Britt Engineering Associates, Inc. Birmingham, ALL

Design Guide: Supporting FRP Piping Systems

By: Frank Britt PE

This paper presents a method of analysis and illustrations of typical supports that were developed specifically for Fiberglass Reinforced Plastic (FRP) Pipe. Britt Engineering Associates manufacturers a complete family of pipe and duct supports. These designs include features resulting from suggestions by design engineers and construction people who have determined how improvements would make the design and installation easier and faster. This family of designs is 30 years old and yet continues to grow and improve because we listen to the people who use them.

In the late 60's and early 70's, FRP materials were being developed that would propel the market of FRP pipe to new heights. FRP was being specified in new applications where only specialty alloys had been used and, as the applications expanded, FRP was becoming the complete problem solver. Resin manufacturers were developing new Polyester and Vinyl Esters. Fabricators were developing manufacturing methods that improved quality and reduced costs. In 1974 reports indicated that corrosion applications of FRP were to be the growth industry of the future, but about that same time some users were finding that frequent piping failures were causing concern.

One of the major manufacturers of resins determined that most of the piping failures could be eliminated through the use of proper supports, guides, and anchors. The technical information presented in this catalog is the result of the cooperative effort of this manufacturer and an engineering firm that resulted in the installation of a completely successful system that used FRP almost exclusively. These principles of pipe design along with the supports in this catalog have been used in thousands of piping systems with complete success.

When deviations to catalog standards are required, Britt Engineering Associates is prepared to provide design assistance and is equipped to furnish any specials that might be required. Britt Engineering Associates is continually cooperating with engineers, designers, and construction personnel in the specification of hangers and supports, and will assist in the interpretation of applicable piping codes. All supports are manufactured in the US using domestic materials only.

Britt Engineering Associates supports are almost always made to order since the outside diameter of FRP pipe varies depending on the manufacturer, wall thickness, and corrosion liner thickness. Being custom made it is important to order the supports as early in the schedule as possible. The company will work closely with your engineering and purchasing department to insure the best possible fit up of support to the pipe and that schedules are met.

The supports illustrated in this paper are intended for installation and service as designed and specified herein. Exceeding support spans, hanging one pipe beneath another, lack of component support and attempting to modify supports are some examples of misapplication. If there is a question about application, call Britt Engineering Associates. Our supports are

How do I start?

- **Review piping specifications.**
- **Review piping drawings.**
- **Review structural drawings**
- **Review valve and fitting specifications.**
- **Locate possible hanger locations.**
- **Analyze thermal movement, stress, and flexibility of the piping system.**
- **Calculate hanger loads.**
- **Select hanger types.**
- **Check hanger clearance around existing piping and equipment**

The following notes concerning the design and installation of FRP pipe and supports are provided as a help to the designer or engineer. These design notes are intended to serve as a guide to the proper use of the supports described in this catalog, and while it is impossible to cover every piping condition, experience indicates that approximately 95% of the support requirements can be met through the use of these standard designs. If the designer is faced with special conditions where a special design might be required he should contact Britt Engineering Associates for assistance.

The principles of design and analysis for FRP pipe differ considerably from the principles of design for the metallic pipe. The analysis of steel pipe normally begins with maximum flexibility, and the final support-guide-anchor design ends when allowables are achieved. When dealing with FRP pipe, the analysis normally begins with a fully anchored system and the final support-guide-anchor configuration is established when the minimum stress condition is reached (based on the available structural steel).

The fully anchored FRP piping system is often referred to as an anchor to anchor system. This simply means that an anchor is placed at each end of a straight run of piping. The pipe is restrained by the anchors from growing thermally and is guided to prevent buckling. This arrangement is never considered with a metallic pipe, but the low compressive modulus of FRP allows anchoring. The anchor loads are normally less than 1/60th that of steel but must be considered in the structural design of the support system, especially in large diameter pipe.

Many vendor catalogs include tables that the designer can use to determine support, guides and hanger spacings. The spacings are usually based on a specific gravity of 1.2, a liquid temperature of 160 or 180 degrees F, and a limited deflection of 1/2". This information is useful for estimating but in most instances the spacings are not based on total pipe stress. Very seldom is pressure stress considered in the derivation of these tables. In FRP piping systems it is very important that the total stress is considered when selecting support spans. By using the equations presented in the technical section of this catalog the designer can accurately define support and guide spacings and be assured that the pipe is designed to operate within the specified allowable stress.

The use of the procedures outlined in the Technical Section of this catalog will

Greatly improve the reliability and service life of any FRP piping system. The same procedures will work equally well with duct systems. As these procedures were being developed, it became evident that there were no commercially available standard supports for FRP piping. Many different designs were illustrated in many of the catalogs, but a review of the designs indicated that additional work would be needed to make them work. Britt Engineering Associates developed a family of special FRP pipe support designs that was based on the maximum loads that might be expected in FRP piping. This family of supports has been used in almost every environment and in almost every condition found in process industries. Over the past 18 years, new designs have been added to expand the applications, and the size range was extended to pipe diameters of 108" and 120".

When specifying the supports shown in this catalog the designer will recognize the ease of application and will become familiar with the unique features that are important to the design of an FRP system. The long support with a full bonded liner eliminates failures due to local stresses. The low profile of all Britt Engineering Associates supports keeps the pipe close to the structural steel thus reducing the size and amount of auxiliary steel. Selecting standards greatly reduces design time and the standardization of supports reduces manufacturing costs. Interchangeability and standardization reduces or eliminates all field rework thereby reducing construction costs. Each support is clearly marked for easy identification.

As a word of caution, the designer is reminded to call Britt Engineering Associates when the need for sizes and loads exceed the support tables in this catalog. While Britt Engineering Associates has other standards that have been developed for special applications, the use of these supports must be checked against actual conditions.

Duct systems can be supported using the same basic designs shown in this catalog; however, since duct systems very seldom have fluid loads, the supports can be much lighter. All installation dimensions remain the same.

The designer should review the following design considerations to insure that all supports are correctly used. If there are any deviations from these standard practices and designs, the designer should contact Britt Engineering Associates.

1. FITUP of SUPPORT - The designer must specify the maximum OD of the FRP pipe to insure proper support fit. Pipe specifications normally require the pipe manufacturer to maintain a tolerance +1/8" - 0.0" on the OD and the manufacturer is required to state the maximum OD in his quotation. The support will be manufactured to fit within 1/16" of the maximum OD.

2. LOCATION of SUPPORTS - When supporting pipe inside of a building, the building steel will provide the easiest support points. If the support spacing is based on the spacing of the structural steel and is found to exceed the calculated support spacing, use a slightly (1/16") thicker pipe wall and re-run spacing calculations. Continue adding wall thickness until the required span is reached or until added wall thickness starts to decrease span capability. If the pipe does not span, then intermediate supports, requiring the addition of auxiliary steel, are required. Of course, a comparison of the increased pipe cost vs. the cost of auxiliary steel will allow the designer to decide whether a heavier pipe will offer advantages.

3. LOCATION of GUIDES - Guides serves as supports and also provides lateral restraint to prevent buckling of the pipe when the pipe expands due to elevated temperatures. Smaller piping will require more frequent guiding, and in some cases, the use of guides may be required at every support point. Larger piping may require every other support point to be a guide. Calculations should be made to determine exact requirements.

5. FIXING of ANCHORS - FRP anchors are designed to grip the pipe lightly and are never to be allowed to clamp the pipe with any excessive force. The anchor is fixed to the pipe by applying shear collars, or FRP bands to the pipe on either side of the anchor. Except for very unusual cases the collars are applied in the field after the anchor has been installed. The collars are built up of layer's of 1-1/2 oz. mat to a thickness that allows the anchor to bear against the collar. See Fig.130

6. RISER SUPPORTS - Vertical runs of pipe inside of a building normally are supported on floor sleeves or off of curbs surrounding a pipe chase through the floor. Riser supports or riser guides when required are fixed to the pipe using the same shear collars as used with anchors. However the collar need only be applied to the top side of the support so that the weight of the riser can be carried by the riser support. The rule for riser guide spacing is the same as other guides unless the pipe is subjected to wind loads where more frequent guiding is required. It is important to note that loads for riser supports can be very high, especially in large diameter pipe. Loads in excess of support ratings will require special designs and should be brought to the attention of Britt Engineering Associates

7. SUPPORTS for INSULATED PIPE - Special supports are used to accommodate up to 4" of insulation. In all except very special cases the supports, anchors, and guides are attached to the pipe and are not designed to clamp or support the outside of the insulation. When heat tracing is required the tracing passes outside of the support. *** Important *** If heat tracing is required contact Britt Engineering Associates for special details and designs.

8. COMPONENT SUPPORTS - It is very important that all valves and inline components be supported independently of the pipe. In some instances, it is necessary to anchor the component where heavy actuators are cantilevered off of the valve or component or where external loads or dynamics might damage the pipe. Components in vertical and horizontal pipe runs require support although components in vertical runs may not require independent support of each component,

9. EXPANSION - The thermal expansion of FRP is two times that of steel and requires special attention especially where a fully anchored system is not used. Expansion joints and expansion loops are sometimes specified, but these add a weakness to the system. Expansion loops in addition to adding extra piping will add as many as four fittings and at least eight more joints. Each joint is an additional point of weakness. If lack of structural restraint presents a problem where anchor loads might preclude the use of the anchored system, there are several other design methods that can be employed, but in most cases, the anchored system can be incorporated. The description of the other design methods is beyond the scope of this manual because these are special cases. If there is a problem in using the anchored technique call Britt Engineering Associates and we will be glad to discuss specific applications.

10. COATINGS – Hot dip galvanizes is the most common finish but a high-quality prime coat that is applied by spray coating is available. Paint systems are in compliance with EPA regulations regarding VOC and hazardous materials. It is very important that the designer selects a corrosion resistant coating that will withstand the environmental conditions in the area where the pipe supports are to be installed. If special high-performance coatings are required these should be specified in the purchase documents. Britt Engineering Associates is able to provide any coating system that might be required and can also provide assistance in the selection of special coatings.

PIPE PHYSICAL PROPERTIES COMPARISON [1]

	Filament Wound (2)	Centrifugally Cast (3)	Hand Lay-up (Contacted Molded)	Polyvinyl Chloride	Low Carbon Steel
Modulus of Elasticity in Tension Axial 77° F, psi	$1.0 - 2.7 \times 10^6$	$1.3 - 1.5 \times 10^6$	$0.8 - 1.8 \times 10^6$	$3.5 - 4.0 \times 10^5$	29×10^6
Ultimate Axial Tensile Strength 77° F, psi	8,000 - 10,000	25,000	9,000 - 18,000	6,000 - 7,000	50,000 - 70,000
Ultimate Hoop Tensile Strength 77° F, psi	24,000 - 50,000	25,000	9,000 - 10,000	6,000 - 7,000	50,000 - 70,000
Modulus of Elasticity in Beam Flexure 77° F, psi	$1 - 2 \times 10^6$	$1.3 - 1.5 \times 10^6$	$1.0 - 1.2 \times 10^6$	3.5×10^5	29×10^6
Thermal Expansion in. / in / ° F	$8.5 - 12.7 \times 10^{-6}$	13×10^{-6}	15×10^{-6}	3.0×10^{-5}	6.0×10^{-6}
Heat Deflection Temperature 264 psi ° F. (4)	200 - 300	200 - 300	200 - 250	155 - 165	N/A
Thermal Conductivity BTU/hr./ft.^{2}/° F/in..	1.3 - 2.0	0.9	1.5	1.0 - 1.4	300 - 350
Specific Gravity	1.8 - 1.9	1.58	1.3 - 1.7	1.3 - 1.6	7.85

1. For exact values contact pipe manufacturer.
2. Values shown for Filament-Wound Pipe are based on pipe wound at an angle of approximately 54°
3. As published by a leading manufacturer of centrifugally cast pipe.
4. ASTM D 648

Design Considerations for FRP Piping Systems

Background - The use of fiberglass reinforced plastic (FRP) in the construction of pipe for process piping systems is becoming more and more popular. The possibilities of its utilization in new and unique ways have outgrown the available body of knowledge necessary to assure its proper application. The shared interest among designers is to extend the range and quality of those and other new applications. There are many years of practical experience in every area of FRP application, yet there is little published data that would allow an engineer to establish basic ground rules for the design of an FRP process piping system. Recently, there has been tremendous growth in the use of FRP in piping systems, and it appears that this growth will continue.

The purpose of this report is to present the basic principles that have been used successfully to design FRP piping systems and also to describe problem areas that have caused difficulty. The main emphasis of this report is toward piping design rather than material selection. The task of material selection has been much simplified through the efforts of resin suppliers who provide complete corrosion data for the proper selection of a resin system. Most resin suppliers will also provide case histories detailing the behavior of their products in almost every environment and application.

Mechanical Properties - After the selection of a resin system, a determination as to the type of pipe must be made. There are three major categories of FRP pipe construction. They are: (1) contact molded, (2) filament wound, and (3) centrifugally cast. The mechanical properties of the pipe are closely linked to the method of fabrication, and those properties vary considerably among the three types.

Despite conjecture as to the advantages and disadvantages of each type of pipe construction, it has been found that any of the three can be utilized if the pipe is of high quality and if the system has been properly designed and supported. The specific mechanical properties of the pipe selected are incorporated into the design of the system. This includes the location and type of support. The mechanical properties inherent to the method of pipe fabrication are discussed in a later section.

The most important factor in the design of a piping system is the determination of the mechanical properties of the pipe over the operational temperature range of the system. The catalogs for many pipe manufacturers list the range of properties for various laminates, but very few provide performance data at elevated temperatures. The equation which is used to determine the design aspects of any structural system utilizes factors for the mechanical properties under the expected design conditions, including temperature. Without this information, the designer is severely handicapped.

Britt Engineering Associates, Inc.
Birmingham, AL

Support Design

ANCHOR LOAD

$$F_A = \underbrace{A_t E_T \Delta T \alpha}_{\text{THERMAL LOAD}} + \underbrace{P A_f}_{\text{PRESSURE LOAD}}$$

WHERE:

α = THERMAL COEFICIENT OF EXPANSION

A_t = CROSS-SECTIONAL AREA, TOTAL WALL, in.^{2}

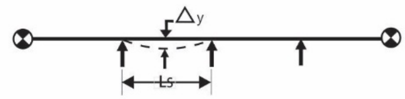
$\Delta T = T_{OP} - T_{INS}$, °F

P = MAXIMUM OPERATING PRESSURE, lb/in.^{2}

A_f = FLOW AREA, = $\frac{\pi D_f^2}{4}$

NOTE: ANCHOR LOAD IS INDEPENDENT OF PIPE LENGTH

FIGURE 3 - Anchor loads



SUPPORT SPAN REQUIREMENTS:

A. DEFLECTION LIMITED, Δy = 1/2 INCH

$$L_s = \sqrt[4]{\frac{460.8\, E\, I}{W}} \bullet \frac{1}{12}$$

B. STRESS LIMITED $\sigma_n = \frac{\sigma_{tu}}{5} - \sigma_p$

$$L_s = \sqrt{\frac{.67\, \sigma_n\, S}{W}}$$

USE SMALLEST VALUE

WHERE:

E = YOUNG'S TENSILE MODULUS AT OPERATING TEMP., lb/in.^{2}

I = MOMENT OF INERTIA, STRUCTURAL WALL, in.^{4}

W = WEIGHT/FOOT.PIPE + FLUID, lb/ft.

σ_n = NET ALLOWABLE STRESS, lb/in.^{2}

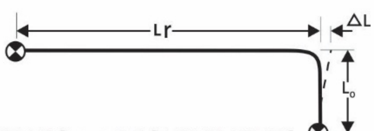
σ_{tu} = ULTIMATE TENSILE STRESS, lb/in.^{2}

σ_p = PRESSURE STRESS, $\frac{P A_s}{A_t}$

S = SECTION MODULUS, STRUCTURAL WALL, in.^{3}

As = AREA, STRUCTURAL WALL

FIGURE 4 - Support Spans.



OFF-SET LEG (L_O) REQUIREMENTS:

A. STRESS LIMITED (CANTILEVER BEAM WITH LOAD AT FREE END)

$$L_O = \sqrt{\frac{3 \Delta L\, E\, D_O}{\sigma n}} \bullet \frac{1}{12}$$

B. BENDING MOMENT LIMITED

$$L_O = \sqrt{\frac{6 \Delta L\, E\, I}{M_{MAX}}} \bullet \frac{1}{12}$$

USE LARGEST VALUE

WHERE:

Lr = LONGEST RUN INTO ELBOW. (ft. in.)

Δ_L = THERMAL EXPANSION = Lr ΔT α in. (12)

E = YOUNG'S TENSILE MODULUS AT OPERATING TEMP., lb/in.^{2}

D_O = PIPE OUTSIDE DIAMETER, in

σn = NET ALLOWABLE STRESS

M_{MAX} = MAXIMUM ALLOWABLE BENDING MOMENT, in.-lb (MANUFACTURER'S TEST DATA)

FIGURE 5 - Offsets

GUIDE SPACING REQUIREMENTS:

$$L_G = \sqrt{\frac{\Pi^2\, I\, I}{A_t\, \alpha \Delta T\ (2)}} \bullet \frac{1}{12}$$

EULER EQUATION FOR PIN ENDED COLUMNS

WHERE:

L_G = GUIDE SPACING ft.

I = MOMENT OF INERTIA, STRUCTURAL WALL, in.^{4}

A_t = CROSS-SECTIONAL AREA, TOTAL WALL, in.^{2}

W = COEFFICIENT OF EXPANSION, in./in.°- F

$\Delta T = T_{OP} - T_{INS}$, °F

(2) = FACTOR FOR ECCENTRICITY OF LOADING OR DEVIATION FROM PIN COLUMN

FIGURE 6 - Guide Spacing

Figure 1 shows the change in modulus at elevated temperatures for two filament wound polyester pipes. This type of data is required in system analysis if the design is to be sound

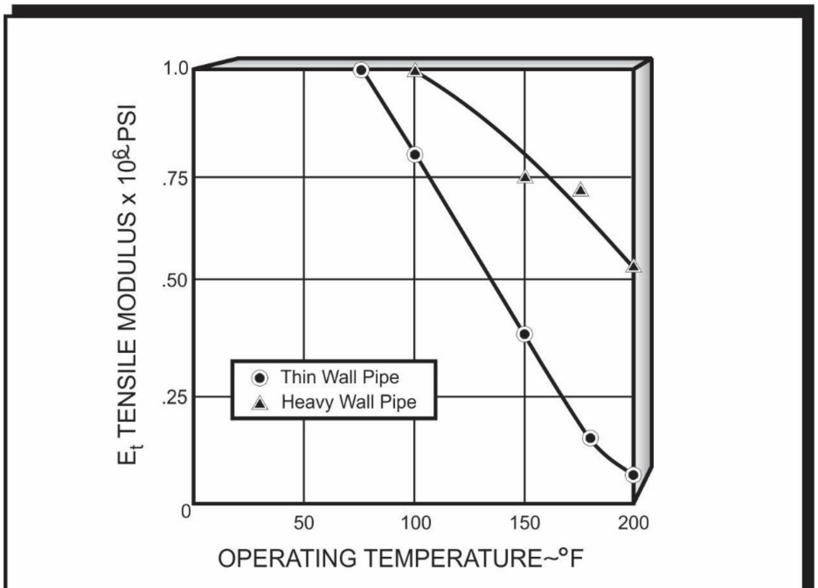


FIGURE 1 - Tensile modulus, E_t vs temperature, F °

Comparisons - The following compares and contrasts the design features and advantages of the three types of FRP pipe:

Contact Molded. The high resin to glass fiber ratio of this pipe makes it ideal for highly corrosive fluids. In order to meet the strength requirements in the hoop direction, it usually has a thicker wall than the other types of pipe. For this reason, it is heavier. Also, since it is virtually hand made, it is more expensive. Strength in the axial direction is higher than filament wound pipe. Because the pipe is hand made, it is subject to wider manufacturing tolerances than the other types of pipe. This is especially important to the support designer who is responsible for the designed fit of supports. Contact molded pipe is highly recommended for use where it might be subject to a severe exterior environment. Fittings are normally joined to the pipe using the butt and strap method.

Filament Wound. A high glass content and precise fiber orientation make this type of pipe ideal for pressure applications. Machines are used more in its fabrication, so the tolerances are closer, the mechanical properties more consistent, and the production cost is lower than for contact molded pipe. Due to the low resin to glass fiber ratio, a corrosion liner of a minimum 100 mils should be provided. Since the axial strength of filament wound pipe is less than that for contact molded pipe, at the same pressure rating, the filament wound pipe will require a much closer support spacing. This is due to the thinner wall common with filament wound pipe. The preferred method of joining fittings and pipe is the butt and strap method, although several manufacturers provide tapered bell and spigot ends for joining pipe and fittings. The bell and spigot joint is an adhesive joint that is dependent on the glue line between the bell and spigot.

Centrifugally Cast. This type of pipe is almost fully machine made, and it provides the most consistent mechanical properties and the closest tolerances. It has a lower glass fiber content than filament wound pipe and features higher corrosion resistance. The smooth outside diameter also facilitates a more consistent support design. Cast pipe, due to fiber orientation and higher glass content, has a higher axial strength than either the filament wound or contact molded pipe. Cast pipe has an unreinforced corrosion liner which is susceptible to damage by impact, but if the pipe is properly handled and supported, it should pose no problems. Fittings are normally of the socket weld type that can be overwrapped if added joint security is desired. However, with correct installation procedures and inspection, the overwrap is generally considered unnecessary.

Design Considerations

Contact molded FRP pipe, made according to PS 15-69, is normally rated by pressure in increments of 25 psi up to 150 psi. Standard machine made pipe does not follow this type of rating and the designers should refer to the ultimate pressure rating listed in the manufacturer's catalog. It is important to note that these ratings are based on the allowable pressure of a continuously supported pipe subject to pressure stress only. Since piping systems are almost never continuously supported, the stresses of bending must be considered when determining the allowable working pressure of an FRP pipe. The equations presented in the section on Support Design take these stresses into account.

Wall thicknesses are based on a 10:1 safety factor in the hoop direction and it is customary to use a 5:1 or 6:1 safety factor in the axial direction. By maintaining these safety factors in the design, stress risers in elbows and other fittings will be within the allowable stress limit.

The method of design layout preferred by **Britt Engineering Associates** is an anchor to anchor design. This design method can be economical and offers many advantages. The anchor to anchor system is more rigid and less susceptible to damage due to dynamic loading. This system also provides a means for controlling expansion (thermal and pressure), thereby reducing the length of offsets and eliminating the need for expansion joints. Anchors are placed on either side of every change in pipe direction and as near to the fitting as possible. The amount of structural steel required to absorb the loads imposed on the anchors can be minimized by keeping the pipe elevation close to the steel and by utilizing tension members between anchors. It is important to recognize that the pipe must be guided between anchors to prevent buckling. In cases where there are long straight runs, anchors should be placed no more than 150 to 200 feet apart.

When the anchor to anchor design cannot be used, and the pipe must be hung with rod hangers, a great deal of care should be taken to ensure flexibility. However, a pumped system that is too flexible will vibrate and destroy itself if vibrations are within the resonant range. Excessive stresses can also be induced by wind loads. To reduce vibration and wind load effects, the pipe should be laterally restrained at specified intervals along the pipe. These restraints should not be located near changes in direction where offset legs are required for flexibility.

Design Techniques

Many piping system failures that occur during hydrostatic testing, or even after years of service, have been attributed to poor workmanship. These failures are due to an overstress condition which was caused by either poor workmanship or unsatisfactory design. The task of the designer is to eliminate, as much as possible, the likelihood of failure. With sufficient effort spent on the design and in the instruction of installation personnel, failures can be effectively reduced. It is hoped that the design techniques presented here will help to standardize a conservative design approach. Beyond this, a great deal of work is necessary to standardize installation techniques, especially the methods for fabricating joints.

In an effort to reduce the possibility of failure, the designer should seriously consider the following:

Keep the pipe run away from high traffic areas where damage from equipment impact is likely.

- Keep flange joints to a minimum.
- Provide vents at each high point.
- Provide drains at each low point or pocket. (Drains with blind flanges will allow the line to be drained if repairs are necessary.)
  - Ensure that all supports, anchors, and guides are installed prior to the hydro test. (This cannot be overemphasized since the pipe system can be severely damaged without proper pipe support.)
  - All valves and valve operators, or components in the system, must be independently supported.
  - Riser supports for long vertical runs should be guided or restrained to reduce vibration and wind load effects.

When setting up for hydro testing, open all high point vents to remove all air and connect the pump to the lowest point in the system. (The pump should be a small, positive displacement pump [3 to 5 gpm] and should be equipped with a pressure regulator that will allow the system pressure to build slowly.)

Economic Considerations

With material prices and the cost of labor rising frequently, a cost comparison between an FRP system and any other is meaningless since cost data is out of date before it is printed. FRP is normally selected because of its corrosion resistance. However, one important point that should be made concerning any comparison is that the total installed cost to be considered. Many studies do not include data on the support system required for FRP pipe. This is because most analysis procedures tend to regard all piping systems as being supported in the same manner and at the same relative cost. In addition, the cost of auxiliary steel, and the labor necessary to install that steel should be evaluated.

The service life of each system is an important factor and should be included in the evaluation if sufficient historical data can be obtained. Many designers would probably elect to use materials other than FRP when the installed price of the two systems is relatively close, but the extended service life of FRP systems will usually be more favorable. Generally, experience at Britt Engineering Associates has indicated that FRP systems are more economical than other systems in pipe sizes above 4 inches where special metallic materials are considered.

Applicable Codes and Standards

There are very few codes or standards applicable to the design of FRP piping systems. The designer should be familiar with the American National Standard Code for Pressure Piping (ANSI) B31.3, although it deals mainly with metallic pipe it has been expanded to cover non-metallics including thermoplastic and thermoset materials. The only other standard that could prove useful for design purposes is the NBS Voluntary Product Standard PS 15-69, which covers custom contact molded FRP equipment. This document is no longer published by NPS, but copies can be obtained through some of the resin and glass manufacturers. The tables for pipe included in this Standard should be used with care.

The American Society for Testing and Materials (ASTM) has published standards for Plastic Pipe and Building Products, Section 8, Volume 08.04, 1993. This document is a compilation of test procedures and methods for establishing material and mechanical properties for plastics used in piping.

A number of codes and standards are being developed to promote standardization of the product, but they are not available at this time. One excellent guide that is available is a book entitled "Corrosion -- Resistant Plastic

Composites in Chemical Plant Design" by J. H. Mallinson, published by Marcel Dekker, New York , 1988. Another book that provides good overall coverage of the use of FRP is "Fiberglass Reinforced Plastics Deskbook" by N.P. and P.N. Cheremisinoff, Ann Arbor Science, Michigan, 1978.

The Composites Institute of the Society of Plastics Industry published a "Fiberglass Pipe Handbook" in 1989 that is a document that was written by the Fiberglass Pipe Institute, New York. The handbook is a compilation of technical sections covering above and below ground piping systems, and while it is an excellent reference for piping design, the methods of analysis and design of supports presented in this book are not the same as recommended in this catalog.

The use of expansion joints and expansion loops are very rarely used in practice, and the supports recommended in the handbook should not be used except in very light duty service.

Layout of Piping Systems

The preliminary piping layout for FRP piping is the same as for any other system (Figure 2). Once a general piping arrangement has been selected, an isometric of the system should be made and the following steps taken:

- Locate available support steel and establish the location of additional support steel as required. Existing bridges, pipe racks and building structural steel will establish the available support spacing.
- Locate anchors at each change in pipe direction and as close as possible to elbows.

- Locate riser supports and component supports. Riser supports can be tentatively located on 10-foot centers until calculations are made.
- Establish support design criteria and pipe wall thickness required using the equations in the section on Support Designs factoring the operating temperature and pressure of the system. An iterative process is employed to obtain wall thickness and to define acceptable support spans.
- Tabulate support design criteria shown in Table 1 and rearrange support spacing and anchor locations on the isometric to meet design criteria. Add guides at locations determined in the table.
- Check offset leg requirements between anchors at directional changes. Relocate anchors as required to meet offset requirements.
- Rearrange riser support locations. The distance between centers should not exceed the guide spacing. In areas where offset leg requirements cannot be met, consideration should be given to

rerouting the pipe to provide more flexibility.

Table 1 (Sample Only)

Nominal Pipe Size	Wall Thickness (Inches)	Support Span (Inches)	Offset Leg (Inches)	Guide Spacing (Inches)	Anchor Load (Inches)
4"	.202	8.3	.47√ L	11.5	3500
6"	.202	9.6	.64√ L	16.7	5200
10"	.250	12.3	.82√ L	28.0	9842
12"	.265	13.1	.90√ L	33.7	12250

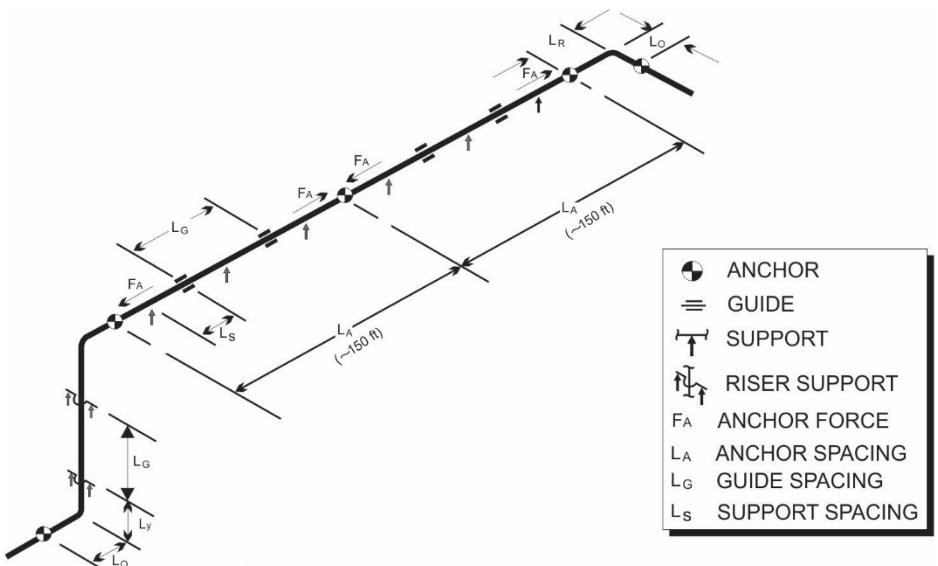


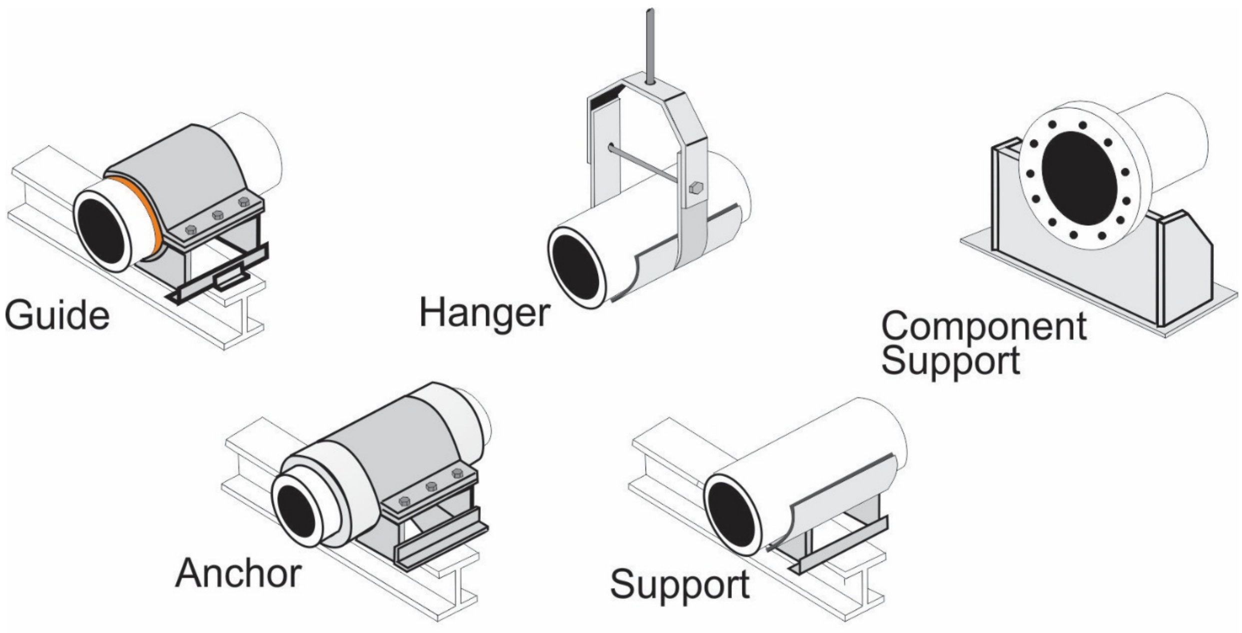
Fig. 2 Typical pipe run

Vibration - Pump or equipment vibrations are usually absorbed by the piping system; however, it is a good practice to use an expansion joint with tie rods at the pump discharge if the discharge pipe can be anchored. Care must be exercised to insure that the pump is capable of handling the thrust loads and/or thermal loads that are developed by the fittings.

Water Hammer - There are several recommended methods for reducing water hammer effects. There are several air chamber designs available that will help reduce shock but the best method is to design the system so that slugging does not occur. Slowing the response time of the control valves to a minimum of eight to ten seconds will usually achieve this.

Cavitation - This is caused by a restriction in the line, such as a control valve, that causes a drop in local pressure due to high flow velocities through the restriction. Gate valves should be used where possible instead of butterfly valves.

Conclusions - The experience at Britt Engineering Associates has positively shown that the design approach used in this report will provide a satisfactory system if reasonable care and control is exercised when the pipe is installed. The supports, guides, and anchors shown in this catalog have been designed to match the analysis and support requirements for FRP pipe and have been proven through 18 years of service. The finish and/or coatings on the support should be selected to match the environmental conditions of the process system and should be specified by the designer. Standard finishes for Britt Engineering Associates support are either epoxy primer or hot dip galvanize. Special coatings are available and Britt Engineering Associates can assist the designer in the selection of the most cost efficient coating system.



Suggested Supports for FRP Pipe

This design guide presents a system of analysis and design that has been adopted and successfully used by many professional engineers and engineering companies however, the user must have knowledge of piping engineerinmg and standard practice. A complete design must also include a detailed specificaton for FRP pipe and fittings. Britt Engineering Associates can provide assistance for checking dsigns, calculatons and offers guidelines for pipe specifications.