Fiber Glass Systems NOV
STAR • SMITH • FIBERCAST

Installation and Application Practices

Threaded Line Pipe

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READ FIRST:

Revisions have been made to the sections listed below of the Installation and Application Practices for Threaded Line Pipe (Issued 3/1/2006, Supersedes 11/02/04):

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- 2.2.1 - Ditch Preparation
  - *Fluid Applications*
  - *Gas Applications*

2.5 Star Super Seal Connections (page 14)
- 2.5.2 - Standard O-Ring Sizes and Types
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- 2.7.1.2 - Fiberglass Flat Faced Flanges
  - *Drawings*
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1.0 Receipt, Handling and Inspection

1.1 Transportation

Following are the primary concerns for Domestic U.S.A. or Inland Shipments:

- Dedicated **(Fiberglass Only)** 34 ft. to 40 ft. flat bed trailers (oilfield hauler).
- We do not recommend pipe hanging off the trailer.
- Transporting the pipe on racks above a small truck (headaching) can cause potential impact damage.
- Do not use chains for tie downs, only straps.
- Tie downs should be located near the dunnage, 4 times minimum.

International shipments require:

- Dedicated **(Fiberglass Only)** 40 ft. either open top or high cube containers.
- Fiber Glass Systems (FGS) loads all containers at factory.
- It is highly recommended that the containers are not unloaded at port of destination.
- Shipments where the containers can not be transported inland require the pipe to be crated at factory.
- Crates can be installed inside of containers for removal at the port of destination and then transported inland.
- Sea worthy crates and insertion crates for containers are both available.

1.2 Load Inspection

The inspector should:

- Check quantities, report deviations.
- Look for load shifting, check for missing dunnage.
- Watch for excessive bending caused by over-tightening of straps.
- Check for missing thread protectors and thread damage, replacement protectors can be purchased.
- Look for impact damage (blister caused by abrasion or blow with a sharp object).
- Quarantine or mark joints which appear damaged, do not install damaged pipe.

1.3 Unloading

Common practices include:

- Bundled pipe - breaking a bundle allows the pipe to move freely.
- Forklifts are commonly used with a spotter man to avoid damaging other bundles.
- Use a spreader bar and slings for off loading with a crane.
- Never allow pipe to roll off trailer to racks or ground.

1.4 Storage

Protect the pipe as follows:

- Set the pipe on a surface free of sharp rocks.
- Leave the separator boards between the pipe layers.
- If pipe racks are used, strip them with lumber to protect the pipe from sharp edges.
- Use four racks equally spaced to avoid permanent bending particularly for longterm storage.
- Storage for 1 year or more requires coverage with a tarp to avoid UV discoloration.
- Thread protection must remain in place to avoid degradation of thread tolerance.

1.5 Ultraviolet Effects

- Ultraviolet effects on the pipe are limited to surface discoloration. Eventually, "fiber bloom" or fusing will occur if the pipe is left exposed to the sun long enough; the degradation is limited to the outer 0.005-0.01 inch of the pipe. (Table 1.5a)

  Fiberglass pipe may be protected from the ultraviolet rays by painting with a heavily pigmented industrial coating or by coating with an ultraviolet absorbing agent.

  Since FGS tubulars have a 50% design safety factor built in, the surface effect of ultraviolet is minimal and does not reduce the long-term performance of these products significantly.

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Ultraviolet Effects on Fiberglass pipe

Table 1.5a

Time Exposed	Pipe Conditions
6 months	Pipe color changes from green to tan, no effect on physical properties
1 year	Pipe color becomes dull tan and shiny fibers. No effect on physical properties
2 years	Approximately 50% of the pipe surface shows shiny fibers. No effect on physical properties
3 years	Approximately 90% of the pipe surface shows shiny fibers. No effect on physical properties
5 years	Pipe will be fuzzy with the entire outer layer of glass exposed. No further damage to pipe will occur. Pipe will operate at 100% of rating with no problems.

1.6 Reshipping and Stringing Line Pipe

Necessary precautions include:

- Loose pipe must be loaded with the joints staggered like from factory.
- Separate each layer of pipe with wooden dunnage. CAUTION - never groove pipe and pyramid like steel is shipped.
- Always use straps to tie down pipe, never chains.
- Never drop the pipe off the truck, avoid sharp rocks.
- Place uprights on the trailer to keep the pipe from falling off the trailer while stringing.
- Lay the pipe on the opposite side of the ditch where the dirt is piled.
- Do not remove thread protectors.

2.0 Line Pipe Installation

2.1 - Introduction

Many standard oilfield installation techniques are used to install fiberglass line pipe. During the installation, Fiber Glass Systems, LP. recommends that a company trained field service representative be on site for the purpose of training the installation crew and inspection of delivered product. It is also suggested that pre-bid or installation meetings occur with a representative in attendance.

Prior to starting an installation, several parameters must be defined:

- Type of service.
- Service conditions such as natural gas require 1 to 2 pressure range jumps for precaution against physical damage.
- Buried or above ground installation.
- Low pressure or high pressure pipe.
- Type of joining system.
- Required fittings.
- Acquire proper tools, make-up wrenches, select lubricant and accessories.
- Check the effect of make-up thread loss on the quantity of pipe ordered (Table 2.4.2a).

2.2 Buried Installations

2.2.1 - Ditch Preparation

Burying fiberglass pipe is preferred over above ground installations:

Fluid Applications:

- **High pressure** line pipe ≥ 2000 PSI requires a minimum of 3 feet of cover.
- **Lower pressure** ≤ 2000 PSI requires a minimum of 2 feet of cover.
- Compacted, sandy or fine grain soil installation conditions are preferred.

CW

- Fiberglass line pipe must be buried below the freeze depth or insulated to protect against freezing.
- **Rocky conditions** require extra precaution of a minimum 6 inches of sand pad around the pipe. Special rock pulverizing equipment may be considered.
- The **ditch bottom** must be level such that the pipe does not support the backfill.

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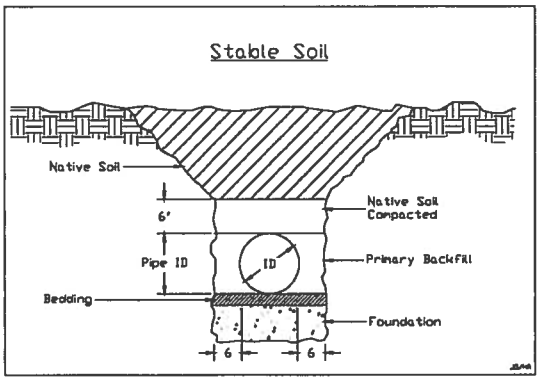
2.2 Buried Installation *(continued)*

Gas Application:

- **ALL gas applications** - Line pipe requires a minimum of 3 feet of cover.
- An increase of 1 to 2 pressure range jump for precaution against physical damage.
- Type of joining system.
- Testing with air is recommended.

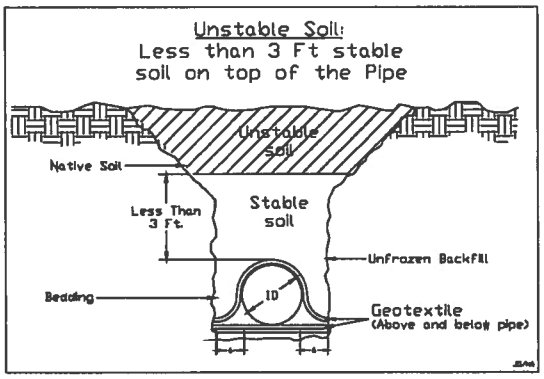
Figure 2.2.1a



- **Swampy, unstable soil procedures:**

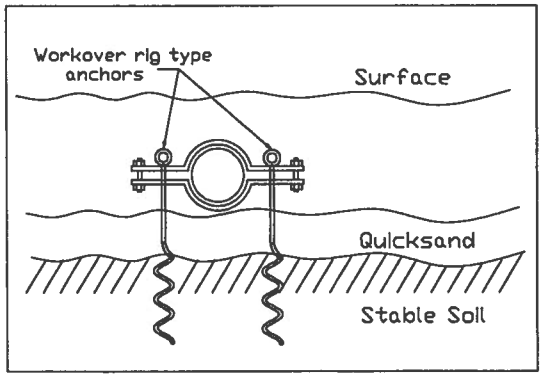
A. First, attempt to excavate deep enough to find a stable layer of soil. If this is not possible then there are several options.

Figure 2.2.1b



B. Special anchors can be designed if there is concern that the pipe will float or raise toward the surface. These anchors are special designed depending on the conditions. Many are complete saddles which go 360° around the pipe and are welded to work over rig type screw anchors (Figure 2.2.1c). The spacing between anchors is the same as the support span listed for above ground supports (See FGS Product Data Specifications).

Figure 2.2.1c



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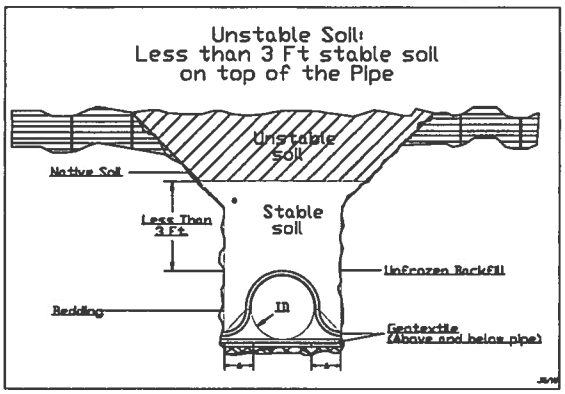
2.2 Buried Installations
(continued)

C. **Stabilization of the soil** can be achieved with filter cloth such as geotextile. This material has proven useful to stabilize the ditch bottom in boggy, wet conditions. Geotextile can be placed below the pipe to reduce sinking and above the pipe to stabilize backfill (Figure 2.2.1d).

Figure 2.2.1d



D. **Unstable ditches** where the connections can not be left open for hydrotest inspection require a daily 50 PSI air test. This test must be performed on the line to insure against leaks that may become covered and difficult to find during the final hydrotest.

E. Steel casing with end seal may become necessary in the event that a stable bottom can not be found or geotextile will not work.

CW · **Sub-Freezing climates** may require additional consideration. Stabilization of the ditch in some regions, such as Canadian Muskeg, may only be possible in the winter when the ground is frozen. The following are some techniques which have been used successfully:

A. Prior to installing the pipe gradual compaction of the ice can be achieved by driving over the pipeline route with light vehicles over a period of time.

B. The ditch is prepared by first pushing away the snow and then excavating the surface ice. Lay the surface ice away from the installation area so it does not become mixed with the unfrozen material.

C. Excavate until you find a stable layer of soil. If this is not possible then use geotextile and sand bags.

D. Steel casing with end seals may become necessary in the event that a stable bottom can not be found or geotextile will not work.

E. Since frozen backfill can not be put in the pipe zone it is recommended that the pipe is installed as the ditch is excavated.

F. Backfill which has been excavated and left overnight will freeze. This material can not be used in the pipe zone. Never attempt to compact backfill by driving heavy vehicles on the ditch line.

G. Preparing the ditch before this line is layed will require additional work to remove snow and fall in of the sides of the ditch.

2.2 Buried Installations
(continued)

- **Avoid over-bending** pipe by qualifying sharp horizontal and vertical changes to the maximum pipe bending radius or deflection per joint (see FGS Product Data Specification).
- **Multiple lines** laid in a single ditch require a minimum spacing of 6 inches between connection outside diameters.
- Remove tree roots from ditch.

2.2.2 - Joining Connections Above Ground

- Requires qualification of the minimum bending radius when the pipe is lowered into the ditch.
- Use only straps for handling pipe, never chains.
- Larger diameter ≥ 4½" products and heavy wall products are best to join in the ditch and may require lift equipment, use slings with a spreader bar (2 contact points).

2.2.3 - Joining Connections in the Ditch

- Requires attention to wrench movement.
- The ditch width must accommodate full movement of the wrenches or it must be widened (bell holes) at the connections.

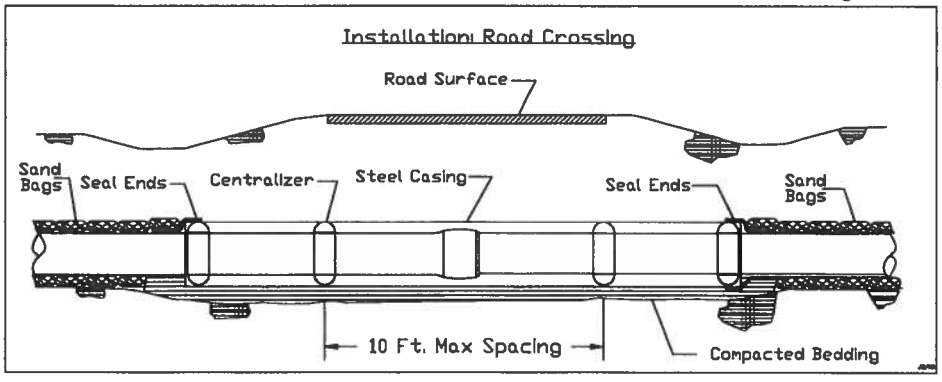
2.2.4 - Recommended Products for Joining in the Ditch

- ≥ 3" 3500 PSI
- ≥ 4" 3000 PSI
- ≥ 5" 1000 PSI
- ≥ 6" 1000 PSI
- ≥ 8" 500 PSI
- All 10" and 12"

2.2.5 - Road Crossings

- Road crossings require steel conduit, abrasion centralizers and end seals.
- Protect the pipe at the entry and exit of conduit against settling shear from sharp edges.

Figure 2.2.5a



- Avoid over-bending pipe to enter or exit road bore conduits. Either prepare the ditch for a gradual elevation change, or use fittings.
- Stabilize soil beneath casing to minimize settling.
- Sand bags eliminate pipe movement due to pressure or temperature fluctuations.

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2.2 Buried Installations *(continued)*

2.2.6 - Fittings Thrust Blocks

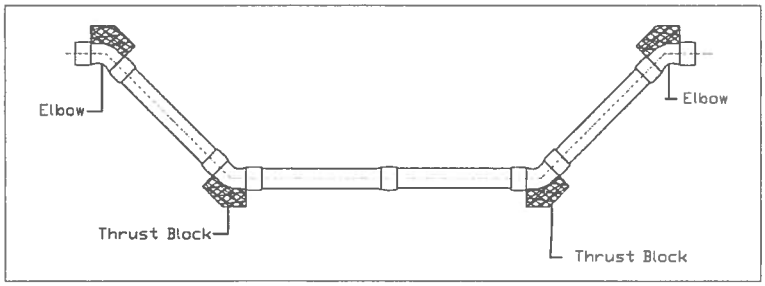
Concrete thrust blocks or sand bags are required on some 45° elbows, 90° elbows and tees that flow from the branch into the main. The following is a list of recommended products:

Table 2.2.6a

Size	45° Elbows		90° Elbows		Tees	
	Concrete	Sand Bag	Concrete	Sand Bag	Concrete	Sand Bag
1½"	NR	>3000	NR	>3000	NR	>3000
2"	NR	>3000	NR	>3000	NR	>3000
2½"	NR	>3000	NR	>2500	3000	2500
3"	NR	>2500	NR	>2500	3000	2500
4"	NR	>2000	>3000	>2000	>3000	2000
5"	NR	>1500	>1500	800-1250	>1500	800-1250
6"	>2000	800-1500	>1500	800-1250	>1500	800-1250
8"	>1500	800-1000	>1250	800-1000	>1250	800-1000
10"	>1000	450	>750	<500	>750	450
12"	>1000	450	>750	<500	>750	450

Sand bagging is an alternative in some instances. The 3" 2500 PSI, 4" 2000 PSI, 4" 2500 PSI, 8" 1000 PSI and 10" 450 PSI products require sand bagging and compaction of 90° elbows and tees.

Figure 2.2.6a



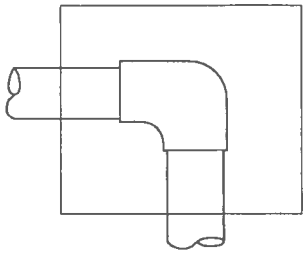


Figure 2.2.6b

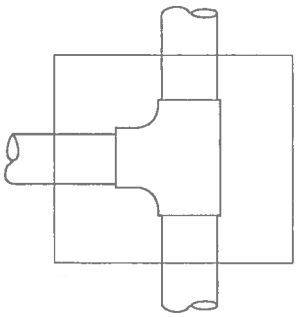


Figure 2.2.6c

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2.2 Buried Installations *(continued)*

2.2.7 - Backfill Guidelines

- Loose select backfill free of rocks or large tree roots must be used in the pipe zone (12" around the pipe).
- Do not backfill over connections until hydrotesting is complete.
- *CW* · **Cold weather back-filling** with frozen material in the pipe zone must be avoided since impact damage can occur.
- *CW* · Never compress the backfill on top of the pipe by driving heavy equipment on the ditch line as this will crack the pipe.
- See Hydrotest Preparation 2.6.2.
- **DO NOT** backfill a ditch full of water. Pump the ditch out, check the layout of the pipe for voids beneath the pipe. Fill any that are found, then backfill with dry soil.
- **Swampy areas** with unstable soil require special attention. Anchors or steel sleeving the pipe is required in some instances.

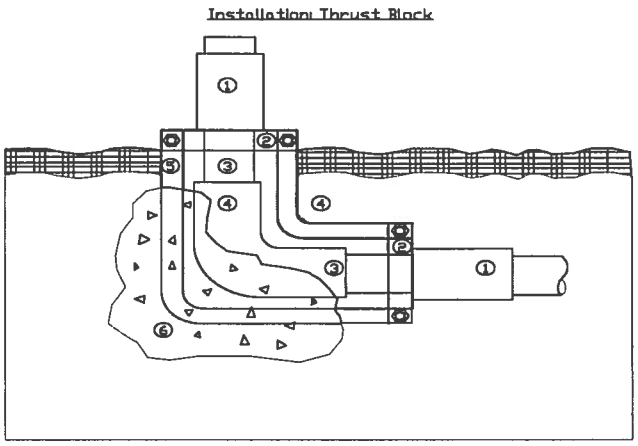
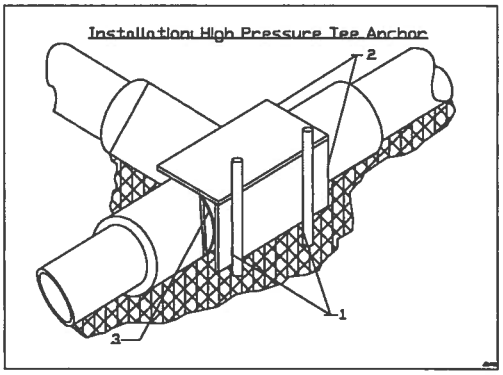


Figure 2.2.7a

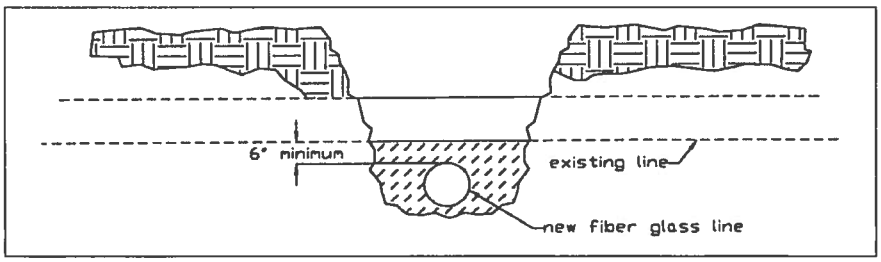
Figure 2.2.7b



2.2.8 - Line Crossings

- **Line crossing** must be padded for abrasion.
- Install the fiberglass under existing lines whenever possible.
- Good practice is to leave a minimum of 6 inches between lines.

Figure 2.2.8a



2.3 Above Ground Installation

2.3.1 - Support Spacing

- Support spacing must not allow the pipe to support the media being transported (see FGS Product Data Specification for spacing).

2.3.2 - Wear Saddles

- Wear saddles must be used to protect the pipe 360° around the pipe against pulsation abrasion or pipe movement due to temperature fluctuation.

2.3 Above Ground Installation *(continued)*

2.3.3 - Ultraviolet Effects

- See 1.5 Storage and Handling

2.3.4 - Thrust Blocks

- Thrust blocks for above ground installation must be constructed to support fittings listed in Table 2.2.6a; The design must simulate the same support as buried concrete thrust blocks; abrasion padding is recommended.

Figure 2.3.4a

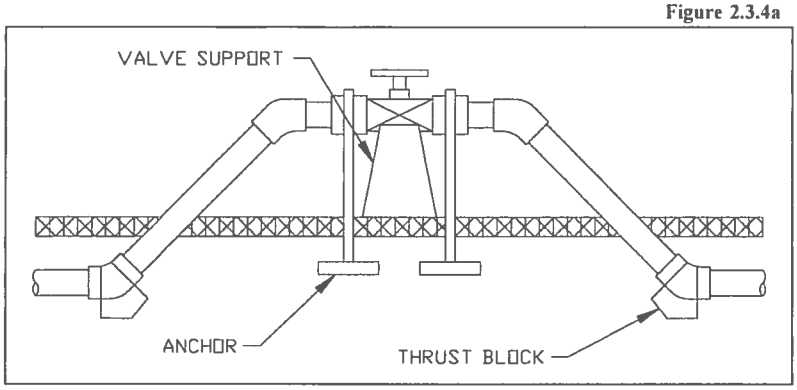
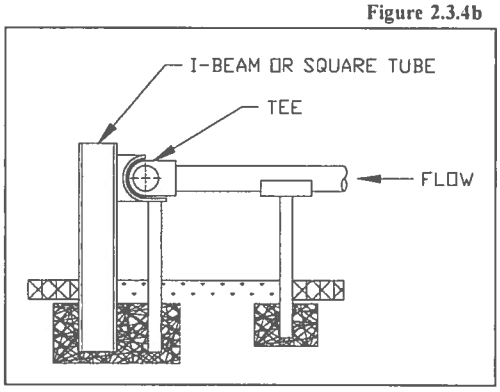


Figure 2.3.4b



2.4 API 8rd Threaded Connections

2.4.1 - Introduction

The ACT molded thread is the industry standard API EUE 10RD, EUE 8RD and OD 8RD which is available either coupled or integral joint. FGS also offers a precision diamond ground API thread for lower pressure line pipe. Depending on the size and pressure rating the connection utilizes either a teflon based lubricant (***STAR***tec™) or a proprietary sealant called Hi-Pro to achieve the seal. All API threaded products can be installed using Hi-Pro. Listed (Table 2.4.2a) by size and pressure are the recommended lubricants and the estimated number of connections, which can be made up per container with daily installation rates.

2.4.2 - Make-Up Tools

Make-Up tools are designed to provide uniform 360° compression on the pipe while applying the required make-up torque. The FGS friction wrench, along with one of three different strap wrenches, are required for proper make-up. The following table (Table 2.4.2a) are the combinations of recommended wrenches for each size pipe:

PRECAUTIONS

- Never use typical oilfield pipe wrenches on fiberglass pipe. Chain tongs may be used on high pressure fiberglass fittings, but not on pipe.
- The integral joint connection is conical shaped. Care must be taken if a friction wrench is used on the female integral joint for back-up. Excessive force could cause damage to the integral joint female in the transition area. The friction wrench is designed for use on the male upset, which is flat and round.

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Table 2.4.2a

Thread Size	1.90"	2 3/8"	2 7/8"	3½"	4"	4½"	5½"	6 5/8"	7"	8 5/8"	9 5/8"
Make Up Length Loss	2.06	2.56	2.88	3.13	3.88	3.50	4.38	3.88	4.50	4.50	4.75
Male Upset	Metal Friction Wrench (MFW)										
IJ Female	No. 5			No. 11			MFW	No. 20		No. 30	
STARtec™ - Jts./Gal.	100	100	100	68	50	50	34	34	34	26	26
Hi Pro Plus™ - Jts./Kit	33	25	20	16	12	12	10	8	8	4	3
Installation Feet/Day	5000 to 7000 ft.	5000 to 7000 ft.	5000 to 6000 ft.	3000 to 4000 ft.	3000 to 4000 ft.	2000 to 3000 ft.	2000 to 3000 ft.	1000 to 2000 ft.	1000 to 2000 ft.	1000 to 2000 ft.	1000 to 2000 ft.
Crew Size(1)	4 to 5	4 to 5	4 to 5	5 to 6	5 to 6	5 to 6	6	6	6	6	6
Thread Standoff	FGS industry standard API EUE 10rd, EUE 8rd and OD 8rd threads are designed to advance to the "power tight" position with "2" thread standoff. Due to manufacturing thread tolerances, it is not uncommon to see "1 to 3" thread standoff, with "2" threads standoff being the average.										

Notes:
(1) - INCLUDES CONTRACTOR SUPERVISOR
FOR FURTHER ASSISTANCE WITH TABLE 2.4.2a, CONTACT A FGS SERVICE REPRESENTATIVE.

2.4.3 - Cleaning and Inspection

- Thread protectors must be left in place until ready for joining pipe.

CW · Frozen ice will make thread protectors impossible to remove, heat the ends of the pipe with a tiger propane torch until they release.

CW · If an open flame is not permitted, methyl alcohol can be used to melt the ice out of the connections or heat blanket (electric or chemical.)

CW · Clean threads with a wire brush (solvents can be used, but the threads must be dried thoroughly).

CW · Frozen ice or other debris must be removed from the threads prior to joining.

2.4.4 – Lubricant

FGS offers two different lubricants for use with API threaded connections. Our standard lubricant is a Teflon based lubricant called *STARtec*™. *STARtec*™ offers excellent lubrication for ease of make up along with optimum sealing characteristics.

FGS also offers a specialty two-part thread sealant called Hi Pro Plus™ which can be used on all FGS API threaded connections. When cured, Hi Pro Plus™ becomes a solid thread seal for worry free connections. The primary usage of Hi Pro Plus™ is for high pressure applications or when field installation expertise is limited. Installations where Hi Pro Plus™ should be considered are on all 3000 psi, 4" 2500 psi, 6" 1500-2000 psi and 8" 1000 to 2000 psi products. Hi Pro Plus™ works best on installations above 50° F (10.00° C). When ordering Hi Pro Plus™, specification of jobsite temperature is required. Curing of Hi Pro Plus™ at low temperatures can be accelerated by the use of electric heat blankets.

The use of *STARtec*™ lubricant or Hi Pro Plus™ thread sealant is required to maintain the warranty of Fiber Glass Systems products.

2.4.4.1 – *STARtec*™ Lubricant

- Apply lubricant evenly with a typical dope brush to **both the male and female** thread (the entire root of the thread must be coated).
- The number of joints which can be installed per gallon of lubricant is available in Table 2.4.2a.

CW · The lubricant must be kept warm 65°F (18.3°C) in order to apply it evenly.

CW · Never use solvent to thin the lubricant, even in cold weather.

CW · Installation temperatures near or below freezing require heating of the lubricant or storage where it will stay warm between assembly of connections.

CW · Agitate or stir the lubricant frequently to keep it from balling up.

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2.4 API 8rd Threaded Connections *(continued)*

2.4.4.2 – Hi-Pro Plus™ Thread Sealant

- Using the mixing stick, scoop out **all** of the contents of one jar of hardener component B into one jar of base component A. Do not split the kit. The base is a light-colored paste; the hardener is a dark paste.
- Thoroughly mix the two components together until a uniform color is achieved and the particles in the bottom of the container are evenly dispersed.
- Use the brush provided to spread a thin, even coat of sealant on all exposed pin and box threads, removing any excess.

CW · If the sealant is difficult to spread, warm the joint enough for the sealant to spread easily. Do not overheat.

CW · The cure of Hi Pro Plus™ below temperatures of 50° F (10.00° C) requires electric heat blankets

- Hi Pro Plus™ must be cured prior to hydro testing.

2.4.5 - Joining Procedure

- Support pipe behind the female end to allow tool movement and leveling.
- Alignment is very important for full thread engagement (particularly for large diameter pipe).

CW · Weather near or below freezing requires heating of the male and female ends with a tiger propane torch. The ends shall feel warm by touch of your hand.

- **Avoid cross threading** by paying attention to alignment.
- Stab the joint **gently** until full engagement is felt.
- Rotate the pipe by hand.
- Rotation of the pipe can be assisted by using a strap wrench or a spinning tong.
- **Cross-threaded connections** must be backed out, cleaned and inspected for damage, then restart the procedure.
- **Final torque** is applied using a friction wrench on the male upset and a strap wrench on the female connection.
- **FGS API threaded connection** is designed to monitor make-up torque by position. **(Refer to Table 2.4.2a for thread standoff)**
- Some instances may require a handle extension on the wrench which will reduce the required force to reach full makeup.
- Power Tongs can be effectively used on sizes 6" (1500 to 2500 psi) and 8" (1000 to 2000 psi).
- Care must be given on heavy wall and large diameter pipe not to over-bend during the process of lowering into the ditch. (See FGS Product Data Specification, Maximum Deflection).
- Never allow the pipe to whip into the ditch on its own weight.
- Always use straps on the pipe, never chains for lifting.
- Construction of a side boom supported trolley or two wheeled platform has proven successful for heavy pipe support and leveling.
- Installation rates and required crew sizes are listed in Table 2.4.2a by pipe/thread size (improved rates can be achieved depending on crew and conditions).

2.5 Star Super Seal Connections

2.5.1 - Introduction

The **Star Super Seal** connections are a preparatory self restrained mechanical o-ring seal:

Star Super Seal Low Pressure		Star Super Seal High Pressure	
2" - 6"	4 threads per inch	2" - 6"	3 threads per inch
		8" - 12"	2 threads per inch

The connection provides fast, reliable installation, even in very severe weather conditions. The seal is achieved by compressing an o-ring between two parallel mating surfaces without the use of a taper. Several types of o-rings are available for various applications.

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2.5 Star Super Seal Connections *(continued)*

2.5.2 - Standard O-Ring Sizes And Types

- It is recommended that extra o-rings are ordered and kept on the installation site for replacement of any that are found damaged or missing.
- O-rings are shipped separate from the pipe.
- If circumstances require a local source of replacement o-rings, the following is the required ordering information (Table 2.5.2a):

Table 2.5.2a

	Product Size	Pipe I.D.	Pressure Rating	O-Ring Durometer	O-Ring Compound	O-Ring Size
Star Super Seal - Low Pressure	2	2.22	500	70	Nitrile	*2-228*
	3	3.33	500	70	Nitrile	*2-237*
	4	4.33	375	70	Nitrile	*2-245*
	6	6.39	300	70	Nitrile	*2-260*
	6	6.39	450	70	Nitrile	*2-260*
	8	7.74	300	70	Nitrile	*2-369*
	8	7.74	1000	70	Nitrile	*2-369*
	10	9.84	1000	70	Nitrile	*2-449*
	12	11.81	1000	70	Nitrile	*2-453*

	Product Size	Pipe I.D.	Pressure Rating	O-Ring Durometer	O-Ring Compound	O-Ring Size
Anhydride - SSSHP	2	2.00	2500	70	Nitrile	2-227
	3	3.00	2500			2-338
	4	3.91	2000			2-346
	6	5.85	1500			2-361

2.5.3 - Make-Up Tools

The required make-up tools are two strap wrenches. Friction wrenches are not necessary since the required torque for Super Seal is minimal. The following chart shows the size strap wrenches recommended for each size pipe

Table 2.5.3a

Pipe Size	2"	3"	4"	6"	8"	10"	12"
Make Up Length Loss (SSS LP)	2.63	2.63	2.88	3.13	4.75	5.125	5.125
Make Up Length Loss (SSS HP)	3.75	4.35	4.35	4.85	---	---	---
Male Upset	No. 5			No. 11			
IJ Female	No. 5		No. 11				
Fittings Friction Wrench*							
Installation (Feet/Day) SSS LP	6500 to 9100 ft.	3900 to 5200 ft.	2600 to 3900 ft.	2000 to 3000 ft.	1800 to 2800 ft.	1500 to 2500 ft.	1500 to 2000 ft.
Installation (Feet/Day) SSS HP	9100 ft.	5200 ft.	3900 ft.	3000 ft.	---	---	---
Crew Size (1)	3 to 4	4 to 5	4 to 5	5 to 6	5 to 6	5 to 6	5 to 6
(1) -INCLUDES CONTRACTOR SUPERVISOR							

* NOTE A friction wrench may be required for fittings alignment

CAUTION: Never use typical oilfield pipe wrenches on fiberglass pipe. Installation rates are based on warm climate. Freezing weather will slow this process down.

2.5.4 - Cleaning and Inspection

CW · **Frozen ice** will make thread protectors impossible to remove, heat the ends of the pipe with a tiger propane torch until they release.

CW · If an open flame is not permitted, methyl alcohol can be used to melt the ice out of the connections or heat blanket (electric or chemical).

- Thread protectors must be left in place until ready for joining pipe.
- Once the protectors are removed, inspect the male and female connection for debris and damage to sealing surfaces and o-ring (such as nicks, cuts, or gouges) that will prevent proper sealing.

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2.5 Star Super Seal Connections *(continued)*

CW
- Frozen ice must be removed prior to joining.
- Do not use metal brushes or compounds containing solvents for cleaning.
- Cleaning with the use of a soft brush with water for warm weather applications if necessary are recommended (dry before proceeding).
- Keep connections clean and off the ground.

2.5.5 - Lubrication

- Do not use thread compounds of any kind.
- Clean, Hydraulic fluid, light weight motor oil, waterless soaps (not for cold weather), or abrasion free hand cleaners are recommended for make-up.
- Inspect the o-ring for damage
- Lightly lubricate the female threads, the male threads and the o-ring.

2.5.6 - Joining Procedure

- **CAUTION** - Do not over-tighten the connection, the O-ring will make the seal.

CW
- Sub-Freezing temperature requires the warming of the male and female end of the pipe.
- Check alignment to prevent connection damage.
- The 8", 10", and 12" Super Seal connections are match mark for thread engagement. Align the starter thread marks on the male and female prior to engagement.
- Turn the connection slowly to the right by hand until the threads engage.
- The make-up will gently slow as the O-ring compresses.
- Use of the strap wrenches will become necessary as rotation becomes more difficult.
- The make-up will completely stop all at once.
- Star Super Seal can be backed off one full rotation for fitting alignment once full engagement is felt.
- Installation rates and crew sizes are listed in Table 2.5.3a (improved rates can be achieved depending on crew and conditions).

2.6 Line Proof Testing

2.6.1 - Frequency

- **Pressure testing** is recommended on all lines to insure line integrity. The first test must occur before 5000 feet of pipe is installed. Thereafter, test in segments which are as small as practical.
- Daily 50 PSI air test are required for unstable ditches where the connection can not be inspected during hydrotest.

2.6.2 - Preparation

- Backfill must be sufficient to minimize pipe movement with 2 feet on either side of the connection left exposed for joint inspection.
- Soft pigs must be purchased to fit the inside diameter of the pipe.
- Test equipment must be located, capable of monitoring pressure and temperature as a function of time and it must be set up to bleed air from both ends of the line and at high points in the line.

CAUTION: A fresh water source must be located since gas nor air is recommended for proof testing. Produced water is not reliable since it is often contaminated and foamy.

- **Testing at freezing or sub-freezing temperatures** require the mixing of up to 50% Methyl Alcohol with the fresh water used for hydrotesting. Any other additives must be approved by FGS. Test equipment lines must also be filled with 50% Methyl Alcohol to prevent freezing.

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2.6 Line Proof Testing *(continued)*

2.6.3 - Test Equipment

Although other methods have been used, a fiberglass to steel flange combination is the preferred way to set up for proof testing. Following is the required equipment:

- Fiberglass flange of appropriate ANSI rating and thread size.
- Spiral wound flange gaskets.
- Pressure Gauge.
- Check Valve.
- Quick Disconnect.
- Pressure and Temperature Chart Recorder.
- Air Pump and Compressor.
- Electrical Source or Generator.
- Water Truck.
- Fresh Water Source.
- *CW* · Methyl Alcohol Source.
- Heavy Duty Quick Disconnect Hoses.
- Several soft pigs of the appropriate size. Each line should have 2 pigs ran through it. Soft pigs do wear and therefore they should not be used more than three times. The quantity of pigs purchased should take this into consideration.

2.6.4 - Testing

- *CW* · Place two soft pigs in the line at the lowest elevation behind the other (Mix 50% Methyl Alcohol for sub-freezing temperatures).
- *CW* · Pump the pig through the line by pushing it with fresh water.
- Bleed the air at the highest elevation of the line since trapped air will become compressed during testing and will give erroneous results.
- If water appears before the pig, air may be trapped in the line.
- *CW* · Beware of water temperature versus the line temperature, always let the line temperature stabilize before testing.
- Once the air is removed, begin slowly elevating the pressure in increments of 500 PSI (≥ 1000 PSI Pipe) or 150 PSI (< 1000 PSI Pipe).
- Stop and hold the pressure at each increment for 5 minutes.
- The recommended proof test is at **rated pressure**.
- Some products may be tested higher if approved prior to installation.
- Test durations of 2 to 4 hours are typical.
- Inspect the line during the test by walking the line and visually inspecting for leakage, over bending or evidence of damage.

CAUTION: Do not allow uncovered or uninsulated lines filled with water for testing to freeze since the expansion of the ice in the lines can damage the pipe.

2.6.5 - Leak Detection

Locating a leak in a line may become difficult. Variations in ambient temperatures will cause fluctuations in pressure over an extended test. Techniques that have been used to find leaks include:

- Air testing with a maximum pressure of 5 PSI combined with connections coated with soap.
- Dye can be added to the water.
- Air and odorizer gas at not more than 5 PSI.
- Leak repair requires removal of backfill and the lined purged before attempting to disconnect and remove the pipe (see repair methods 2.9)

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2.7 Fiberglass to Steel Connections

2.7.1 – Threaded Connections

- Changing over to steel pipe from threaded connections can be accomplished in a variety of ways (see catalog threaded fittings data). Depending on the pressure requirements, each changeover method has distinct advantages. The following is a list:

Choices

- Fiberglass API 8rd change-over nipples or couplings to steel are available in some pressure classes.
- Steel API 8rd change-over nipples or couplings to steel are available at various supply stores.
- Fiberglass flat faced female threaded flanges.
- Super Seal Male x Male NPT crossovers. (<500 PSI)
- Super Seal Female x Male NPT crossovers. (<500 PSI)
- Super Seal Male x API 8rd Male. (<500 PSI)
- Super Seal Male x Groove. (<500 PSI)
- Super Seal Female x Groove. (<500 PSI)

CW **CAUTION:** Sub-freezing temperatures require insulation of stand or header pipes, which penetrate the surface to prevent freezing. Freezing of a fiberglass line damages the pipe permanently.

2.7.1.1 - Threaded API 8rd Change-Overs

- **Expansion** - due to the higher expansion rate of fiberglass versus steel, the preferred threaded change-over is a fiberglass male to steel coupling.
- **Thread compatibility** - fiberglass API 8rd threads are long form type and vary with typical steel short form 8rd per Table 2.7.1.1a:

Table 2.7.1.1a

Thread Size	API Thread Specification	FGS Thread Length	Make-Up Loss	Diff. Steel Thread Length
1.90"	EUE 10rd API 5B Table 2.6a (L4 min)	2.36	2.06	.500
2-3/8"	EUE 8rd API 5B Table 2.6a (L4 min)	2.94	2.56	.625
2-7/8"		3.25	2.88	.625
3½"		3.50	3.13	.750
4½"		3.88	3.50	.875
5½"	OD 8rd API 5B Table 2.3 (L4 min)	4.75	4.38	.625
6 5/8"		4.25	3.88	.750
7"		4.88	4.50	.875
8-5/8"		4.88	4.50	1.125
9-5/8"		5.13	4.75	1.375

- **API 8rd Thread Removal** - some fiberglass 8rd (long form) threads may require removal (using hacksaw) for proper sealing with steel 8rd (short form) connections. Most steel equipment and steel changeovers are prepared with short form 8rd threads. The steps to qualify thread removal are as follows:

1. Chase the steel connection with a steel nipple.
2. Dry fit the fiberglass to steel connection.
3. If the connection seizes up premature to full engagement, then the steel is probably short form and you must use Table 2.7a for thread removal from front of the fiberglass male.

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2.7 Fiberglass to Steel Connections
(continued)

Thread Removal

Table 2.7a

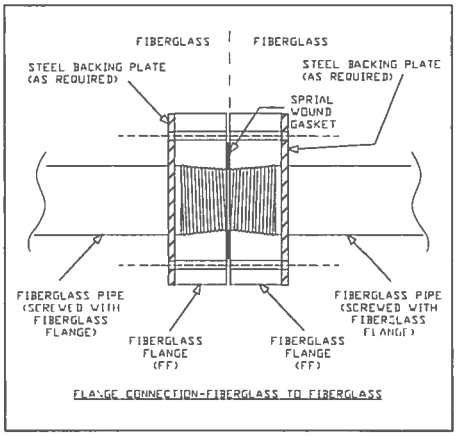
API EUE	1.90"	2-3/8"	2-7/8"	3-1/2"	4"	4-1/2"	5-1/2"	6-5/8"	7"	8-5/8"	9-5/8"
No. of Threads to Cut Off	6	5	6	6	7	7	5	6	7	9	11

Note:
In order to take full advantage of the performance of the fiberglass thread, it is good practice to have the steel threaded connection prepared special to match the fiberglass long form thread.

2.7.1.2 - Fiberglass Flat Faced Flanges

- API 8rd threaded flanges are available in a variety of pressure ranges. Proper gaskets, spacer rings, backing plates, and length bolts must be addressed for installation.

  Fiberglass flanges are thicker than steel flanges and therefore the required bolt length is longer.

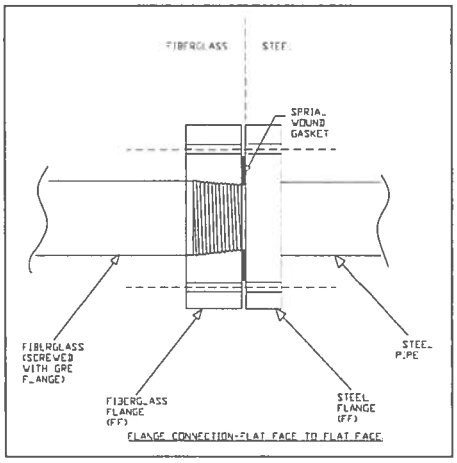


Flange Gaskets

- Spiral wound type.
- Gaskets are purchased separately from flanges.

Steel Backing Plates [1] (Table 2.7.1.2a)

- Required for certain high pressure flanges.
- Failure to use specified backing plates will void product warranty.
- Requires longer bolts to accommodate extra thickness.



Connecting to Raised Faced Steel

- Requires a **special spacer ring** to avoid shearing or cracking the flange when bolts are excessively tightened.
- Specify thickness of flange raise when ordering.
- Machining the raise off of steel flange is an alternative.
- Raised face spacers rings required for make-up of FGS flanges ANSI 600 & higher to steel raised face flanges.

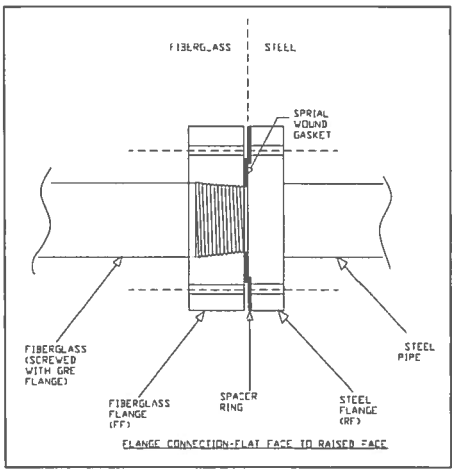


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Table 2.7.1.2a

TYPICAL FLANGE DIMENSIONS (inches)

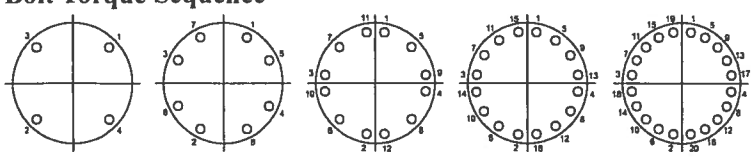
Bolt Pattern	Thread Size	FGS Rated Pressure PSI	Flange O.D.	Flange Width	Bolt Circle	No. of Bolts	Bolt Size	Bolt Lg. FG to FG	Bolt Lg. FG to Steel	Bolt Hole	Bolt Torque	Wt. Lb/Face
ANSI 150												
2" - 150	2 3/8"	300	6.0	3.06	4.75	4	.625	10.0	5.625	.750	89	4.6
2½" - 150	2 7/8"	300	7.0	3.38	5.50	4	.625	12.0	6.063	.750	89	7.0
3" - 150	3½"	300	7.5	3.63	6.00	4	.625	10.0	6.375	.750	89	8.1
4" - 150	4½"	300	9.0	4.50	7.50	8	.625	14.0	7.250	.750	89	13.5
6" - 150	6 5/8"	300	11.0	4.38	9.50	8	.75	14.0	7.438	.875	107	17.5
6" - 150	7"	300	11.0	5.00	9.50	8	.75	14.0	8.063	.875	107	18.4
8" - 150	8 5/8"	300	13.5	5.00	11.75	8	.75	12.0	8.438	.875	107	28.5
8" - 150	9 5/8"	300	13.5	5.25	11.75	8	.75	12.0	8.438	.875	107	24.8
8"SS - 150	8SS	300	13.5	5.00	11.75	8	.75	12.0	8.438	.875	107	28.2
10" SS- 150	10SS	300	16.0	5.75	14.25	12	.875	15.0	10.00	1.00	162	37.2
12"SS - 150	12SS	300	19.0	6.43	17.00	12	.875	16.0	10.62	1.00	162	61.1
ANSI 300												
4½" - 300	4½"	700	10.0	4.50	7.875	8	.75	14.0	7.813	.875	107	17.8
5½" - 300	5½"	700	11.0	4.88	9.25	8	.875	14.0	8.00	1.00	162	22.6
6 5/8" - 300	6 5/8"	700	12.5	4.375	10.625	12	.75	14.0	8.125	.875	107	25.2
7" - 300	7"	700	12.5	5.00	10.625	12	.75	14.0	9.188	.875	107	27.2
8 5/8" - 300	8 5/8"	700	15.0	5.00	13.00	12	.875	12.0	9.188	1.00	162	38.7
9 5/8" - 300	9 5/8"	700	15.0	5.25	13.00	12	.875	12.0	9.188	1.00	162	35.4
8"SS - 300	8SS	700	15.0	5.00	13.00	12	.875	12.0	9.188	1.00	162	38.3
10"SS - 300	10SS	700	17.5	5.75	15.25	16	1.00	15.0	10.87	1.125	244	50.4
12"SS - 300	12SS	700	20.5	6.43	17.75	16	1.125	16.0	11.62	1.25	322	77.4
ANSI 300/600												
1½" - 300/600	1.90"	1400	6.125	2.5625	4.50	4	.75	10.0	5.688	.875	107	4.3
2 3/8" - 300-600	2 3/8"	1400	6.50	3.0625	5.00	8	.625	10.0	6.063	.750	89	5.3
2 7/8" - 300/600	2 7/8"	1400	7.50	3.375	5.875	8	.75	10.0	6.750	.875	107	7.6
3½" - 300/600	3½"	1400	8.25	3.625	6.625	8	.75	10.0	7.125	.875	107	9.7
ANSI 600												
4½" - 600	4½"	1400	10.75	4.50	8.50	8	.875	14.0	8.50	1.00	162	21.2
5½" - 600	5½"	1400	13.00	4.88	10.50	8	1.00	14.0	9.00	1.125	244	34.9
6 5/8" - 600	6 5/8"	1400	14.00	4.375	11.50	12	1.00	14.0	9.00	1.125	244	33.3
7" - 600	7"	1400	14.00	5.00	11.50	12	1.00	14.0	9.625	1.125	244	36.5
8 5/8" - 600	8 5/8"	1250	16.50	5.00	13.75	12	1.125	14.0	10.688	1.25	322	49.8
9 5/8" - 600	9 5/8"	1400	16.50	5.25	13.75	12	1.125	14.0	10.866	1.25	322	47.1
8"SS - 600	8SS	1250	16.50	5.00	13.75	12	1.125	14.0	10.866	1.25	332	49.4
10"SS - 600	10SS	1000	20.00	5.75	17.00	16	1.25	15.0	11.750	1.375	410	76.9
12"SS - 600	12SS	1000	22.00	6.43	19.25	20	1.25	16.0	12.370	1.375	410	95.4
ANSI 900												
3½" - 900	3½"	2000	9.50	3.625	7.50	8	.875	14.0	7.625	1.00	162	13.7
4½" - 900	4½"	2000	11.50	4.50	9.25	8	1.125	14.0	9.250	1.25	322	24.2
5½" - 900	5½"[1]	2000	13.75	4.875	11.00	8	1.125	14.0	9.875	1.375	410	38.9
6 5/8" - 900	6 5/8"	2000	15.00	4.375	12.50	12	1.125	14.0	10.87	1.25	322	39.4
7" - 900	7"[1]	2000	15.00	5.00	12.50	12	1.125	14.0	10.867	1.25	322	43.5
9 5/8" - 900	9 5/8"[1]	2000	18.50	5.25	15.50	12	1.375	14.0	11.75	1.50	510	64.9
ANSI 900/1500												
1 90" - 900/1500	1.90"	3500	7.00	2.5625	4.875	4	1.00	10.0	6.563	1.125	244	5.6
2 3/8" - 900/1500	2 3/8"	3500	8.50	3.0625	6.50	8	.875	10.0	7.063	1.00	162	9.7
2 7/8" - 900-1500	2 7/8"	3500	9.625	3.375	7.50	8	1.00	12.0	7.750	1.125	244	13.6
ANSI 1500												
3½" - 1500	3½"	3500	10.50	3.63	8.00	8	1.125	12.0	8.75	1.250	322	16.8
4½" - 1500	4½"[1]	3500	12.25	4.50	9.50	8	1.25	14.0	10.375	1.375	410	28.0
*5½" - 1500	5½"[1]	3500	14.75	4.88	11.50	8	1.50	14.0	11.75	1.625	615	44.9
6 5/8" - 1500	6 5/8"	2500	15.50	4.375	12.50	12	1.375	14.0	12.25	1.50	510	41.1
7" - 1500	7"[1]	2500	15.50	5.00	12.50	12	1.375	14.0		1.50	510	45.4

[1] - Steel backing plate required

NOTE: When ordering valves, check the size ANSI bolt pattern in the first column versus the thread size ANSI Rating. Some sizes of high pressure (>3000 PSI) line pipe jump thread sizes and bolt pattern.

***ALWAYS** make sure to select the proper fittings by thread size, check the bolt pattern before purchasing valves.

Bolt Torque Sequence



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2.7 Fiberglass to Steel Connections *(continued)*

Bolt Lengths

- Listed for fiberglass to fiberglass and fiberglass to steel make-up (Table 2.7.1.2a).
- All flanges require the use of washers.
- Fiberglass flange width is greater than steel.
- If required, take into consideration a 1/2" for each steel backing plate.

2.7.2 – Bonded Super Seal 2-6 inch (<500 PSI)

- Super Seal 2-6 inch (<500 PSI) is designed for tapered and bonded fittings. The selection available is located under TAB No. 9 – Low Pressure Bonded Fittings Bulleting A1350. The application procedures for these fittings are located under TAB No. 17 – Bonded Line Pipe Installation Manual "Engineering and Design Guide" Manual No. E5000.

2.8 Field Fabrication of Nipples

2.8.1 - High Pressure vs Low Pressure

Special length nipples are often required to locate a fitting in a certain location or to make a repair. The methods for fabricating a special length nipple differ depending on whether the product is High Pressure (≥ 500 PSI) or Low Pressure (≤ 500 PSI). These two products ranges have different inside diameters and joining systems. However, many of the same tools and required accessories are the same.

2.8.2 - High Pressure API 8rd Thread Nipples ≥ 500 PSI

There are six methods for fabricating a nipple or spacing out of a fitting for an API 8rd thread product. All of these methods take into consideration the fact that the API 8rd thread requires an upset from the pipe body.

1. Bell x Male 8rd thread adapters applied to the pipe body.
2. Field molded threads, on the pipe body.
3. Field molded threads, on nipple stock.
4. Field molded threads with a hand build-up.
5. Prefabricated factory molded nipples, from nipple stock.
6. Prefabricated factory precision ground nipples, from nipple stock.

Table 2.8.2a

	THREAD TYPE REQUIRED STOCK	THREAD SIZE (inches) / MAXIMUM PRESSURE RATINGS												COMMENTS
		1½"	2 3/8"	2 7/8"	3½"	4½"	5½"	6 5/8"	7"	8 5/8"	9 5/8"	8SS	10SS	12SS	
FIELD	**Bell x Male Adapter**	2500	2500	2500	2500	2000	1500	1250	---	1000	---	800	500	500	Line Pipe Only
	Molded Threads Pipe Body Req'd	2000 4000	1500 3500	1500 3500	1250 3000	1000 2500	800 2000	500 1250	500 2000	500 1400	500 2000	---	---	---	Rating, Line Pipe Only Not Rating. Pipe Body
	Molded Threads Nipple Stock Standard Jump Size	4000 ---	4000 ---	3500 4000	3000 4000	2500 4000	2000 4000	1000 ---	2000 2500* ---	1400 ---	2000 ---	---	---	---	Line Pipe Only See Product Data for ID
	Molded Threads **Hand Build Up**	2500	2500	2500	2500	2000	1250	800	1500	800	NR	---	---	---	Maximum Rating Achievable
	Min. Layers of Reinforcement	2	2	2	2	2	2	2	2	3	---	---	---	---	Woven Roving
	Recommended Product Range	2000 to 2500	2000 to 2500	2000 to 2500	1500 to 2500	1500 to 2000	1250	800	1250 to 1500	500 to 800	NR	---	---	---	Lower Rated Products Require Many Layers of Reinf
FACTORY	**Molded Threads** Standard Jump Size	4000 ---	4000 ---	3500 4000	3000 4000	2500 4000	2000 4000	1000 ---	2000 2500* ---	1400 ---	2000 ---	---	---	---	Line Pipe Specify thread size and length when ordering Check Product Data for ID
	Precision Ground	---	3000	3000	2500	2000	1000	1000	1250	800	---	---	---	---	Line Pipe Specify thread size and length when ordering

* NOTE 5 95 ID-2000 PSI, 5 50 ID-2500 PSI

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2.8 Field Fabrication of Nipples *(continued)*

2.8.2.1 - Bonded Bell x Male Thread Adapter Application Procedure

- Select the proper Bell x Male Adapter by thread size and pressure rating as follows:

Table 2.8.2.1a

Thread Size	Pipe Pressure Rating	Anhydride/Aromatic Amine Product Code (FBM)	Aliphatic Amine STD. Product Code (FBM)	Aliphatic Amine 15HR Product Code (FBM)
1.90"	1250	*19NR*	*N/A*	*N/A*
	1500	*19NR*	*19NR*	*19NR*
	1750	*19NR*	*19NR*	*19NR*
	2000	*19NR*	*19NR*	*19NR*
	2250	*19NQ*	*19NR*	*19NQ*
	2500	*19NQ*	*19NR*	*19NQ*
2 SSSHP	2500	*2HPSS*	*N/A*	*N/A*
2 3/8"	750	*N/A*	*N/A*	*23NR*
	800	*N/A*	*23NR*	*N/A*
	1000	*23NS*	*23NR*	*23NR*
	1250	*23NS*	*23NR*	*23NR*
	1500	*23NS*	*23NR*	*23NR*
	1750	*23NS*	*23NR*	*23NS*
	2000	*23NS*	*23NS*	*23NQ*
	2250	*23NS*	*23NS*	*23NQ*
	2500	*23NP*	*23NQ*	*23NP*
2 7/8"	750	*N/A*	*N/A*	*27NU*
	800	*27NT*	*27NU*	*N/A*
	1000	*27NT*	*27NU*	*27NU*
	1250	*27NT*	*27NU*	*27NU*
	1500	*27NT*	*27NU*	*27NT*
	1750	*27NS*	*27NT*	*27NS*
	2000	*27NS*	*27NS*	*27NQ*
	2250	*27NQ*	*27NR*	*27NQ*
	2500	*27NQ*	*27NQ*	*27NP*
3 SSSHP	2500	*3HPSS*	*N/A*	*N/A*
3½"	500	*35NT*	*35NU*	*35NU*
	750	*N/A*	*N/A*	*35NU*
	800	*35NT*	*35NU*	*N/A*
	1000	*35NT*	*35NU*	*35NU*
	1250	*35NT*	*35NU*	*35NU*
	1500	*35NT*	*35NU*	*35NS*
	1750	*35NS*	*35NS*	*35NS*
	2000	*35NS*	*35NS*	*35NR*
	2250	*35NR*	*35NR*	*35NQ*
	2500	*35NQ*	*35NR*	*35NP*
4 SSSHP	2000	*4HPSS*	*N/A*	*N/A*
4½"	500	*45NT*	*45NU*	*45NU*
	750	*N/A*	*N/A*	*45NU*
	800	*45NT*	*45NU*	*N/A*
	1000	*45NT*	*45NU*	*45NT*
	1250	*45NT*	*45NU*	*45NS*
	1500	*45NS*	*45NS*	*45NR*
	1750	*45NR*	*45NR*	*45NR*
	2000	*45NR*	*45NR*	*45NP*

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Table 2.8.2.1a (cont.)

Thread Size	Pipe Pressure Rating	Anhydride/Aromatic Amine Product Code (FBM)	Aliphatic Amine STD Product Code (FBM)	Aliphatic Amine 15HR Product Code (FBM)
TC5½"	500	*N/A*	*0055NR*	*N/A*
	800	*N/A*	*0055NR*	*N/A*
	1000	*N/A*	*0055NR*	*N/A*
	1250	*N/A*	*0055NQ*	*N/A*
	1500	*N/A*	*0055NP*	*N/A*
6 5/8"	500	*0065NV*	*0065NS*	*0065NS*
	750	*N/A*	*N/A*	*0065NU (5.50 ID)* *0065NS (5.93 ID)*
	800	*0065NV*	*0065NU (5.50 ID)* *0065NS (5.93 ID)*	*N/A*
	1000	*0065NS*	*0065NU (5.50 ID)* *0065NR (5.93 ID)*	*0065NT (5.50 ID)* *0065NQ (5.93 ID)*
8 5/8""	500	*0085NU*	*0085NS*	*0085NS*
	750	*N/A*	*N/A*	*0085NR*
	800	*0085NU*	*0085NR*	*N/A*
8SS	500	*N/A*	*088R*	*N/A*
	800	*N/A*	*088R*	*N/A*
10SS	500	*N/A*	*05AR*	*N/A*
12SS	500	*N/A*	*05CR*	*N/A*

Required Tools and Accessories

- Hack saw or circular saw equipped with carbide blade.
- Conventional tapering tool capable of making a taper of 1 inch increase of OD in 16 inches of length (or 1 to 16 ratio) which gives approximately a 1¾° taper.
- Epoxy Kit and rubber gloves.
- Electric heat collar, propane torch or chemical heat pack.

Preparation

- Calculate the length of the nipple by subtracting the laying length (center to center) of the fittings to be assembled and adding the insertion depths (see fittings data) of the nipple.
- Add adhesive lubricating factor to the nipple of 1/8" to 1/4" for each taper to be bonded to the nipple length previously calculated.

EXAMPLE:

Measured Distance	-	Fittings Laying Lengths	+	Taper Insertion Depths	+	Adhesive Lubricating Factors	=	Nipple Length To Cut

- Mark the pipe with a wrap around.
- Cut the pipe with a saw.
- Apply a 1¾° taper with a typical tapering tool.
- Avoid over tapering the end of the pipe too thin.

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2.8 Field Fabrication Of Nipples *(continued)*

2.8.3 - Bonding Procedure

2.8.3.1 - Environment

- The pipe surface temperature during bonding should be 65°F to 100°F (18.3°C to 37.8°C).
- The surface must be warmed if below these temperatures.
- The bonding surface must be totally dry.
- Humidity during bonding must be addressed because bonding is not recommended on wet surfaces.
- Work areas must be protected against blowing sand or dust as it is detrimental to bonding.

2.8.3.2 - Surface Bonding Preparation

- The joining surfaces must be visually examined for cleanliness/damage and UV degradation.
- UV degradation is detected by sanding and looking for color changes or loose fiber.
- Refinishing by sanding or re-tapering is required if UV degradation is detected.

2.8.3.3 - Joint Cleaning

- Solvents can be used to remove grease, oil, mud or fingerprints, however, the surfaces must be totally dry before bonding can proceed.
- *All factory prepared surfaces must be sanded prior to applying adhesive.*
- Sanding is preferred over using solvent whenever possible.

2.8.3.4 - Adhesive Mixing

- Always wear rubber gloves.
- Stir the epoxy contents of the can with the wooden tongue depressor to insure mixture of settled material (particular attention to stirring is required for kits which have been stored more than 6 months) which should be smooth and free of lumps.
- Warm the epoxy by heating the can if the temperature is below 60°F (15.6°C).
- Pour the entire contents of the pre-measured amine hardener into the epoxy.
- Do not attempt to split a kit.
- Stir the amine hardener into the epoxy using the wooden stick.
- Care must be taken so that the amine hardener is not spilled (affecting the mixture).
- Scrape the inside of the can to insure that all epoxy is mixed (mixing should take at least 2 to 3 minutes).
- The working time or "pot life" for thoroughly mixed adhesive varies from 30 minutes at 70°F (21.1C) to 10 minutes at 100°F to 120°F (37.8°C to 48.9°C).

NOTE: DO NOT USE THE MIXED ADHESIVE IF IT IS TOO HOT TO TOUCH. CABOSIL (WHITE POWDER) IS SUPPLIED WITH EACH ADHESIVE KIT, BUT IT IS NOT USED FOR MIXING ADHESIVE FOR THE PURPOSE OF ADHESIVE BONDED CONNECTION. DO NOT USE CABOSIL (WHITE POWDER) TO THICKEN THE ADHESIVE. CABOSIL IS ONLY USED FOR MOLDING 8RD THREADS.

2.8.3.5 - Joint Assembly

- The joints must be axially aligned.
- Bonding surfaces must be at the appropriate bonding temperature.
- Bonding surfaces should never be touched by fingers or tools after cleaning.
- Apply a thin layer of the mixed adhesive, normally with a brush, to the female first and then the male taper.
- The adhesive coat should be 3 to 10 mils (excessive adhesive may interfere with obtaining a locked position).
- Slowly stab the tapered male end into the integral joint female.
- Turn the male connection to the right until full engagement is felt.
- Wipe off excessive adhesive with disposable towels.

CAUTION: Excessive adhesive can cause epoxy icicles inside the pipe.

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2.8 Field Fabrication of Nipples *(continued)*

2.8.3.6 - Heat Assisted Curing

- The Adhesive Bonded Connection must be heat cured if the temperature is below 70°F (21.1°C).
- The adhesive will set up if left for 24 hours at temperatures above 75F (23.9°C).
- Electric heat collars or chemical cure packs are available that generate 250°F (121.1°C) for a minimum of 30 minutes.
- Heat assisted curing insures that the connection has reached its full chemical and physical properties.
- The use of come-a-longs equipped with nylon straps are recommended for the purpose of restraining the bonded fittings joints while they cure.
- Propane torches can only be used for curing on Bell x Male adapters where a steel coupling can be screwed to the adaptor that can accept the flame derived heat.

2.8.3.7 - Examination / Documentation

- Each joint must be visually inspected and documented.
- Number each connection made and add initials of person responsible.
- Keeping an inspection sheet per API 15TL4, Appendix C is good practice.

2.8.3.8 - Procedure / Personnel Qualification

- It is recommended that each person responsible for working on the connections be qualified and tested per API 15TL4, Appendix B.

2.8.4 - Field Molded Thread Procedure

- Prior to beginning the process of making a thread, the pipe must be qualified to the diameter of the thread mold. If the pipe is not large enough to accept the full thread, either **nipple stock must be purchased or a field upset must be fabricated to maintain product pressure rating (see procedure 2.8.2.3)**.

Required Tools and Accessories

- Hack saw or circular saw equipped with carbide blade.
- Conventional tapering tool capable of making an API 8rd taper of 1 inch increase of OD in 16 inches of length (or 1 in 16 ratio), which gives approximately a 1¾° taper.
- Steel thread mold (FGS).
- Mold release and application brush.
- Epoxy thread paste kit.
- Heat collar, propane torch, or chemical heat pack.
- Wear rubber gloves while mixing epoxy.

Environment

- Pipe surface temperature of 60°F (15.6°C) to 70°F (21.1°C), warm the connection if below 60°F (15.6°C).
- Thread surface shall be clean and totally dry.
- Wet surfaces are not recommended.
- Blowing sand and dust requires protection.

Pipe Preparation

- Square cut the pipe to the proper length using a hacksaw, taking into consideration the laying length of the fittings and the insertion depth of the thread.
- Taper the pipe using a conventional tapering tool with a 1¾" taper.
- The taper should cover the entire length of the mold.
- Verify the mold fit to the taper, there should be no looseness.
- Make sure all oil, grease, mud, fingerprints, sand, etc. are removed with sand paper or solvent.
- If solvent is used, it must be allowed to completely dry before proceeding.
- Once cleaned, the bonding area should not be touched.

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2.8 Field Fabrication of Nipples (continued)

Pre-heat thread mold

Apply mold release agent

Mix thread paste

Apply paste to mold

Apply paste to pipe

Stab mold on pipe

Clean excess paste from mold

Mold Preparation

- Clean and warm factory supplied and approved thread molds to touch (100°F to 130°F or (37.8°C to 54.4°C).
- An even smooth coat of release agent should be applied uniformly with a stiff brush to the threads and both mold faces.
- Excess release agent must be removed.
- There should be no visual signs of release agent.

Thread Paste Preparation

- Low temperature storage of epoxy paste mixture can cause settling.
- Scrape the epoxy on the inside of the can lid into the can.
- Warm the contents of the can and mix it thoroughly with a stir stick before use.
- Pour the entire bottle of amine hardener into the can of epoxy paste.
- Do not attempt to split the portions.
- Using the stir stick, mix the amine hardener thoroughly into the epoxy paste.
- Do not spill any of the amine out of the can.
- Scrape the sides and bottom of the can to insure that all of the epoxy is mixed.
- Mixing takes at least 2 to 3 minutes.
- The set-up time or pot life for a thoroughly mixed adhesive varies form 30 minutes at 70°F (21.1°C) to 10 minutes at 100°F to 120°F (37.8°C to 48.9°C).
- **DO NOT USE THE MIXED PASTE IF IT IS TOO HOT TO TOUCH.**
- Depending on the thread paste temperature, adjust the past viscosity with Cab-O-Sil (white powdery substance) provided with epoxy kit.
- The consistency of the paste should be like whipped cream.
- Make sure the Cab-O-Sil is thoroughly mixed.
- The amine to thread paste ration is 27 grams amine to 500 grams paste (although the epoxy thread paste kits are pre-measured, this ratio can be verified by using a scale).

Threading

- Fill the thread mold with the mixed thread paste using the stir stick (tongue depressor).
- Force the paste into the thread cavity by moving it across the thread, in one direction, from the small end of the mold to the large.
- Cover the full surface of the thread, try to break or remove any air pockets present in the thread.
- Cover the tapered end of the pipe with approximately 1/8" of mixed epoxy paste.
- Roll the paste around the tapered area in a fashion which assists breaking any air pockets that are present.
- Build a ¼" thick bead of paste around the small end of the taper to assist in compression of trapped area.
- Using a stabbing motion, insert the large end of the thread mold on to the tapered pipe, shove the mold in a straight, smooth fashion.
- Once the surfaces touch, run the mold clockwise until the mold is locked onto the tapered surface.
- Thoroughly clean the excess epoxy paste from the front and rear of the mold (excessive thread paste left on the mold will cause difficult torque requirements for mold removal).

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2.8 Field Fabrication of Nipples *(continued)*

Heat Assisted Curing

- Complete cure requires 24 hours at 75°F (23.9°C).
- Faster cure times and optimum chemical and physical performance requires the application of heat.

Table 2.8.4a

CURE METHODS	REQUIRED STEPS
Electric Heat Collars	250° F (121.1° C) for 30 minutes. Do not overlap. Instalate in cold weather.
Propane Torch	Apply to end of mold first, then evenly heat mold. Avoid blistering pipe.
Chemical Heat Blanket	Follow manufacturers instructions. CAUTION: Wear respirators and avoid breathing fumes. Insulate in cold weather

- Thread cure can be checked at the back of the mold with a knife blade.
- The thread must resist puncture.

Mold Removal


Tap mold lightly


Unscrew mold


Inspect thread

- Tap the mold lightly on all sides using a small hammer.
- Unscrew the mold using a strap wrench, avoid using a pipe wrench since this type wrench can bend the mold.
- Support the pipe during the mold removal such that it does not become over bent due to torque requirements.
- Using a metal friction wrench or a 360° padded vise for backup during mold removal is a good practice.

Thread Inspection

- A fully cured thread should be shiny in appearance and substantially free of voids.
- Check the thread hardness using a center punch on the back two threads.
- Full quality inspection requires reference to thread visual inspection standards.

2.8.5 - Field Fabrication of Pipe Upset

Pipe that is not heavy enough to accept a full length taper for the thread mold can be built up using Special Woven Roving Glass. The procedure consists of the following:

- Taper or sand the end of the pipe to be threaded.
- Do not leave any areas shiny or unsanded since this does not provide a good bonding surface.
- Mix the thread paste per procedure 2.8.4-Thread Paste Preparation, always wear rubber gloves.
- Saturate 2" to 4" width glass (comes in a roll) with Epoxy Thread Paste.
- The saturated glass is wound over the end of the pipe which has been tapered and sanded.
- The number of wraps of woven roving required depends on the difference in the pipe outside diameter and the diameter of the required upset for the thread (See Product Data Specification).
- Once the upset is large enough, the normal field threading procedure can be followed over the wet uncured upset from **"mold preparation to thread completion"**.

NOTE: This method has shown satisfactory results, however, it requires an expertise level obtained by special training and experience.

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2.9 Repair Methods

Introduction - The repair of FGS line pipe primarily involves the installation of a flange set. Lower pressure products offer alternative methods to flange sets, but are limited in pressure rating. The following are the repair methods and the limitations of each:

CAUTION: Make sure that the line is properly vented prior to starting repair work.

2.9.1 - Flange Set

- Primarily for API 8rd products ≥ 500 PSI and high pressure ≥ 500 PSI super seal.
- Set includes 2 flanges, nuts, bolts, washers and gaskets.
- Depending on the location of the leak, a decision must be made as to how to reconnect the line with the flanges.
- The use of a minimum length nipple may be required to install the flange set.

OPTIONS:

1. Make use of the undamaged pipe by rethreading the ends in the field allowing for the flange set. Reference the field thread rating chart 2.8.2 for the proper threading method to maintain the system pressure rating (not for high pressure super seal).

2. If extra pipe is available, replace the damaged joint with a new joint which can be shortened in the field to make room for the flange set and a minimum length nipple. The pressure rating of the system can be maintained using this system on any API 8rd product (not for high pressure super seal).

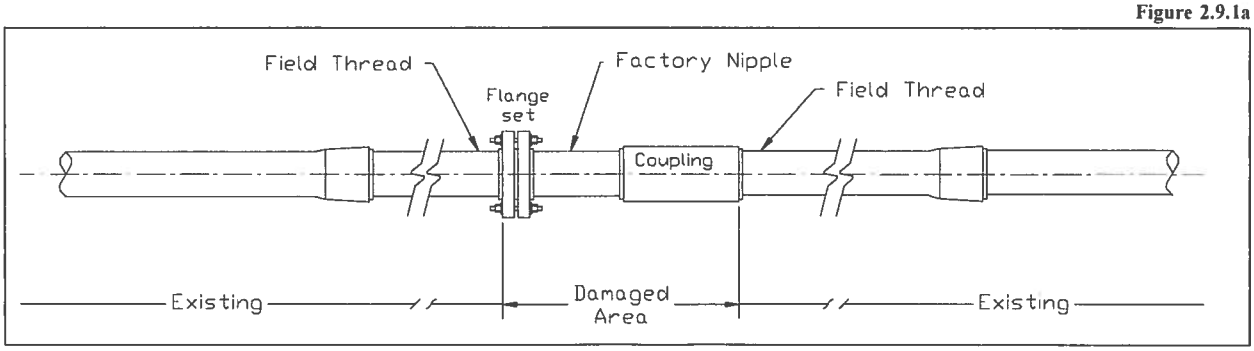
3. Purchase a prefabricated repair joint designed to mechanically replace a full (30 ft. nominal) joint of pipe and make room for a flange set. This method works for API 8rd and is recommended for high pressure super seal products.

OPTION ONE PROCEDURE:

- Consider the length of the damage. If the width of a set of flanges will repair the area, a nipple (long enough to repair the damage area) and a coupling will be required along with the flange set.

  - Cut out the damaged area of the pipe using a hack saw taking into consideration the total laying length of the parts needed to make the repair.
  - Depending on how long the damaged area is, an extra joint of pipe may be required.
  - Rethread both square cut ends using procedure 2.8.2.2 for field threads or bell x male adapters.
  - Install the flange set.

Figure 2.9.1a



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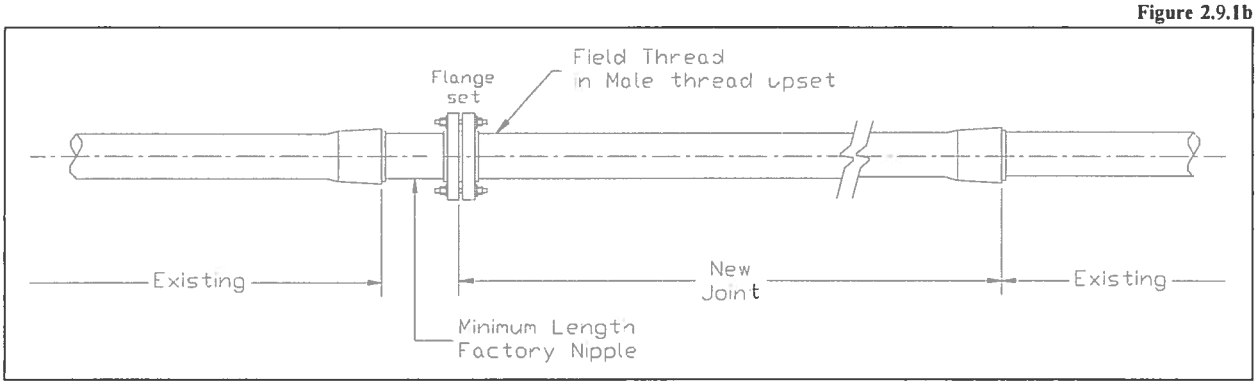
OPTION TWO PROCEDURE:

- Cut the damaged joint using a hack saw.
- Remove both remaining ends using (2) FGS metal friction wrenches.
- Replace with a new joint of pipe.
- Shorten the joint as required to fit the flange set and a minimum length nipple.
- Do not cut the pipe in the pipe body, only in the upset area.
- Field thread the pipe.
- Install the flange set.

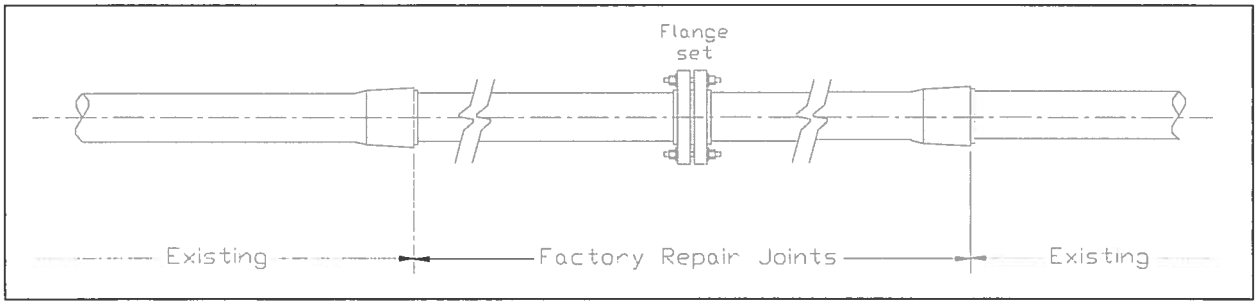
Figure 2.9.1b



OPTION THREE PROCEDURE:

- Cut the damaged joint of pipe using a hack saw.
- Remove both remaining ends using (2) FGS metal friction wrenches.
- Replace the damaged joint with the special length repair joints.
- Install the flange set.

Table 2.9.1c



2.9.2 - Bonded Flanges or Bell x Groove Adapters

- Only for ≤ 500 PSI products with low pressure inside diameters (2.22, 3.33, 4.32, 6.39, 7.74, and 9.84 inch).
- Requires tapering equipment.
- Follow bonding procedure 2.8.5.
- Bell x Groove adapters require the purchase of the appropriate size victaulic coupling.

2.9.3 - Sleeve Couplings (Bell x Bell)

- Limited to pressure ranges listed for Bell x Male adapters (see 2.9).
- Requires tapering equipment.
- Follow bonding procedure 2.8.5.
- Requires the use of two come-a-longs equipped with straps to apply compression to the connection during curing.

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2.9 Repair Methods *(continued)*

2.9.4 - Bonded Saddles

Are not considered permanent repairs and they cannot be applied over a wet surface. The following is the maximum pressure that a bonded saddle should be attempted:

Table 2.9.4a

PIPE SIZE	1½"	2"	2½"	3"	4"	5"	6"	8"	10"	12"
MAX. PRESSURE RATING (PSI)	450	450	300	300	225	225	225	225	225	225

- **Patch length** - a length of good pipe is cut and split longitudinally for 120° of circumferential coverage and at least long enough to cover the damaged area plus 2 feet on each side.
- **Preparation** - sand the area to be patched and the interior of the saddle with 40 grit sand paper; remove all gloss or shine.
- **Cleaning** - sanded areas must be thoroughly cleaned of all foreign material, oils, grease and fingerprints (sanding is preferred); if cleaning solvent is used, the surfaces must be thoroughly dried.
- **Bonding** - use a heavy coat of epoxy adhesive on both surfaces (mixed and cured per procedure 2.8.5).
- Snap the patch in place over the damaged area.
- During **curing** hold the patch in place with several typical hose clamps, spaced 6 inches along the patch.
- **Do not pressurize until fully cured**, check hardness with knife blade.
- Leave the patch visible for inspection while under pressure.

2.10 - Hot Oil Treatment for Paraffin Build-Up

- *The Maximum exposure temperature shall not exceed the following:*
  - *Anhydride may be hot oiled up to 180° F (82° C) at 50% of standard (label) pressure rating.*
  - *Aliphatic may be hot oiled up to 200° F (93° C) at 80% of standard (label) pressure rating.*
  - *Aromatic may be hot oiled up to 200° F (93° C) to the standard (label) pressure rating*
- *It is good practice to minimize the temperature and increase exposure time rather than increasing the temperature.*
- *Establish circulation of the oil in the line at the lowest temperature possible. Once the temperature is established, the temperature can be brought up gradually to maximum temperature with pressure equal to or less than the rated pressure of the line.*
- *If additional higher exposure temperature above the maximum recommeded value is required, consult Fiber Glass Systems, L.P. for specific approval as the line could be damaged.* ***Do not exceed the pressure rating at the rated temperature.***

2.11 - Pump Selection and Pulsation Dampeners

- Multiple piston pumps such as Triplex, Quadraplex, and Quinaplex are preferred.
- Avoid Positive Displacement pumps that will shock the pipe.
- Pulsation dampeners placed on the intake and discharge are good practice and recommended.
- Sand bagging of fiberglass pipe installed near pumps is good practice to avoid abrasion from rock infested backfill.

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5.0 Hydraulic Characteristics

Introduction

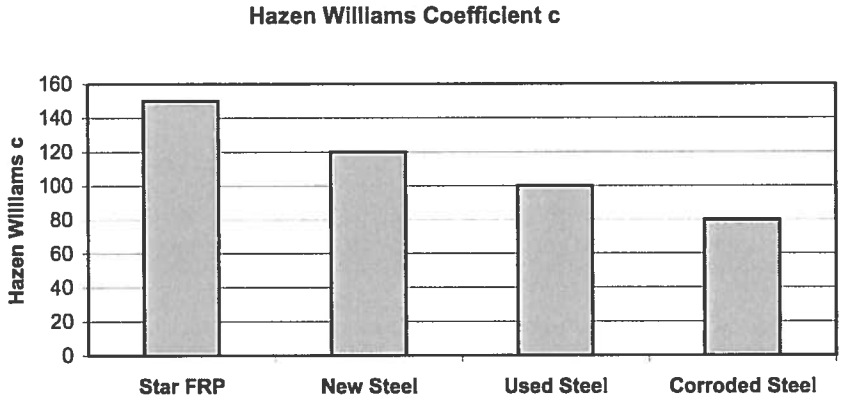
The smooth interior and larger than steel inside diameter of FGS Tubulars improves the flow and operational characteristics of the system over steel pipelines. Generally, these advantages can result in the following improvements:

- Down sizing the pipeline, results in a lower purchase price of the line pipe.
- Reduce the pumping power requirement or the number of pumping stations.
- A higher velocity achieved will minimize the paraffin, asphaltene, scale, hydrate or other types of build up on the inside of the pipe.

5.1 Pressure Reduction

FGS tubulars have an absolute roughness of 0.00021 in. and a corresponding Hazen Williams coefficient (c) of 150. By contrast, commercial steel tubulars have an absolute roughness of 0.00180 in. and a Hazen Williams coefficient (c) of 120.

The following chart demonstrates the effect of increased pipe wall roughness over time when steel pipe is used and exposed to the long term effect of corrosion.



5.2 Effects of Inside Diameter

In most cases, the inside diameter (ID) if Fiber Glass Systems pipe is greater than that of commercial steel pipe used in similar pressure ranges. This results in a greater and improved cross sectional flow area for the piping system. Further, this results in a reduced and improved fluid or gas velocity for a given flow rate.

To demonstrate this effect, the following table shows a percentage increase in cross sectional flow area in FGS tubulars when compared to commercial steel pipe.

Pipe Size	Internal Diameter, in.			Cross Sectional Flow Area, sq. in.		
	FGS FRP	ID, Sch 80	% Increase w/FRP	FGS FRP	Steel, Sch 80	% Increase w/FRP
1½"	1.44-1.50	1.500	0.0%	1.8	1.8	0.0%
2"	1.94-2.00	1.939	3.1%	3.1	3.0	6.4%
2½"	2.23-2.43	2.323	4.6%	4.6	4.2	9.4%
3"	2.94-3.00	3.900	3.4%	7.1	6.6	7.0%
4"	3.75-3.90	3.826	1.9%	11.9	11.5	3.9%
5"	4.75	4.813	-1.5%	17.6	18.2	-3.0%
6"	5.50-6.19	5.761	7.4%	30.1	26.1	15.4%
8"	7.50-7.98	7.625	4.7%	50.5	45.7	9.5%
10"	9.84	9.564	2.9%	76.0	71.8	5.9%
12"	11.80	11.374	3.7%	109.4	101.6	7.6%

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5.3 Flow Calculations

Empirical flow calculations may be used to determine pressure differentials and flow capacities (rates) for a given piping system.

For flow of water through a given piping system, the Hazen Williams equation is used for comparison of flow characteristics in fiberglass and in steel piping systems as follows:

$$\Delta p = \frac{4.53L}{d^{4.87}}\left(\frac{Q}{C}\right)^{1.85}$$

where:
- Δp = pressure differential, in psi
- L = line length, in ft.
- Q = flow rate, in gallon/min
- d = pipe internal diameter, in.
- C = pipe wall roughness coefficient, dimensionless

Assuming same pipe line length and flow rate (L and Q), the following relation holds true:

$$\frac{\Delta p_1}{\Delta p_2} = \left(\frac{d_2}{d_1}\right)^{4.87}\left(\frac{c_2}{c_1}\right)^{1.85}$$

where: Δp_1, d_1, and c_1 are for Fiberglass
Δp_2, d_2, and c_2 are for Steel

The difference of this value from the numerical value of one (1.0) gives the percentage of improvement in pressure differential of Star Fiberglass over commercial steel pipe.

For fluids other than water, the Darcy-Weisback equation is used for comparison of flow characteristics in fiberglass and in steel piping systems as follows:

$$\Delta p = \frac{.001294 f L \tau V^2}{d}$$

where:
- Δp = pressure differential, in psi
- f = friction factor
- L = line length, in ft.
- τ = fluid density, lb/ft³
- V = fluid velocity, in ft/sec
- d = pipe internal diameter, in in.

For the same line length and unit weight of Liquid (τ), the ratio becomes:

$$\frac{\Delta p_1}{\Delta p_2} = \left(\frac{d_2}{d_1}\right)\left(\frac{f_1}{f_2}\right)\left(\frac{V_1}{V_2}\right)^2 \quad \text{or} \quad \frac{V_1}{V_2} = \sqrt{\left(\frac{\Delta p_1}{\Delta p_2}\right)\left(\frac{f_2}{f_1}\right)\left(\frac{d_1}{d_2}\right)}$$

where: Δp_1, d_1, f_1, V are for Fiberglass
Δp_2, d_2, f2, V_2 are for Steel

The difference in these values from the numerical value of one (1.0) gives the percentage of improvement in pressure differential or fluid velocity, respectively, of FGS fiberglass over commercial steel pipe.

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5.4 Pressure Differential Improvement

By combining the effects of increased ID, increased cross sectional flow area, and reduced roughness in pipe wall, Star fiberglass pipe shows appreciable improvement in reduction of pressure differential across a pipe line for a given flow rate, Furthermore, this improvement of pressure differential reduction with fiberglass tubulars becomes magnified for used or corroded steel lines. This relationship is demonstrated in the following table:

Pipe Size	Inside Diameter (ID), in.		% Overall Increase in Pressure Drop with Steel Pipe			
	FGS FRP	ID, Schedule 80	FGS FRP	New Steel	Used Steel	Corroded Steel
1½"	1.44-1.50	1.500	0 %	51 %	112 %	220 %
2"	1.94-2.00	1.939	0 %	76 %	146 %	273 %
2½"	2.23-2.43	2.323	0 %	88 %	164 %	299 %
3"	2.94-3.00	2.900	0 %	78 %	150 %	278 %
4"	3.75-3.90	3.826	0 %	66 %	133 %	252 %
5"	4.74	4.813	0 %	40 %	97 %	197 %
6"	5.50-619	5.761	0 %	115 %	201 %	354 %
8"	7.50-7.98	7.625	0 %	89 %	165 %	300 %
10"	9.84	9.564	0 %	74 %	143 %	268 %
12"	11.80	11.374	0 %	81 %	153 %	283 %

Note: Water used for this example

This benefit in pressure drop reduction using fiberglass pipe will translate into energy savings and associated costs. Substantial reductions in horsepower requirements for pumping are seen with the reduced pressure drops offered by fiberglass pipe.

5.5 Flow Rate Improvement

The flow capacity of a given piping system can be increased with the use of FGS fiberglass tubulars. The benefits of this are demonstrated in the following table, this time showing percentage increases possible with fiberglass pipe in flow rates across a pipe line of a given fluid, length and pressure differential, comparing Star fiberglass pipe to new, used, and corroded commercial steel:

Pipe Size	Inside Diameter (ID), in.		% Overall Increase in Flow Capacity with Fiberglass Pipe			
	FGS FRP	ID, Schedule 80	FGS FRP	New Steel	Used Steel	Corroded Steel
1½"	1.44-1.50	1.500	0 %	20 %	33 %	47 %
2"	1.94-2.00	1.939	0 %	26 %	39 %	51 %
2½"	2.23-2.43	2.323	0 %	29 %	41 %	53 %
3"	2.94-3.00	2.900	0 %	27 %	39 %	51 %
4"	3.75-3.90	3.826	0 %	24 %	37 %	49 %
5"	4.74	4.813	0 %	17 %	31 %	45 %
6"	5.50-619	5.761	0 %	34 %	45 %	56 %
8"	7.50-7.98	7.625	0 %	29 %	41 %	53 %
10"	9.84	9.564	0 %	26 %	38 %	51 %
12"	11.80	11.374	0 %	27 %	40 %	52 %

Note: Water used for this example

Substantial savings may be realized in the purchase of a pipeline system if these phenomena are taken into account.

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5.6 Line Down Sizing

It has been shown that appreciable flow improvements are characteristic of fiberglass piping over steel piping. In certain cases, it is possible to down size a pipeline system using fiberglass instead of steel piping. This means that a smaller diameter fiberglass pipe may be used for the same purpose as a steel pipe yet still achieve required flow parameters of flow rate and pressure differential. Down sizing can result in substantial cost reduction during purchase of a piping system. Consider the following example:

Requirements: Water injection system where flow rate must be minimum 1,000 barrels per day, but with a maximum pressure differential of 100 PSI.

Options: Consider the following table of calculated results:

Schedule 80 Carbon Steel Pipe vs. 2,500 PSI FRP Pipe
Line Length - 10,000 ft.

Requirements:	Q = 1,000 BWPD minimum Δp = 100 PSI maximum			
Pipe Size **Material**	**2"** **Steel**	**2½"** **Steel**	**2"** **FRP**	**Corroded** **2½"** **Steel**
ID (in.)	1.939	2.323	1.90	2.323
Hazen Williams (c)	120	120	150	80
Q @ 100 psi Δp	863	**1,388**	**1,080**	925
Δp @ 1,000 BWPD	131	**55**	**87**	115

Results: A 2" carbon steel line could not satisfy the required flow rate at the maximum pressure differential, nor could it satisfy the required maximum pressure differential at the minimum flow rate. Therefore, an increase in line size to 2 ½" for carbon steel would be required. However, a 2" FGS fiberglass line would be capable of satisfying both the flow rate and the pressure differential requirements. Therefore, a line Down Size is possible with fiberglass.

Note also that as the 2 ½" carbon steel line has corroded, it can **no longer** satisfy the flow rate and pressure differential requirements. Since **fiberglass does not corrode**, this phenomenon does not occur and the 2" down sized line remains adequate for the required service.

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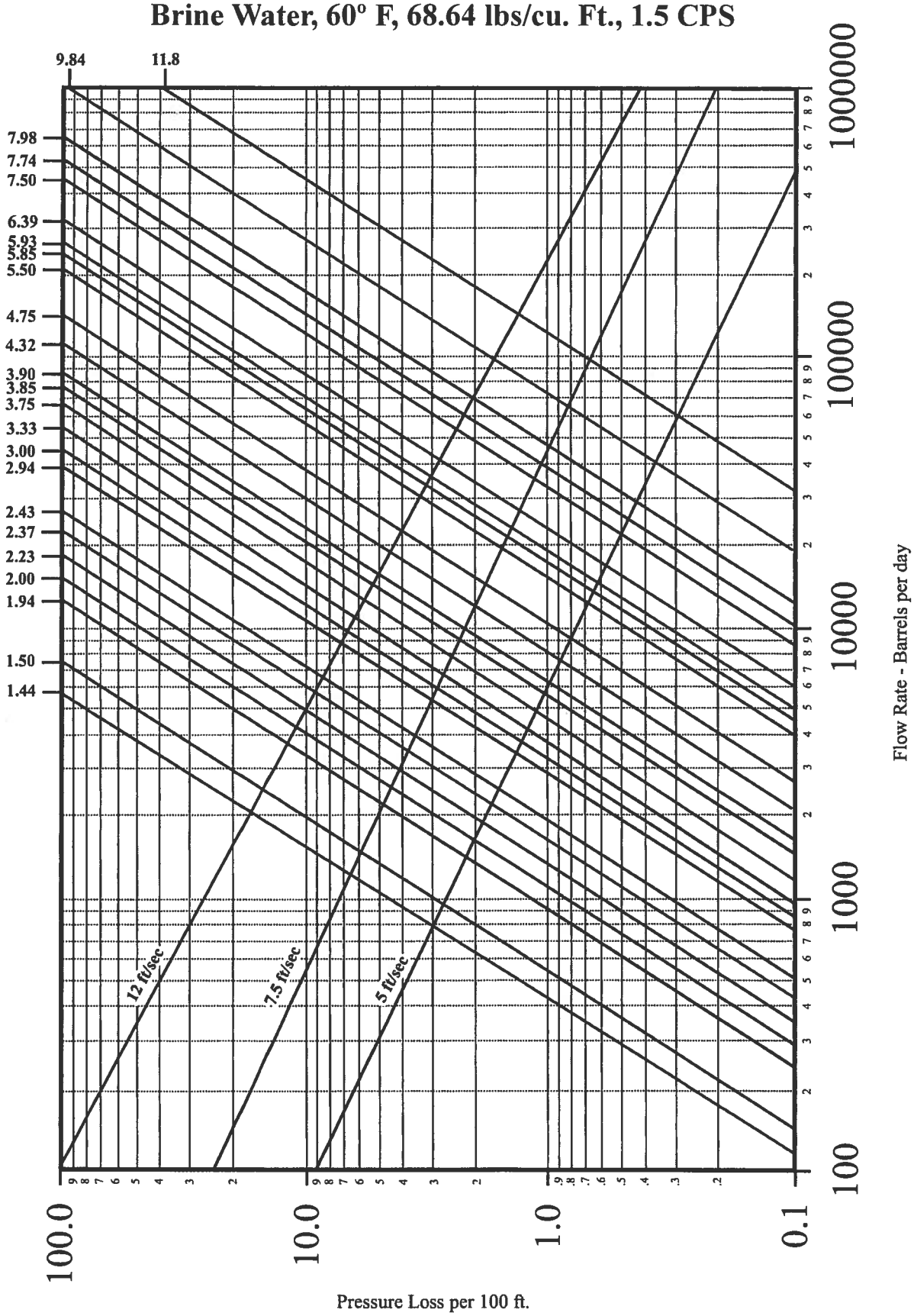
Pressure Loss/Pipe ID
Brine Water, 60° F, 68.64 lbs/cu. Ft., 1.5 CPS



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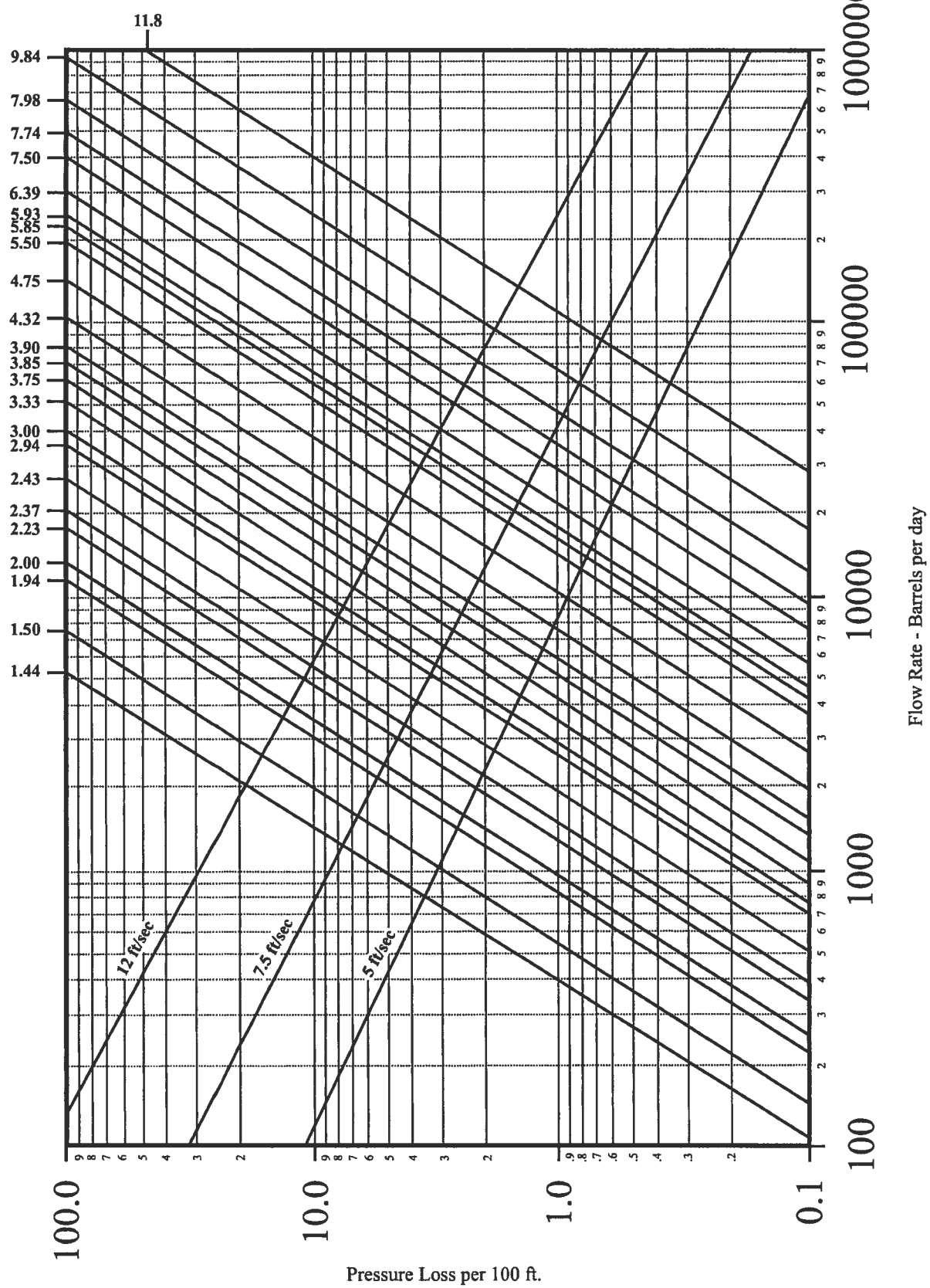
Pressure Loss/Pipe ID
API 40, 60° F, 51.5 lbs/cu.ft., 7.0 CPS



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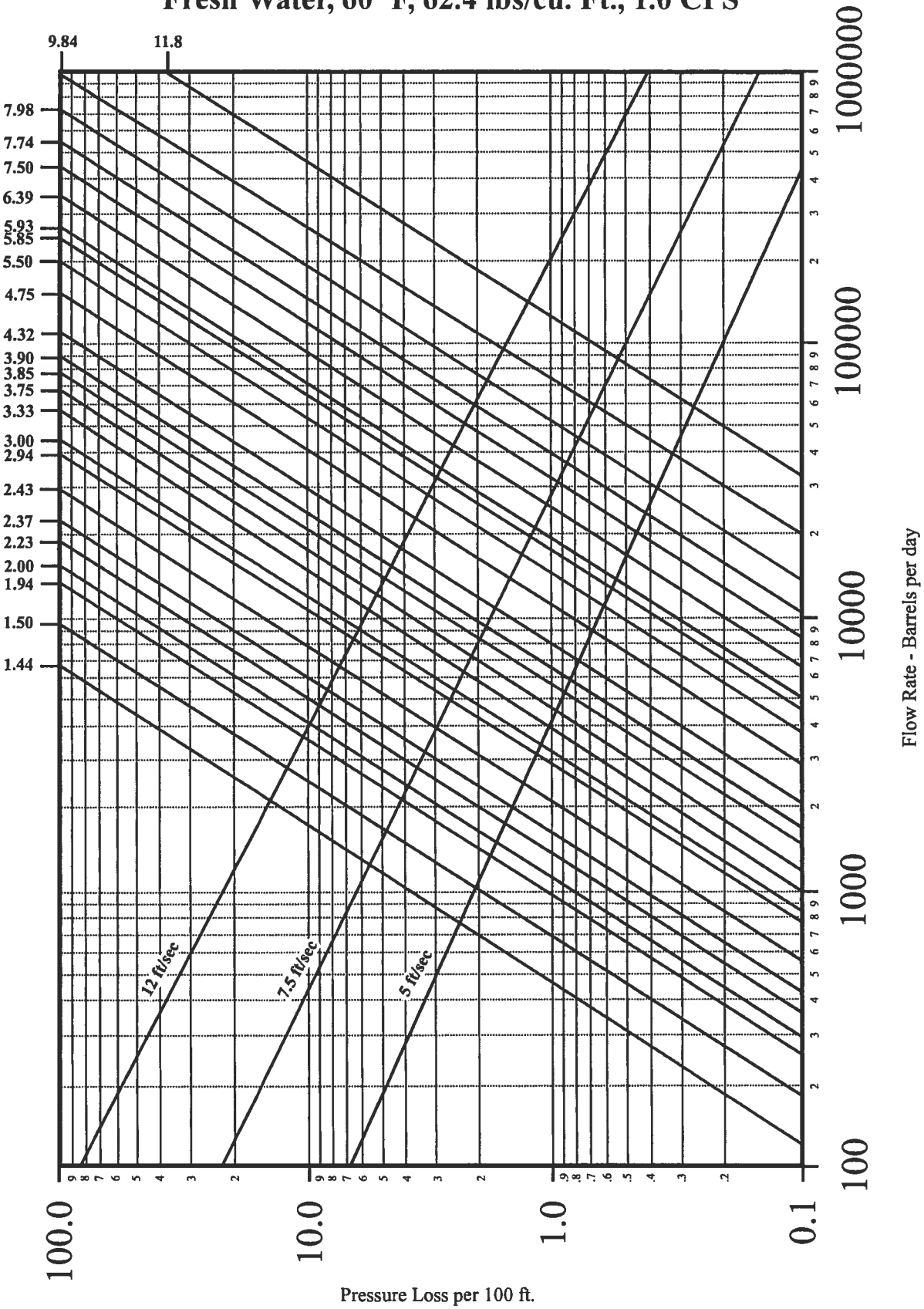
Pressure Loss/Pipe ID
Fresh Water, 60° F, 62.4 lbs/cu. Ft., 1.0 CPS



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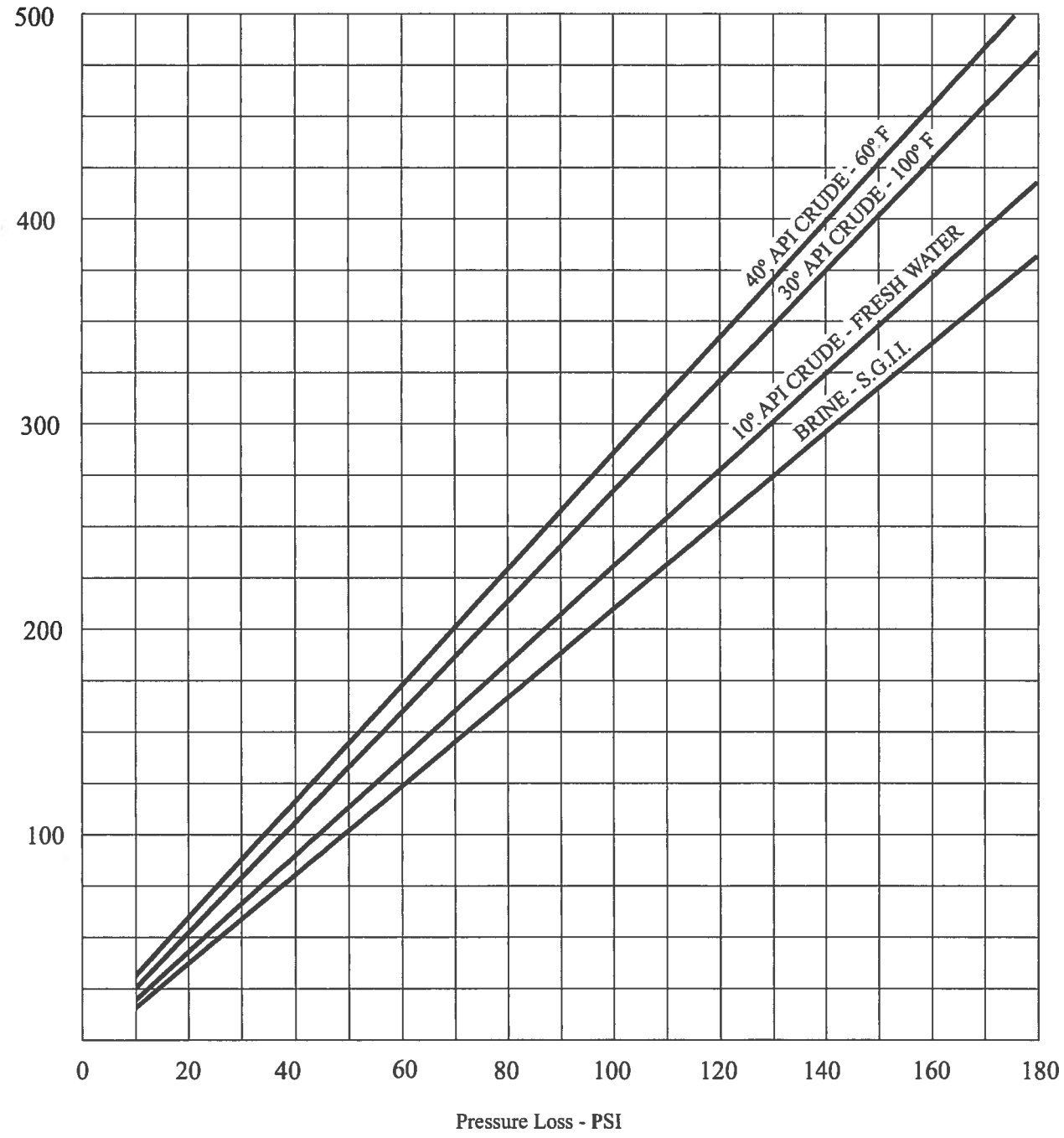
Head Loss (ft) vs. Pressure Loss (psi)



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Fluid and Gas Pressure Drop

Gas Pressure Drop and Fittings Equivalent Feet

Pipe Size	Pipe ID Range	One phase gas flow at transition point*		Equivalent feet of pipe added per fittings for pressure loss calulation			
		Transition Flow Rate MSCFH	Pressure Drop per ft. (psi)	45°	90°	Tee-Run	Tee-Branch
1½"	1.44-1.50	60	.0139	2	2.7	2.3	3.0
2"	1.94-2.00	104	.0088	2.5	4.6	3	9.0
2½"	2.23	135	.0073	3	5.6	3.6	10.8
	2.37-2.43	150	.0068	2.8	5.2	3.2	9.6
3"	2.94-3.00	224	.0048	3.1	5.7	3.7	11.1
4"	3.75						
	3.85-3.90	381	.0030	5.0	9.3	6.2	18.6
5"	4.74	530	.0023	5.7	10.5	7.4	22.2
6"	5.50	702	.0019	7.0	12.5	9.0	27.0
	5.85-5.93	791	.0016	7.5	13.9	9.4	28.2
	6.19						
8"	7.50						
	7.74	1260	.0010	8.0	14.8	13.5	40.5
	7.98						
10"	9.84	1952	.0007	15	35	18	45
12"	11.80	2680	.0005	20	40	25	55

* **For two phase gas-liquid flow calculation, a more in depth evaluation is required. Please contact Fiber Glass Systems, LP for additional information.**

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5.7 Water Hammer Development in FRP Tubulars

Sudden change in fluid velocity in a pipe can cause water hammer. These changes are generally associated with valve closure time or pumps star and stop.

If the value closure time does not exceed the time required for the first pressure wave to travel to the end of the line and back to the valve, a maximum surge pressure will develop.

Calculating Water Hammer Pressure Wave:

A. Calculate pressure wave velocity within the pipe:

$$a = \frac{12\sqrt{\frac{k}{\rho}}}{\sqrt{1+\frac{k}{E_h}\left(\frac{OD+ID}{OD-ID}\right)}}$$

B. Calculate maximum surge pressure:

$$Ps = \frac{a}{g}\frac{V}{2.31}$$

In which: $V = \frac{Q}{A} = \frac{0.409(Q)}{ID^2}$ means velocity.

C. In this instance, actual design pressure can be in the following range:
$P_d = P \pm P_s$

NOTES:

a. The rate of velocity change can be controlled so that no great force is imposed on the pipeline by controlling the time in which valves are opened and closed and the pumps are started and stopped.
b. Hoop modules of elasticity for fiberglass tubulars is lower vs. steel (3.0×10^6). The pressure wave velocities will be lowered.
c. The use of pulsation dampeners can significantly reduce the pulsations induced by the pumps.
d. Peak pressure can be controlled by the proper type of valve and pump (slow start).
e. Installation and product design will be based on the maximum surge pressure.
f. Thrust blocking of the pipe line will also be based on maximum surge pressure.

INDEX:

A = Pressure Wave Velocity (ft./second)
K = Bulk Modules of Fluid (313,000 psi for H2O at 60° F)
ρ = Fluid Density (Slug/FT^3, 1.938 for H_2O at 60°F)
E_h = Hoop Modules of Elasticity
ID = Inside Diameter (Inches)
OD = Outside Diameter (Inches)
G = Acceleration due to gravity (32.17 ft/sec^2)
V = Mean Fluid velocity (ft/sec)
P_s = Maximum surge pressure (psi)
Q = Flow rate (gallon/minute)
P = Operating Pressure (psi)
P_d = Design Pressure

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5.8 Erosion in FRP Tubulars

Solid sand particles suspended in a fluid, impacting the wall of FRP Tubulars, can cause severe erosional problems

Erosion Can be Minimized using the Following Guidelines:

A. **Epoxy System.** Use an epoxy system that exhibits the highest adhesions performance between the epoxy systems and the glass. (Epoxy has shown superior erosion performance over vinylester and polyesters)

B. **Use a Resin Rich Liner.** Epoxy by itself has shown better erosion performance than glass/ epoxy combinations. It seems that epoxy will absorb the force of an impact at a higher rate. The erosion rate is reduced as much as 30% with the employment of a resin rich liner.

C. **Minimize the Impact Angle.** Generally, it is found that the maximum erosion rate in a pipeline occurs at impact angle or 50-60 degrees. However, for FRP products, the angle is at the normal impact of 90°. This rate reduces exponentially with almost no effect at 0° impact angle. Therefore, we need to minimize tee's, 90° elbows and 45° elbows and try to take advantage of minimum bending radius of the pipe or use elbows of lower angle's (22.5° or 11.25°)

D. **Minimize the Flow Velocity.** The particle impact velocity is generally described in the power law form of:

$$E \propto V^n \quad (n \text{ is found to be 2 to 3})$$

NOTES:

a. Increases in sand concentration will increase the erosion of the product linearly.
b. The erosion rate is also a function of particle size and shape.
c. Erosion is closely linked to corrosion. Erosion accelerates the corrosion problem in a metal piping system by continuously removing the protective oxide layer.

5.9 Abrasion in FRP Tubulars

The removal of material due to sliding contact between two solid surfaces is called abrasion. Abrasion is a totally different phenomenon than erosion.

Abrasion Can Be Minimized Using the Following Guidelines:

A. **Good Soil and Good Soil Compaction** will minimize the sliding contact between the pipe and its surroundings.

B. **Softer Material** will always be abraded first. Therefore, a heavy rock that makes contact with FRP pipe will abrade fiberglass pipe if a sliding action is present (minimize this).

C. **The Use of Pulsation Dampeners** can significantly reduce the pulsation and vibration induced by the pumps.

D. **Thrust Blocking** of high pressure 45° elbows, 90° elbows and tee's will minimize the movement due to pressure changes.

E. **Water Hammer** development due to sudden changes in fluid velocity generally associated with valve closure time or pump start and stop, needs to be minimized and controlled.

F. **The Use of Rubber Padding** will prevent abrasion in the support area if vibration, pulsation or expansion and contraction (due to temperature fluctuations) exist.

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6.0 Acid Treatment of Line Pipe or Tubing

Acidizing Procedure

- Hook up the acid truck to the well/line.
- Check to see that the tubing annulus is full to the surface, fill to the surface if necessary.
- The acid in the pump truck must be between 60°F and 100°F.
- Pump the acid at the minimum pressure necessary to force the fluid into the formation or through the line.
- The well head pressure must not exceed 75% of the rated pressure.
- The exposure time shall not exceed 4 hours.
- If the acid pumping is interrupted, immediately flush the line pipe or tubing.

CAUTION: The acid must not be left to sit in the fiberglass pipe. Line pipe will require pigging the line to avoid leaving traces of acid in valleys, low spots, or bends in the line.

- Once the required amount of acid is pumped, immediately flush the well/line with water or **BRINE** until a minimum of five times the volume of the pipe has been injected.
- Do not leave the acid sitting in the fiberglass pipe.

Tubing Precautions (Aliphatic Amine and Aromatic)

- Extremely hot wells (≥175F) require cooling down prior to acidizing, contact Fiber Glass Systems, LP. for specific considerations.

Line Pipe Precautions

- Avoid over-bending pipe during installation (see 2.0 and catalog product data for minimum bending radius). Exceeding the minimum bending radius can cause stress cracking which could lead to acid attack during acid treatment for scale build-up.
- Flush the line using a pig ahead of the flush water.
- The volume of flush water through each branch of the line must be calculated to meet the minimum requirement of five times the volume of the line.

7.0 Training Personnel

7.1 Pre-Bid/ Installation Meeting

- Review handling and storage .
- Review installation procedures.
- Qualify equipment (power tongs, elevators, slips, hand tools).
- Review installation schedule.

7.2 Responsibility Of The FGS Service Representative

- Train and advise the supervisor and crew members in these recommended practices.
- Provide testing after training to qualified personnel who handle fiberglass tubulars.
- Any new or substitute crew member and supervisor must be trained prior to taking over activities; at a minimum, two crew members and a supervisor must be on location who are experienced and qualified according to these procedures.

NOTE: FGS representatives will not substitute for a crew member, nor be responsible for supervising the crew.

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8.0 Warranty

Seller warrants that PRODUCTS manufactured by Seller when properly installed, used, and maintained shall be free from defects in material and workmanship. Seller's responsibility under this warranty shall be limited to replacing or repairing PRODUCTS, at Seller's option, the PRODUCTS that prove defective in material or workmanship within one (1) year from the date of installation, provided that Buyer gives Seller prompt notice of any defect or failure and satisfactory proof thereof. Any defective product must be returned to Seller's factory, or any other repair facility designated by Seller. Seller will deliver replacement of defective PRODUCTS to Buyer freight prepaid to the destination provided for in the original order. PRODUCTS returned to Seller for which Seller provides replacement under this warranty shall become the property of the Seller.

This limited warranty does not apply to failure of PRODUCTS caused by abrasive materials, exposure to aggressive fluids, improper application, mishandling, or abuse.

In the event PRODUCTS are altered or repaired by the Buyer and/or end user without prior written approval of the Seller, all warranties are void. Equipment and accessories not manufactured by the seller warranted only to the extent of and by the original manufacturer's warranty. A new warranty period shall not be established for repaired or replaced materials, PRODUCTS, or supplies. Such items shall remain under warranty only for the remainder of the warranty period on original materials, PRODUCTS, or supplies.

The foregoing warranties are in lieu of all other warranties, whether oral, written, express, implied or statutory. Implied warranties of fitness and merchantability shall not apply. Seller's warranty obligations and Buyer's remedies thereunder (except as to title) are solely and exclusively as stated herein. In no case will Seller be liable for consequential damages, labor performed in connection with removal and replacement of the PRODUCTS, loss of production or any other loss incurred because of interruption of service.

IMPORTANT NOTICE

This literature is intended as a guide only. All values listed in this product specification are nominal. Unsatisfactory product results may occur due to environmental fluctuations, variations in operating procedures, or interpolation of data. We suggest that personnel using this data have specialized training and experience in the application of these products and their normal installation and operating conditions. Your intended application of these products should be verified for propriety by your engineers. We expressly disclaim responsibility for any consequential or incidental damages resulting from the installation or use of these products since we do not determine the degree of care utilized during the product installation or service. We reserve the right to revise this data, as necessary, without notice. We welcome comments regarding this product literature.