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