Water treatment applications that pass the acid test

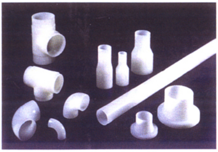
by Scott Robichaud

Over the past several years, many water treatment plants in the southeast United States faced troubles with their existing piping systems that used sulfuric acid as a method of chemical dosing. Problems have included pipeline damage, leaks, joint failures, chemical spillage and downtime. It has been determined that these problems have been caused by a decrease in availability of low concentration acid (in the range of 93 percent). Piping manufacturers have responded, using a thermoplastic material as a solution.

A dose of prevention

Increasingly, the preferred method for treating water uses reverse osmosis (RO) membranes. This method is commonly used in regions where water is considered brackish, having a light salt content, as RO technology is a superior method for removing salts from the water supply. However, scaling is a common challenge for plants using RO membranes. Scaling is the buildup of salts on the membrane, which greatly reduces functionality and eventually causes failure. Common scales include silicates, sulfates, phosphates and carbonate. In areas where the water is brackish, calcium carbonate is the most common scale.[1]

Scaling elimination is best accomplished through prevention, as once scales begin to build up, they can be very difficult to remove. There are several methods for preventing scale formation, including lime softening, ion exchange, acid dosing and anti-scalant chemical dosing.[2] While each method has advantages and disadvantages, chemical dosing is a cost-effective method that has proven to be simple to operate and reliable.



AsahiAmerica's Ultra Proline Piping System, made of Halar® (E-CTFE), provides water and wastewater plants with superior protection again chemically induced system failure. The system is available in both single and double wall configurations.

In chemical dosing, sulfuric acid in concentrations from 93 to 97 percent is dosed into the main feed water line prior to the membrane facility. The acid is generally gravity-fed or pumped at low pressure to day tanks. From the day tank, acid is pumped at high pressures to inject into the feed water supply, prior to the membrane plant.

Most plants specify 93 percent sulfuric acid for the treatment. A typical plant serving 140,000 people will use about 1,600 to 1,900 gallons of acid per day. The piping materials most commonly used to convey and inject the acid are carbon steel or polyvinylidene fluoride (PVDF). Carbon steel has many drawbacks, including maintenance requirements, which make it less attractive for plant owners. Therefore, PVDF thermoplastic piping, which features excellent chemical resistance to most acids, is widely used. It is generally available as a single-wall or double-contained piping system.

An added stress

In certain regions of the United States, 93 percent sulfuric acid has decreased in availability. However, the acid is readily available in 98 percent concentrations, as this concentration is a bi-product of phosphate production. The reduction in availability of 93 percent acid, combined with the cost savings of using the more common 98 percent acid, caused many facilities to switch their acid supply from 93 to 98 percent. Many facilities running PVDF piping systems assumed that there would be no issue with using this acid in their pipelines.

In various sites, failures of piping systems occurred within three to six months of changing to a higher concentration acid. The culprit of the failure was neither the piping material nor the sulfuric acid itself. In concentrations of 98.3 percent or higher, sulfuric acid has a natural contaminant, known as sulfur trioxide (SO_3). SO_3 acts as a stress cracking agent for PVC, CPVC, PP and PVDF materials. Figure 1 shows pipe failure due to the presence of SO_3 in the sulfuric acid.

Sulfuric acid with a concentration of 98 percent is typically supplied in a concentration range from 98.1 to 98.9 percent. This has led to the new common terminology of 98+ percent sulfuric acid. This 98+ percent sulfuric acid (with SO_3) attacks both PVDF pipe and steel pipe.

Figure 1: PVDF pipe failure due to presence of sulfur trioxide.

Surface tension

Failure in steel pipe comes in the form of hydrogen grooving of the pipe wall surface. In most applications, sulfuric acid will wear away steel pipe at a rate of 0.02" per year.[3] However, the formation of tiny hydrogen bubbles in the media will create grooving on the pipe's inside surfaces, creating deeper wear and quicker failure with weep holes. Maintenance programs and regular material inspection are required when using steel for sulfuric acid applications.

It is possible to use carbon steel in a sulfuric acid application, since the material forms a protective film of iron sulfate, which slows the corrosion process.[4] However, in addition to the formation of iron sulfate, the corrosion process forms hydrogen gas, which can actually "scrub" the iron sulfate off the pipe surface, leaving it vulnerable to chemical attack.

During normal flow periods, hydrogen is in the flow of the media and is not troublesome. During stop and start conditions, though, as well as in 90° elbows and weld gaps, the hydrogen will form and accumulate. When the process starts again, the hydrogen is pushed along the surface, wearing away the protective layer. Once the layer is removed, the steel will be readily attacked until the iron sulfate layer can be reformed.[5]

Many thermoplastic materials will stand up to sulfuric acid applications. However, the presence of SO_3 will create stress cracks in the pipe material. These are normally small longitudinal cracks, one to two inches, through the pipe wall.

A solution passes the acid test

A copolymer of ethylene and chlorotrifluoroethylene (E-CTFE) is a proven solution for these problems. This material has been successfully tested and used in sulfuric acid and sulfur trioxide applications.

It makes both technical and economic sense to build new systems and upgrade existing systems to piping and valves made of E-CTFE. Since the availability of 93 percent sulfuric acid has proven to be in a shortage at times, piping systems must be capable of accepting all concentrations of acid, from 93 to 98.9 percent. It would be detrimental for a plant to experience downtime due to an acid availability problem.

E-CTFE piping systems are generally more expensive than PVDF systems. However, 98 percent sulfuric acid is approximately 20 percent less expensive than 93 percent, depending on the supplier. A typical plant serving 140,000 residents will use 1,600 gallons of 93 percent acid per day. Switching to 98 percent acid will reduce consumption by roughly 4 percent. Therefore, a typical plant can expect a savings of more than $35,000 per year by using E-CTFE piping systems with a higher concentration of sulfuric acid. Table 1 depicts results from a cost study further illustrating this point.

Design and installation considerations

While selecting the proper piping material is critical for smooth operation in water treatment plants, it is also important to consider the piping design and installation method. For best results, the piping system supplier should be involved in these recommendations.

Government regulations and required protective measures may help determine the design and installation. Piping is both above grade and below grade. Above grade piping has a single wall configuration. However, when running the pipe underground, it must be double contained using a double wall configuration to protect the ground water. This is an EPA guideline, according to the Code of Federal Regulation, 40 CFR 280. In pump houses where sulfuric acid is pumped up to higher pressures of 60 to 100 psi, it is common that pipe is placed behind protective plastic doors for safety reasons.

Other design considerations involve determining the most effective and efficient methods to obtain specific goals. At an injection well used in chemical dosing, there are a number of options for effective injection of the acid into the main water supply. A recommended process is to use an injection quill, which will inject the chemical into the center of the pipe, creating a better blend of acid in the water. Figure 2 shows a drawing of an injection quill. During periods of interruption to the acid feed, water will flood into the injection line, creating an exothermic reaction as high as 180° to 200°F (82° to 93°C) in the pipeline. To minimize the thermal stress, check valves should be utilized to prevent water back flow.

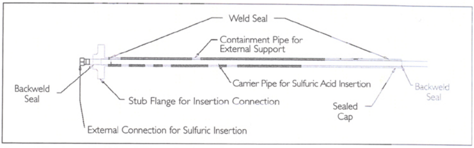


Figure 2: Injection quill, which will inject the chemical into the center of the pipe, creating a better blend of acid in the water.

TABLE 1: COST STUDY

	Cost/ Ton	Gal/ Ton	Cost per Gallon	Gallons/ Day	Gallons/ Year	Cost/Year	Difference
Cost of 93% H_2SO_4	$42.00	130.7	$ 0.32	1,600	584,000	$187,666.41	$37,533.28
Cost of 98% H_2SO_4	$35.00	130.7	$ 0.27	1,536	560,640	$150,133.13	

Cost data is from an anonymous acid supplier. Consumption is from an anonymous membrane facility

Resistance is essential

When making the final decision on which piping material to choose for chemical dosing applications, it is important to consider a material that provides low maintenance and, more importantly, chemical resistance to all grades of acid that could be used over the life of a facility. E-CTFE piping systems provide safety, reliability and cost savings to municipal water treatment facilities. The material's resistance to both sulfuric acid and the common contaminant of SO_3 makes it an ideal choice for a piping material. Its chemical resistance is superior to that of other plastics such as PVC, PP and PVDF. Compared to carbon steel pipe it is virtually maintenance-free, providing trouble-free service for at least 10 years.

E-CTFE has been successfully installed in many water treatment RO facilities that use sulfuric acid for the prevention of scaling on membranes. E-CTFE systems are now commonly available, reliable and easy to weld, install and operate. ■

1. *A Fluorescent Technology to Ensure RO Antiscalant Performance*. E.H. Kelle Zeiher, Ph.D. Ultra Purewater. September 2003, Volume 20, Number 7, Page 36.

2. *A Fluorescent Technology to Ensure RO Antiscalant Performance*. E.H. Kelle Zeiher, Ph.D. Ultra Purewater. September 2003, Volume 20, Number 7, Page 36.

3. *Rehabilitation of Hydrogen Grooving in Sulfuric Acid Line*. David A. Davies; Sulfuric Acid Today. Spring/Summer 2003. Page 14.

4. *Rehabilitation of Hydrogen Grooving in Sulfuric Acid Line*. David A. Davies; Sulfuric Acid Today. Spring/Summer 2003. Page 14.

5. *Rehabilitation of Hydrogen Grooving in Sulfuric Acid Line*. David A. Davies; Sulfuric Acid Today. Spring/Summer 2003. Page 14.

Scott Robichaud is the executive vice president at Asahi/America, Inc. Asahi/America is a long-term supplier and manufacturer of high purity wet process components. For more information, contact Asahi/America, Inc., 35 Green Street, Malden, MA 02148 USA; (781) 321-5409, (800) 343-3618, fax (781) 321-4421; e-mail: asahi@asahi-america.com, www.asahi-america.com.