FIBERGLASS REINFORCED PLASTIC (FRP) PIPING SYSTEMS

COLUMN PIPE APPLICATIONS ON OFFSHORE STRUCTURES

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Enclosed on the following pages is one in a series of papers written by the Engineering Department of EDO Specialty Plastics on fiberglass reinforced plastic (FRP) piping systems. This paper, on column pipe applications for composite pipe, is one in a line of papers written on the basic principles involved in the selection, specification, and design of the components involved in fiberglass piping systems.

EDO Specialty Plastics, as a designer, manufacturer, and installer of fiberglass pipe systems with two decades experience in the advanced composites industry, provides this paper as a service to its customers involved in the design and selection of fiberglass reinforced plastic piping systems.

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Introduction

FRP pipe has many unique characteristics that distinguish itself from conventional metallic materials and even other plastics. Characteristics such as lightweight, high strength to weight ratio, corrosion resistance, and flexibility all define the products in the FRP pipe industry. It is these characteristics that make FRP pipe attractive for use in offshore and marine applications such as firewater systems, ballast lines, and column pipe for firewater pumps. These unique traits, however, can prove to be a hindrance in the design of FRP pipe systems if not properly understood.

One of the most stringent mechanical requirements for FRP pipe on an offshore structure is the fire water column pipe system used in conjunction with vertical or submersible fire water pumps. Since 1982, EDO Specialty Plastics has been designing FIBERBOND® column pipe, with systems still in service after ten years. This report will first give the advantages of using composite pipe in this application, provide a case history of an FRP column pipe installation and its operation for over ten years, discuss specifications which recommend the use of FRP offshore, and introduce the engineering principles involved in designing FRP pipe for column pipe applications.

The purpose of this report is to provide information on the design and specification of composite pipe for column pipe applications. This is but one of the many applications for FRP pipe in the offshore and marine industry. By reading and understanding the information in this report, the first step is taken toward the successful specification and design of fiberglass pipe in the offshore and marine market.

Advantages of FRP Pipe in Column Pipe Applications

The obvious advantages of FRP in column pipe applications include its inherent corrosion resistance and its lightweight. FRP is ideal for seawater applications because the raw materials, resin and glass, are resistant to the service environment. The composite product also weighs approximately 1/5th of carbon steel, thus providing a much lighter weight component.

There are many additional advantages of FRP that are often overlooked or disregarded. The lightweight property of FRP lends itself to better handling and easier installation. This in turn provides better safety, more efficient installations, and a lower installed cost. The FRP product also has a lower maintenance cost, as seen in the case history.

Advantages of FRP Column Pipe

Corrosion Resistance	**Lightweight**
Ease in Handling	**Low Installed Cost**
Low Maintenance	**Long Service Life**
Good Fatigue Properties	

FRP column pipe also has advantages in manufacturing and design. In manufacturing, there is no hot work involved in welding pipe, fittings, and flanges. The flanges can be custom manufactured with special drillings to mate with the firewater pump and other existing equipment. In design, the flanges can be made heavier to handle the additional axial loads involved in column pipe design. The welds can also be custom designed to deal with these stringent conditions.

A Case History of FRP Column Pipe on Offshore Structures

The attached pictures from a typical offshore column pipe application demonstrate the advantages of properly designed systems with engineering analysis. The first group of pictures, Nos. 1 through 4, shows an actual installation of the FIBERBOND® Column Pipe, while the second group of pictures, Nos. 5 through 7, shows inspection of a column pipe system after ten years in service.

There are severe mechanical conditions associated with this type application. The FIBERBOND® column pipe is hanging in a vertical position, anywhere from 50 ft to over 140ft in length, with flanges every 5 or 10 ft. The flanges are normally machined for "spiders" to hold the pump shaft in alignment. The FIBERBOND® column pipe is placed inside the steel casing where it is subjected to severe corrosion, both internal from seawater and external from a warm, moist salt air environment with alternating wet/dry conditions.

The FIBERBOND® column pipe is placed inside a steel casing with centralizers for protection from wave action, however, the column pipe must be designed to hold the dead weight of the motor, impeller, and bowls, depending on the type pump used, plus the torque and pressure surge when the pump is started. In the Gulf of Mexico, the fire water pump is tested every two weeks in accordance with API and MMS guidelines.

Specifications for the Design of Column Pipe on Offshore Structures

One of the disadvantages of using FRP is the limited availability of specifications and standards in the industry. However, there have been a number of excellent specifications written on FRP for offshore applications and for general use.

One such document with considerations for FRP on offshore structures is the API 14G document dated December 1, 1993, entitled "Recommended Practice for Fire Prevention and Control on Open Type Offshore Production Platforms." This specification recommends the"...lift column assembly should be constructed from materials resistant to corrosion by sea water such as fiberglass pipe or internally coated steel pipe" based on years of successful service in the Gulf of Mexico.

The ASTM D2996 specification, Standard Specification for Filament Wound "Fiberglass" Pipe, is a general specification covering filament wound FRP products. Filament wound FRP pipe is often used in offshore applications because of its excellent mechanical properties. This ASTM specification covers the design, testing, and specification of filament wound FRP pipe.

Other general specifications include ASTM D2992, Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" Pipe and Fittings, and ANSI B16.5, Pipe Flanges and Flanged Fittings. The ASME B31.3 code is often consulted for the design of FRP components in chemical plants and on offshore structures, however, the 31.3 code does not address specific details in designing FRP components; it only presents a general overview.

In general, when selecting materials for column pipe, properties such as mechanical strength, corrosion resistance, service design life, fatigue, and weight are often important and should be considered. In addition to these properties, cost factors such as first time cost, installation cost, and maintenance cost need to be evaluated.

Column Pipe Design

The design of FRP column pipe presents unique considerations not found in other areas of design on offshore structures. The column pipe has to be designed for the internal pressure of the firewater pump, but in addition to this, it must withstand external axial loads due to the pump dead weight, including the bowl assembly and the impellers, the fluid dead weight, and the weight of the column itself. The stresses created from these loads must not exceed the design stress of the system.

The stress design becomes a critical factor for the pipe, flanges, and welds. The pipe must have a heavy wall to handle the additional axial loads. The flanges must have additional thickness to deal with the combined stress from internal pressure and dead weight. And, the weld must be as strong or stronger than the pipe itself. Thus, when the joining method is selected, the butt & strap joint is usually selected over the adhesive bonded joint. The butt & strap can be custom designed to be as strong or stronger axially than the pipe itself, thus making it ideal for column pipe applications.

There is a deflection limitation as well. The elongation due to the dead weight loads and internal pressure, countered by the reduction due to pressure expansion, must be within the limits of the firewater pump. While pressure expansion is often neglected in metallic pipe design, the same cannot be said for FRP design. Due to the non-isotropic properties and low modulus values of FRP, pressure expansion can often be significant, and in column pipe design, it is often the most stringent design factor. Elongations as low as 0.375 in. (9.5 mm) must be met. This is often a critical design parameter for FRP pipe due to its low axial modulus value.

Included on the following page is a Column Pipe Design Data Sheet. It contains the engineering information required when designing FRP column pipe. Relevant information includes the design pressure and temperature, total column length, dead weights, and allowable vertical deflection. The design pressure and vertical deflection are usually the two most stringent factors in designing FRP column pipe.

FIBERGLASS COLUMNAR PIPE FOR VERTICAL PUMPS
DATA SHEET

DESIGN CONDITIONS:

1. Nominal Pipe Size: ____________

2. Operating Pressure: ____________ 3. Design Pressure: _____________

4. Operating Temperature: _____________ 5. Design Temperature: ____________

6. Fluid contents (if other than seawater): _________________

7. Fluid specific gravity (if other than seawater): _________________

8. Fluid velocity (or volume flow rate): ________________

9. Total Length of Column: _______________

10. Allowable Vertical Deflection of Column: _______________
(Due to dead weight, pressure, and temperature)

PUMP TYPE (Circle One):

1. Submersible (Motor Driven)

A. Pump Weight: _______________ B. Additional Dead Weight: _______________

2. Vertical (With Driver Supported by Structural Steel)

A. Pump Weight: _______________ B. Additional Dead Weight: _______________

C. Downthrust on column due to internal pressure (if known): _______________

ADDITIONAL NOTES (Preferred Resin System, Pressure Surges, Etc.):

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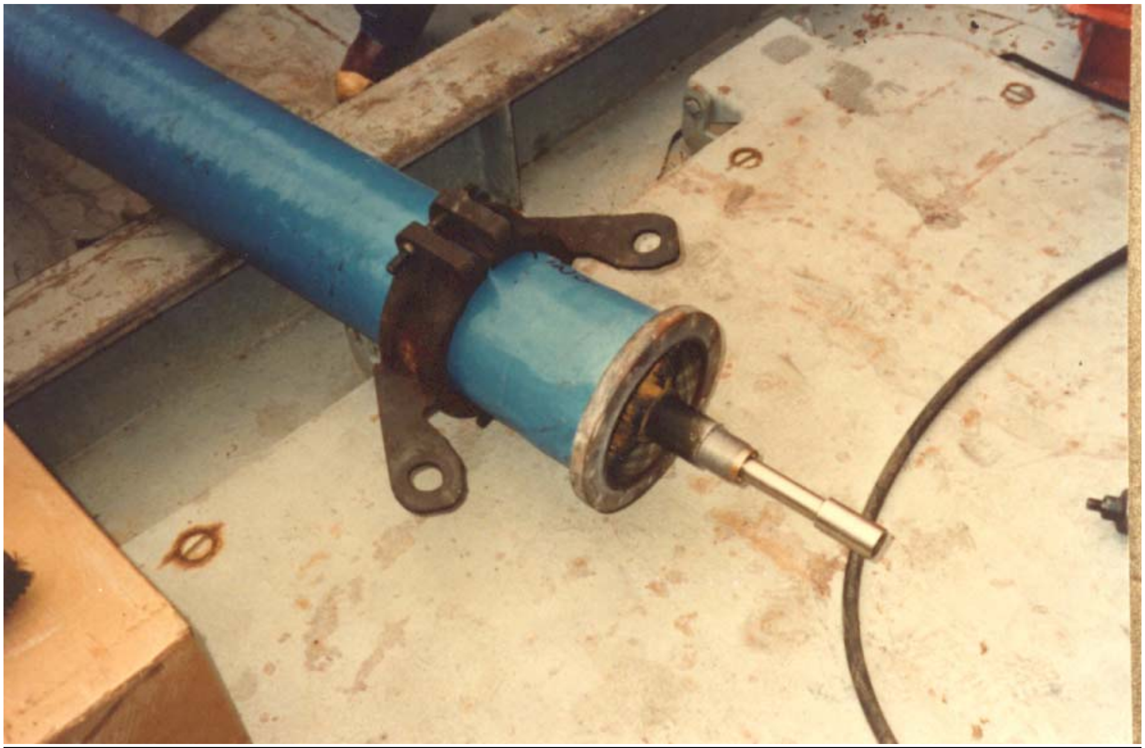

Figure 1. Lifting collar on 8in. (203mm) FIBERBOND(R) column pipe section.

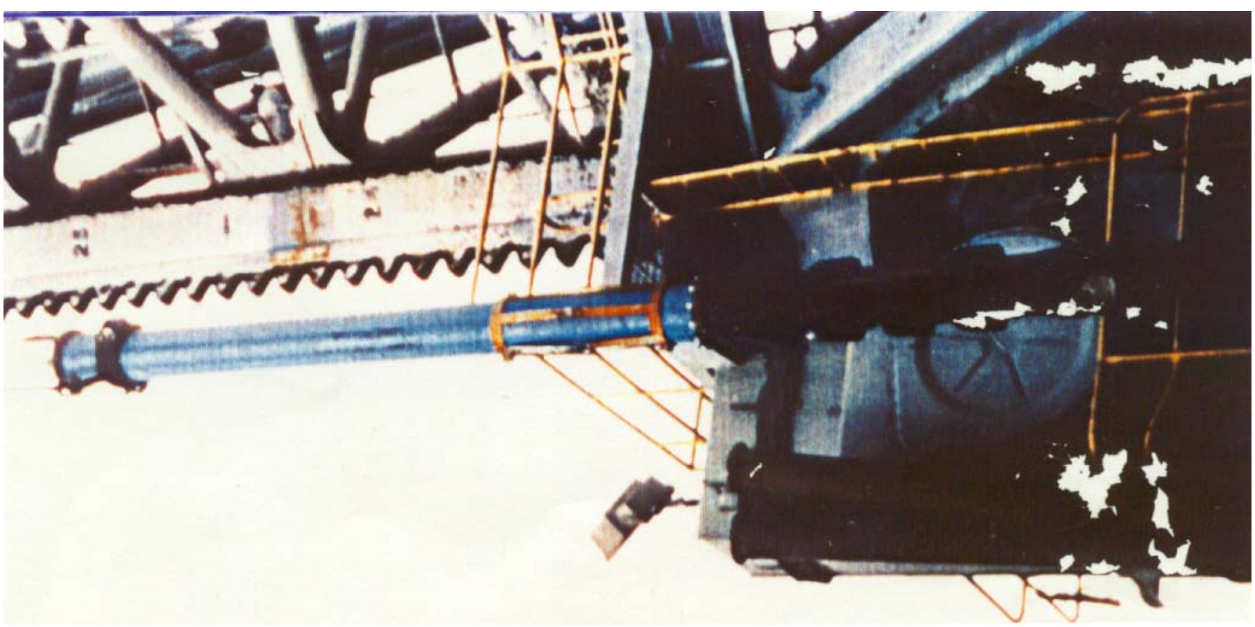

Figure 2. 10ft (3m) bottom section with centralizer and pump lifted into place over casing.

Figure 3. FIBERBOND(R) column pipe section set into steel casing.

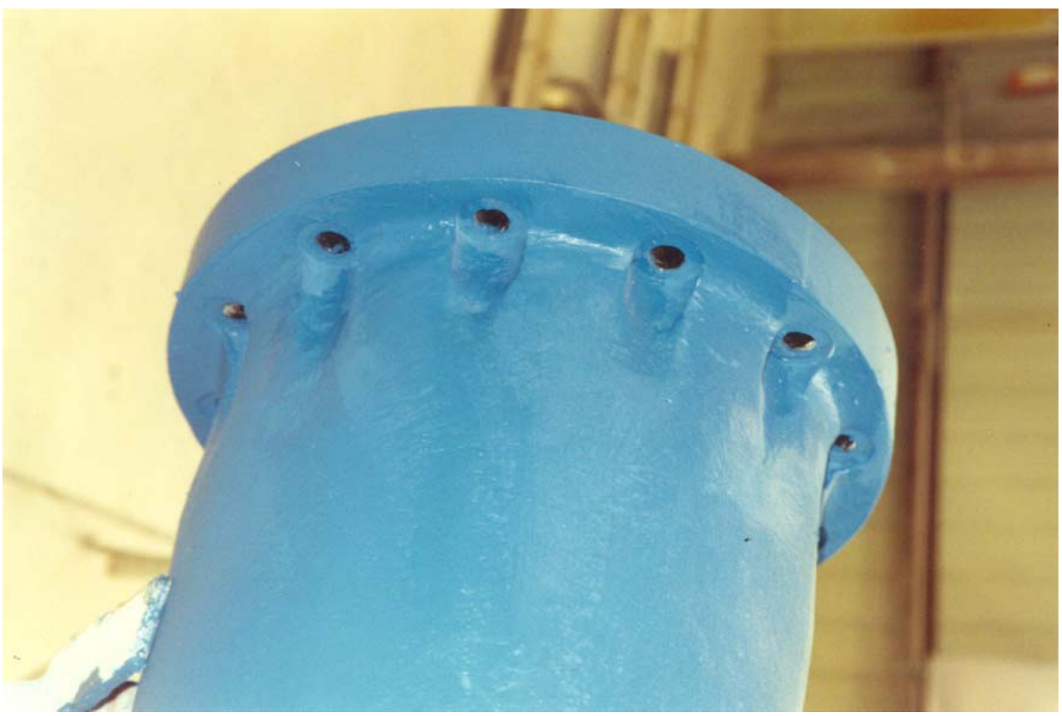

Figure 4. Close up view of FIBERBOND(R) flange with special drilling to match bolt hole drilling on pump. Note there are no "glue joints".

Figure 5. FIBERBOND(R) column pipe in shop for inspection after ten years service in the Gulf of Mexico. Steel column pipe would last an average of three years under same conditions.

Figure 6. Sections of FIBERBOND(R) column pipe after ten years service, next to new sections of FIBERBOND(R) column pipe. There is no structural material loss on the ten-year old column pipe; only a slight "scale" buildup on the exterior. In some places, the gelcoat exterior (blue) is still intact.

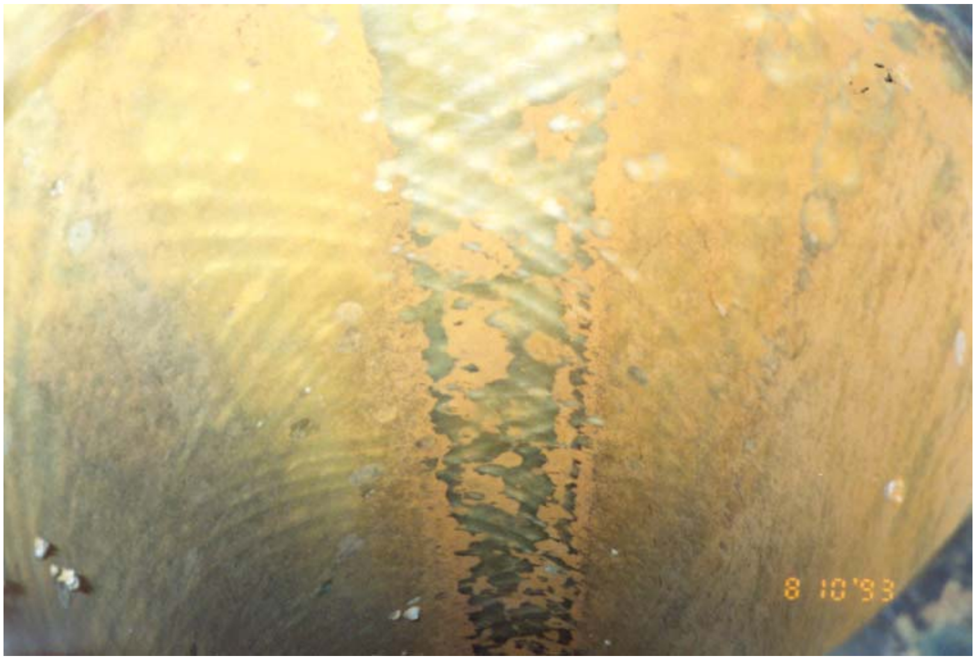

Figure 7. Inspection of interior of FIBERBOND(R) column pipe. Note the limited level of fouling after ten years in the Gulf of Mexico. The liner is still intact; there is only a thin "scale" buildup on the interior.