# Municipal Fiberglass Pipe: Performance and Design Standards

**Sullivan (Sully) D. Curran PE, Former Executive Director**

## Executive Summary

The purpose of this paper is to provide the engineer and those responsible for purchasing municipal piping used in aggressive environments, with an understanding of the material system, design and quality control of fiberglass piping. While purchasing decisions are based on quality, service and price, this advisory provides guidance on how to evaluate the quality of fiberglass Reinforced Thermosetting Plastic (RTP) pipe, joints and manways. And, by specifying ASTM and/or AWWA performance standards, the user is more likely to receive competitive quotations for like products.

## Introduction

Fiberglass reinforced thermosetting plastic ("fiberglass") first became a viable alternative to protected steel, stainless steel and exotic materials in 1950. That year centrifugal cast fiberglass piping was first used in the crude oil production industry as a solution to corrosion problems. By the mid-60's fiberglass was accepted for the storage and handling of chemical and underground flammable and combustible liquids in industrial, municipal water, sewage and pulp and paper processing applications.

It was during the 1960's that manufacturers began to develop nationally recognized standards and test methods for fiberglass municipal piping systems. Today, there are a number of nationally recognized standards and specifications for fiberglass piping. While there are standards developed for military applications, this paper will address the two civilian organizations that publish performance standards for municipal piping, namely American Water Works Association (AWWA) and American Society for Testing and Materials (ASTM.)

## Background

Fiberglass municipal piping contains glass fiber reinforcement embedded in cured thermosetting resin, hence the term Reinforced Thermosetting Plastic (RTP) describes the fiberglass material system. By selecting the proper combination of resin, glass fibers, additives and design, the manufacturer will create a composite material structure that meets the respective performance standard. Following is a discussion on the components of a fiberglass material system.

***a. Glass Fibers*:** All fiberglasses begin as individual filaments of glass drawn from a furnace of molten glass. The glass filaments gathered into a "strand" and surface treated with "sizing" to maintain fiber properties. Glass fibers are designed for several applications such as acid environment, alkali or chemical resistance.

***b. Glass Fiber Forms:*** Glass fibers are manufactured for use by the pipe manufacturer in the following forms:

- *Continuous Roving:* Strands of glass fiber on a cylindrical spool used in filament winding and chop-gun spraying applications.

- *Reinforcing Mats:* Supplied as chopped strands held together with a resinous binder. Typically used for hand lay-up applications.
- *Surface Veils:* Light weight reinforcing mats to provide a resin rich smooth surface without crazing and adds corrosion resistance.

***c.*** ***Glass Fiber Reinforcement:*** The mechanical strength of a fiberglass municipal pipe depends upon the amount, type and arrangement of glass fiber reinforcement within the material system. Strength increases proportionally with the amount of glass fiber reinforcement and is highest in the fiber directions. Following are three general types of fiber orientation:

- *Uni-directional:* Glass fibers are oriented primarily in one direction. Such arrangements are obtained when continuous roving is wrapped around a cylinder or when fabrics with fibers all in one direction are applied.
- *Bi-directional:* Fibers are positioned in two directions 90 degrees apart. Such arrangements may be obtained with woven or stitched fabrics.
- *Multi-directional:* The fibers are positioned randomly with equal amounts of fibers in all directions. Such arrangements may be obtained with the use of chop-gun applications and reinforcing mats.

***d.*** ***Resins:*** The second major component of fiberglass municipal piping is the polyester thermosetting resin system. The resin system is chosen for its chemical, mechanical, thermal properties and undergoes an irreversible reaction when cured in the presence of a catalyst. Cured resins cannot be re-melted and are insoluble.

***e.*** ***Additives:*** Additional compounds are added to resins such as pigments, monomers (e.g., styrene, vinyl toluene), catalysts (e.g., organic peroxides), hardeners and accelerators. For example, catalysts are typically added to polyester resins to accelerate the curing action.

***f.*** ***Fillers:*** Aggregates such as siliceous sand and fillers such as calcium carbonate are routinely utilized to increase modulus and compressive strength.

## Industry Standards and Specifications

Industry trade organizations have developed fiberglass piping standards and specifications that are specific to their industry. In addition, certain third party organizations have developed standards and specifications that are applicable to several industries with similar corrosive environments. Following is a discussion of fiberglass standards and specifications, test methods and their applications:

***a.*** ***American Water Works Association*** maintains the standards for small and large diameter fiberglass pressure piping in potable water pipelines including:

i. AWWA C950 for *Fiberglass Pressure Pipe* which outlines general requirements for materials and manufacture.

ii. AWWA M45 *Manual of Water Supply Practices* which provides information related to design, specification, procurement, installation and understanding of fiberglass pipe.

***b.*** ***American Society for Testing and Materials*** maintains the standards for:

i. ASTM D3754 *Fiberglass Sewer and Industrial Pressure Pipe,* and

ii. ASTM D3262 *Fiberglass Sewer Pipe*.

According to ASTM D3262, Section 5.1 General – "The thermosetting resins, glass fiber reinforcements, fillers and other materials, when combined as a composite structure, shall produce piping products that meet the performance requirements of this specification." [Underline added] Thus, the standard allows for the pipe manufacturers to utilize a variety of unique raw materials which meet the performance requirements provided in the standard.

Further, ASTM D3262 outlines the use of linear regression to extrapolate the 50-year (or 100-year) strain corrosion values for the pipe when using a 1.5 long-term bending safety factor. This standard offers a minimum level of performance for combinations of different materials and/or different# manufacturing methods that will result in different strain corrosion performance levels. To ensure quality fiberglass pipe products, a specifier should ensure the standards are met, or preferable exceeded.

A performance based specification has many benefits including allowing manufacturers flexibility in choosing materials, design and construction to meet the standards' goals and objectives. ASTM D3262, for example, allows for use of different types of reinforcement requiring that they be "commercial grade of glass fiber compatible with the resin used." The standard also allows for fillers and other additives to be used such that "when combined as a composite structure, shall produce pipe products that meet the performance requirements of the standard." These materials may be optimized by a pipe manufacturer to result in the best long-term performance of the product.

iii. ASTM D3681 *Test Method for Chemical Resistance of Glass-Fiber-Reinforced Thermosetting-Resin Pipe in a Deflected Condition.*

The results of the ASTM D3681 strain corrosion test is one of the most critical performance indicators for a fiberglass pipe to be used in a sanitary sewer application. The strain corrosion test is a long-term accelerated aging test which predicts the performance of the pipe when exposed to stress (deflection) and a corrosive test solution.

## Quality Control & Quality Assurance (QAQC)

***Quality Control:*** The manufacture of fiberglass requires the control of materials and processing parameters to ensure consistency and reliability of the end product. Manufacturers maintain control by implementing a quality control program which includes raw materials inspection, vendor certification, in-process inspection, finished product inspection and testing.

***Quality Assurance:*** There is a second level of quality control known as a quality assurance program. This program may be conducted by a qualified outside party and should include the outside party evaluation of the quality control program in place to ensure that it will perform as intended.

## Summary

1. Since the 1950's Fiberglass Reinforced Thermosetting Plastic (RTP) has developed as a proven material for piping applications in an aggressive environment.
2. The manufacturer has different glass-fiber, resin and additive matrices from which to design the appropriate material system to meet the industry performance standard.
3. Fiberglass performance standards and specifications are generally industry and/or application specific.
4. Product quality and performance history are important factors when making a purchasing decision for piping in aggressive environments.

5. Product quality assurance is attainable by:
    - Buyer specification of proven industry performance standards
    - Selecting manufacturer with a proven long term performance history, and
    - Documented Quality Assurance Quality Control program
6. Performance based standards are preferred to prescriptive standards.
    - Performance standards state goals and objectives to be achieved, versus
    - Prescriptive standards, which typically prescribes materials, design and construction methods frequently without stating goals and objectives. [see Reference below]

## Conclusion

# Pipe manufactures may promote that certain types of raw materials should or should not be permitted or required. Claims or justification of particular raw material inclusion or omission are often based on unsubstantiated reasoning in an attempt to give one manufacturer an advantage. As stated earlier, the performance of the pipe according to the testing requirements of the applicable standard should be the determining factor when determining which products to specify. By far the most critical test related to fiberglass pipe in a sanitary sewer environment is strain corrosion per ASTM D3681/D3262.

**Reference:** ASME white paper
"A performance based standard states goals and objectives to be achieved and describes methods that can be used to demonstrate whether or not products and services meet the specified goals and objectives. Contrast a prescriptive standard, which typically prescribes materials, design and construction methods frequently without stating goals and objectives."
The paper can be found in its entirety at:
http://cstools.asme.org/csconnect/pdf/CommitteeFiles/13525.pdf

sdc June 23, 2013