Chemical Resistance: Navigating Material Selection and System Design

The chemical resistance of piping materials influences more design considerations than you might think.

By Brian Helms

What piping system is best for my application? When chemicals are involved, that can be an agonizing question for many plumbing engineers and designers. Although the question is simple, the answer may not be. To find the answer, engineers and designers must evaluate the chemical resistance of piping materials based on the unique parameters of the application.

Chemical resistance is a broad term used to describe the ability of a material to resist degradation from chemical exposure or attack. In the "holy trinity" of piping design criteria (pressure, temperature and chemical resistance), chemical resistance is often the last to be considered. Depending on the application, however, the chemical resistance of thermoplastic piping materials may indeed be the most important factor.

Design Considerations

From industrial pressure to continuous drainage to laboratory drainage applications, the chemical resistance of piping materials influences more design considerations than you might think. Although industrial pressure or even continuous waste drainage applications are tough or harsh, generally the parameters are easy to identify.

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These applications may involve heavily concentrated chemicals at elevated temperatures with no dilution, but the number of chemicals is generally small and the temperature and pressures are well-defined. For example, engineers and designers are often given a complete list of chemicals and temperatures. Knowing these factors alone simplifies specifying a piping system.

In contrast, laboratory drainage piping systems require versatility and must be able to stand up to a broad range of chemicals. Laboratory drainage systems are found in a variety of projects. These projects may have requirements that vary greatly. K-12 or even university chemistry labs will have very different requirements than hospital, pharmaceutical or microbiological laboratories. Even though dilution is typically present, these systems are exposed to many different types of chemicals.

Chemical resistance is probably the single most important factor for engineers in choosing a piping system in laboratory applications, but it's not the only one. The mixing of chemicals can produce an exothermic reaction, a chemical reaction that releases energy in the form of heat. Therefore, in addition to chemical resistance, design professionals must also consider the temperature capabilities of any system they specify.

Material Selection

Engineers select piping systems based on a number of considerations. Past experience is probably the most common consideration. If designers have had success with products in specific applications in the past, they are likely to continue specifying those products in the future. Also, the overall installed cost and ease of maintenance are at the forefront of every building owner's mind and budget.

These are considerations that factor into an engineer's decision to specify a certain piping material as well. Specific application parameters, however, remain at the top of the list of material section considerations for designers. Chemical resistance, expected temperatures and even other factors such as whether the piping system will be installed in plenum areas or underground must be evaluated.

Unfortunately, no one piping system is chemically immune to degradation from every chemical or substance man has ever made. If there were, designers and engineers would simply specify that product and then move on to the next part of the design phase. Every material has strengths and weaknesses. In addition to proper installation, specifying the material best-suited for the application parameters is key for the longevity of any piping system.

Comparing Thermoplastic Chemical Waste Piping Materials

• ***CPVC.*** CPVC has been in the industry for a long time. It was developed in 1958 and first used in piping systems in 1962. Most engineers know CPVC as hot and cold domestic water pipe or even fire protection pipe. The single biggest use of CPVC pipe in the United States, however, is for industrial pressure or chemical process applications.

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CPVC has good broad-based chemical resistance. In general, it exhibits good resistance against strong acids and alkalis but is particularly good with oxidizers and sodium hypochlorite solutions. CPVC is resistant to some dilute water-soluble solvents; however, it has limited resistance to some strong concentrated solvents.

• ***Polypropylene.*** Polypropylene was first invented in the 1950s and has been used to manufacture a variety of piping systems since the 1970s. Commonly used in chemical waste and even domestic water applications today, polypropylene exhibits good chemical resistance against weak to moderately strong acids, bases and water-soluble solvents. However, it can degrade with long-term exposure to oxidizing chemicals such as hydrogen peroxide or sodium hypochlorite.

• ***PVDF.*** Polyvinylidene fluoride (PVDF) has been used in special waste systems since the 1990s and exhibits great chemical resistance to strong acids, weaker bases, solvents and even oxidizers but has limited resistance to some concentrated alkalis.

How Can Chemicals Attack Piping Systems?

Depending on the application and exposure, incompatible chemicals can attack both the inside and outside of the piping system. Incompatible chemicals can infiltrate polymer chains, break down weaker bonds on the polymer chains and even break the molecular chains altogether. Cracking, swelling, splitting and embrittlement are just some of the effects of chemical attacks on plastic piping systems.

These effects are often further compounded by other stresses the piping system is already under like temperature and pressure. Depending on the chemical, type of exposure, environmental conditions and the stress a system is under, the time to failure may vary. Ultimately, the result of exposing a plastic piping system to incompatible chemicals is the same: system failure.

In the past, designers had relatively few sources to rely on to determine chemical compatibility of plastic piping systems. Sources such as the Compass Chemical Resistance Guide for Plastics were available and although thorough, could also be pricey. Today there are many chemical resistance evaluation tools at the designer's disposal. Both raw material and pipe and fitting manufacturers generally publish chemical resistance charts for the materials that they produce.

Many pipe and fitting manufacturers, as well as elastomer manufacturers such as Dupont, also publish mobile or web-based chemical resistance guides free of charge. In addition to these sources, additional information can be found at the following links:

• National Center for Biotechnology Information's PubChem site: https://pubchem.ncbi.nlm.nih.gov

• U.S. National Library of Medicine ChemIDplus site: https://chem.nlm.nih.gov/chemidplus/chemidlite.jsp

• The National Institute for Occupational Safety and Health's Directory of Chemical Safety Resources: https://www.cdc.gov/niosh/topics/chemical.html

• Charlotte Pipe and Foundry's ChemGuide app: https://apple.co/2QIAvWp

These tools, coupled with a thorough evaluation of the chemical composition of substances to be conveyed and knowledge of the application parameters, allow engineers and designers to make informed decisions regarding material selection and system design. ●

Brian Helms, PMP, is a technical services representative at Charlotte Pipe and Foundry Co.