# Using Plastic Piping to Carry Wastewater Chemicals

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## Introduction

Water treatment systems pose interesting challenges for the designer due to the broad range of chemicals that can make up the original flow stream as well as the water treatment chemicals that are chosen to effectively run the system. It is not enough to assume that the contents of the original water are the basis for material choice, as one must also consider the distribution of pH neutralizers (acidic and basic), anti-foaming agents, coagulants, flocculants, and various cleaning agents for parts of the system. Added chemicals intended for the overall good of the water process system (e.g., chlorinated compounds) can turn out to be the most challenging for the chosen materials of construction.

The water treatment process often requires stabilization of the chemicals, removal of solids, elimination of bacteria, and odor control. This article will focus on plastic piping systems that can be considered for the handling of wastewater and for the addition of these necessary additive chemicals that vary from facility to facility.

Oftentimes, the chemicals used in wastewater treatment processes are more difficult to handle than the wastewater itself. This brings challenges, as the chemicals are designed for various purposes, some of which include killing bacteria, stabilizing chemicals, adjusting pH, removing organic or inorganic solids, and controlling corrosion. When designing a wastewater facility, it is critical to consider the makeup of the water and chemicals needed for treatment.

## Thermoplastic Polymer Piping

Just as there are many materials of construction options in metal piping, thermoplastic polymer piping has several options, and this gives the designer the ability to select a best performing material for different aspects of a wastewater system design. Plastic materials like polyethylene, polypropylene, and polyvinyl chloride/chlorinated polyvinyl chloride (PVC/CPVC) have good physical properties as well as broad chemical resistance, but they do not perform well in all applications. These products have upper use temperature limits and, while in most cases they can effectively handle chemical systems that are mostly water, they can have issues over time with some chemicals used to treat water. An upgraded polymer in the fluoropolymer family—polyvinylidene fluoride (PVDF)—is something that can be considered for the harshest applications involving higher temperatures, higher pressure at temperature, and difficult chemistry.

Plastic piping systems favorably differ from metallic systems in that they will never rust, are light and easy to install, are not as sensitive to rapid attack from acid concentration changes, can be less likely to support the growth of solids build up, have no sharp edges, are insulators, and can be easily fabricated with cutting tools and heat welding. On the downside, it is understood that plastics do not have the same physical strength, have higher expansion/contraction rates, and do not have calculable corrosion rates to predict lifetime.

It is important to note that plastic piping systems can be made from just one polymer, often called solid pipe, made using a composite with a casing of fiberglass reinforced plastic (FRP) on the outside, often called dual-laminate, or can be enclosed in metal for structural strength with the corrosion resistance of the polymer on the inside (1). Finally, for the frugal at mind, plastic piping can even be foamed to reduce the cost of the pipe. Figures 1 and 2 show examples of installed plastic piping systems. Figure 3 is an example of two of the many types of plastic valves that are available.

**Figure 1: PVDF welded piping system in fluoride treatment facility.**

Photo courtesy of Simtech Process Systems.

## Wastewater Chemistry

The chemistry of wastewater handling can involve a diverse number of variables. The most obvious is a long list of potential chemicals from various sources. When a piping system is designed for just one chemical, it is relatively easy to select the best material of construction. However, if the same piping system may see 10 different chemicals at various concentrations, then challenges mount. While it is relatively easy to design for a certain pH and a family of chemicals, such as acid or base, when they are all combined at varying rates and then charged with chlorine water, bromine water, peroxide, bleach, chloramines, alcohols, soaps, and more, there is a lot of research that should be done to choose proper materials of construction.

**Figure 2: Plastic piping system showing various types of valves and instrumentation.**

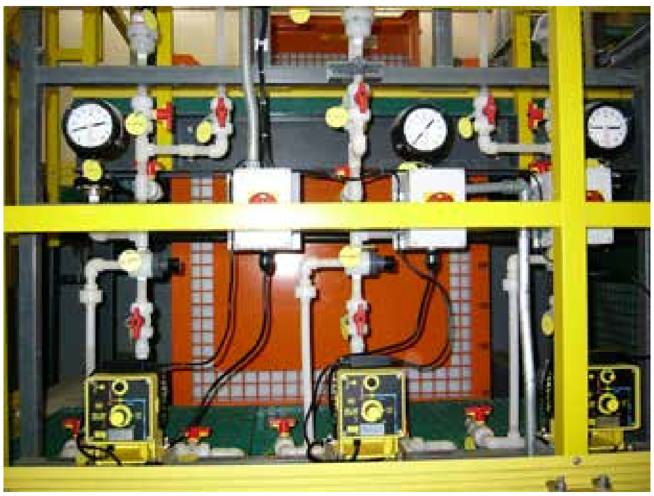

Photo courtesy of Simtech Process Systems.

**Figure 3: Two examples of plastic valves. For systems handling chlorinated chemicals, a red pigmented PVDF is a good material recommendation.**

Photo courtesy of Plast-O-Matic Valves.

As it relates to the chemistry, Table A suggests which plastic piping systems have long-term stability for many common chemicals found in wastewater processing and the reason for those chemicals to be in the process. For comparison, carbon steel and 304 stainless steel (304 SS) were included in the assessment. One would assume that water on its own is not going to be highly detrimental to common piping systems, but this table should help a designer understand the capabilities of these plastics across a wide range of chemical exposure. Table A was created from a group of industrial chemical resistance charts, and the best classification was determined based on this data (2–10). One must keep in mind that a chemical table like this is very general, and the ultimate long-term corrosion resistance will depend heavily on the worst case concentration of each chemical and the duration that the chemical is in the system.

**Table A: Chemical Resistance of Plastic and Metal Piping Under Pressure With Common Wastewater Treatment Chemicals**

| *Chemical* | *Chemical Use* | *PVDF* | *PE* | *PP* | *CPVC/ PVC* | *Carbon Steel* | *304 SS* |
|---|---|---|---|---|---|---|---|
| Algicide | Cleaning Agent | E | E | E | E | X | E |
| Bromine | Cleaning Agent | E | X | X | X | X | X |
| Chlorine | Cleaning Agent | E | S | X | X | X | X |
| Chlorine dioxide | Cleaning Agent | E | S | X | E | X | X |
| Hydrogen peroxide | Cleaning Agent | E | E | S | S | X | E |
| Monochloramine | Cleaning Agent | E | X | X | S | X | S |
| Ozone | Cleaning Agent | E | S | X | S | S | E |
| Sodium bicarbonate | Cleaning Agent | E | E | E | E | X | E |
| Sodium chlorite | Cleaning Agent | E | O | X | E | O | E |
| Sodium hypochlorite (bleach) | Cleaning Agent | E | S | S | E | X | X |
| Calcium hypochlorite | Cleaning Agent | E | E | E | E | X | X |
| Aluminum chloride | Coagulants/Flocculants | E | O | E | E | X | X |
| Aluminum sulfate | Coagulants/Flocculants | E | E | E | E | X | E |

| Chemical | Chemical Use | PVDF | PE | PP | CPVC/ PVC | Carbon Steel | 304 SS |
|---|---|---|---|---|---|---|---|
| Calcium chloride | Coagulants/Flocculants | E | E | E | E | S | E |
| Chromium sulfate | Coagulants/Flocculants | E | E | E | E | X | S |
| Ferric chloride | Coagulants/Flocculants | E | E | E | E | X | X |
| Ferric sulfate | Coagulants/Flocculants | E | E | E | E | X | S |
| Ferrous chloride | Coagulants/Flocculants | E | E | E | E | X | X |
| Ferrous sulfate | Coagulants/Flocculants | E | E | E | E | X | E |
| Iron sulfate | Coagulants/Flocculants | E | E | E | E | X | S |
| Potassium permanganate | Coagulants/Flocculants | E | E | E | S | S | E |
| Sodium aluminate | Coagulants/Flocculants | E | E | E | E | E | E |
| Sodium permanganate | Coagulants/Flocculants | E | E | E | S | S | E |
| Sodium silicate | Coagulants/Flocculants | E | E | E | E | E | E |
| Zinc/ortho-phosphates | Corrosion Control | E | S | E | E | O | E |
| Sodium bisulfite | Dechlorination | E | E | E | E | S | E |
| Sodium fluorosilicate | Fluorination Agent | E | O | O | O | O | O |
| Anhydrous ammonia | Materials Removed | S | E | E | S | S | S |
| Arsenic (acidic form) | Materials Removed | E | E | S | E | X | E |
| Fluoride | Materials Removed | E | X | X | S | X | X |
| Organic matter | Materials Removed | E | E | E | E | O | O |
| Pathogens | Materials Removed | E | E | E | E | O | O |
| Phosphate | Materials Removed | E | E | E | X | S | E |
| Chemical phosphorus | Materials Removed | E | S | S | E | S | E |
| Fluorosilicic acid | pH Neutralizer – Acid | E | E | E | E | X | X |
| Hydrochloric acid | pH Neutralizer – Acid | E | E | E | E | X | X |
| Hydrofluosilicic acid | pH Neutralizer – Acid | E | E | E | S | X | X |
| Muriatic acid | pH Neutralizer – Acid | E | E | E | E | X | X |
| Nitric acid | pH Neutralizer – Acid | E | E | E | E | X | E |
| Phosphoric acid | pH Neutralizer – Acid | E | E | E | E | X | E |
| Sodium hydrosulfite | pH Neutralizer – Base | E | E | E | E | X | E |
| Sulfur dioxide | pH Neutralizers – Acid | E | S | E | S | X | X |
| Sulfuric acid | pH Neutralizers – Acid | E | S | E | E | S | X |
| Carbon dioxide | pH Neutralizers – Acid | E | E | E | E | S | E |
| Calcium hydroxide | pH Neutralizers – Base | E | E | E | E | X | E |
| Calcium oxide (lime) | pH Neutralizers – Base | E | E | E | E | S | S |
| Magnesium oxide | pH Neutralizers – Base | E | E | E | E | E | E |
| Sodium carbonate | pH Neutralizers – Base | E | E | E | E | E | E |
| Sodium hydroxide (caustic soda) | pH Neutralizers – Base | X | E | E | S | E | E |

Notes:
E = Excellent
S = Satisfactory for temporary use
X = Not recommended
O = Data not readily available
PE = Polyethylene
PP = Polypropylene
PVDF = Polyvinylidene fluoride
CPVC/PVC = Chlorinated polyvinyl chloride/polyvinyl chloride

## Additional Concerns for Design

In addition to the chemistry, the designer needs to understand if exothermic reactions could occur from the periodic blending of the chemicals. Another set of concerns would be:

- Are particles involved that can be considered abrasive over time?
- Are the chemicals added to the stream already hot?
- Is the system exposed to direct sunlight and if yes, to what degree?
- Finally, is it designed within the system to use extremely hot water or even steam to clean the flow area?

Another differentiating quality between plastics is their maximum use temperature. This is the highest temperature a material can be used in a system. Wastewater plants not only have systems that use corrosive chemicals, but they also process them at varying temperatures. Thus, it is integral to not only choose the system proper for the chemical but also the temperature rating. Table B describes the general maximum use temperature of each of the plastics. Pressurized piping systems of PVC and polyethylene (PE) are generally used at lower temperatures—60 ˚C and 65 ˚C, respectively—while pressurized PVDF is rated up to 150 ˚C. A designer must plan beyond chemical resistance and consider the temperature rating, potential exothermic reactions, and environmental factors to carefully choose the right material.

Finally, it is important to consider how combining chemical resistance and external conditions can affect the system. While PVDF is very resistant to sunlight, if a natural PVDF pipe handles chemistries with chlorine in the molecule, a pigmented version (often white, red, blue, or black) of PVDF should be used. This pigment acts as an ultraviolet (UV) block so that the energy from the sun does not pass through the pipe and react with the chemical to create free-radical chlorine molecules that can be extra aggressive. Other practical options include simply covering or painting the pipe, covering the entire area from sunlight, specifying dual-laminate structures, or using plastic lined steel. In each case, the UV is automatically blocked from penetrating the pipe, thus assuring long-life performance.

**Table B: Maximum Use Temperature Under Pressure of Various Plastic Piping Materials ***

| | *PVC* | *PE* | *PP* | *CPVC* | *PVDF* |
|---|---|---|---|---|---|
| Max Use Temperature (°C) | 60 | 65 | 105 | 105 | 150 |

*Actual temperature rating is dependent on chemicals involved.

## Summary

There are several material choices available when selecting a wastewater piping system. This guide should serve as a helpful tool for proper material choice.

When designing wastewater treatment facilities, it is essential to be careful of the chemicals used in the design process. One material will not work for all wastewater piping systems. There are several materials to consider during this design process. This article outlined the capabilities of major plastics that should be considered during process design based on their chemical resistance and maximum use temperature under pressure. Choosing the correct plastic system is crucial in wastewater plant design.

## Final Thought

Table A is a chemical resistance chart for chemicals commonly used in wastewater treatment. The data in the table was obtained by cross checking several sources for accuracy. Not all sources are consistent, so the chemical resistance chart should be used as a general guide and for reference only. The corrosion reference data here applies at ambient temperatures, which are assumed to be as high as 50 ˚C (2–10).

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