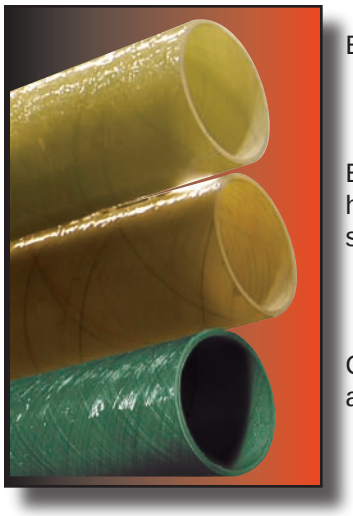
Bulletin No. C3320
March 1, 2008

FIBER GLASS SYSTEMS
Time-Tested
Fiberglass Piping Systems for Water Applications

Choosing a Piping System

Fiber Glass Systems offers:

- Superior Material Performance
  - Temperature range -75° to 275°F
  - Long, corrosion-free life
- Light Weight
  - One-eighth the weight of steel
- Low Cost of Ownership
  - Better flow properties
  - Lower energy cost
  - No cathodic protection or corrosion inhibitors

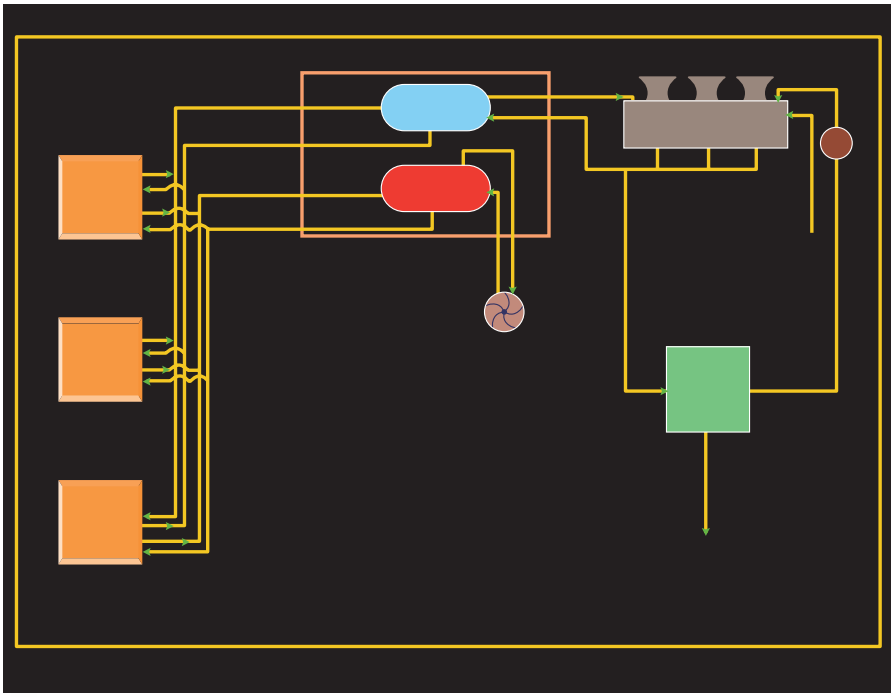


Green Thread®
Especially suitable for dilute acids, caustics, hot-water and condensate return.

Red Thread® II
Extensively used for water and saltwater handling, and light chemical services including salts, solvents, and pH 2-13 solutions that corrode traditional metal piping systems.

F-Chem®
Custom piping — ideal for cooling tower piping and many chemical waste streams. Premium and fire retardant resins available.

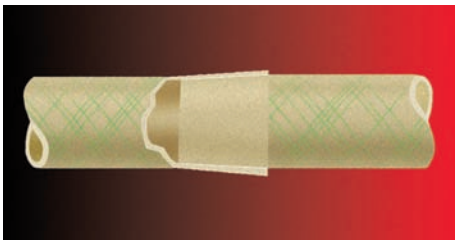
Pipe	Size Range (In.)	Resin	Pressure Rating (psig)	Inner Corrosion Barrier/Liner Thickness (In.)	Temperature Rating	Joint Types	RTRP Classification (ASTM D2310)	Product/ Installation Manuals
Green Thread	1 - 24	Aromatic Amine Epoxy	225-450	.015 - .030	225F/107C	Bell & Spigot	RTRP-11FF	A1300 F6000
Red Thread	2 - 3 4 - 24	Aromatic Amine Epoxy	225-450	Resin Rich	210F/100C	T.A.B. or Bell & Spigot	RTRP-11AF	A1200 F6000
F-Chem	14 - 72	Polyester, Vinyl Ester	50-150	.020 - .250	225F/121C	Bell & Spigot, O-Ring, Flanged, Butt & Wrap	RTRP-12EU	A1880 F6080 F6000



Water Applications

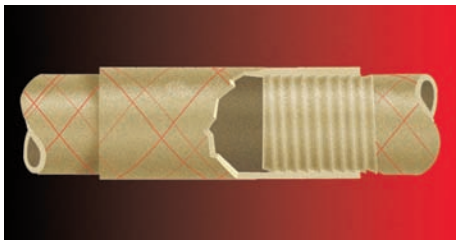
- *District Heating & Cooling*
- *Steam Condensate Return*
- *Heating Water Supply and Return*
- *Chilled Water Supply and Return*
- *Condenser and Cooling Tower Piping*
- *NSF Listed for Potable Water*
- *FM Approved for Underground Fire Mains*
- *Thermal Storage*

Joining Systems



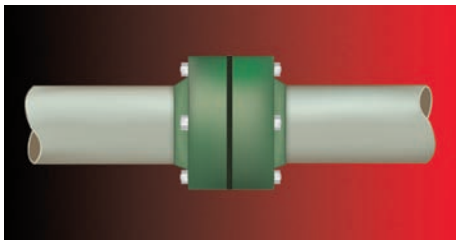
Bell & Spigot

A matched-taper joint secured with epoxy adhesive. Stronger than the pipe itself, in both internal-pressure and axial-tension capability. Resists movement, facilitating joining long runs of pipe without waiting for the adhesive to cure. Can be used with 1-inch to 24-inch pipe diameters.



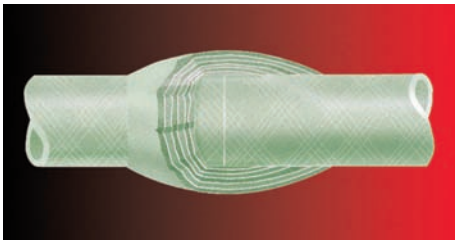
T.A.B.™

The ultra-reliable Smith Fibercast threaded and bonded joining system. Double-lead threading ensures a secure adhesive connection during installation. Available for 2-inch through 6-inch pipe diameters (larger sizes available by special quotation).



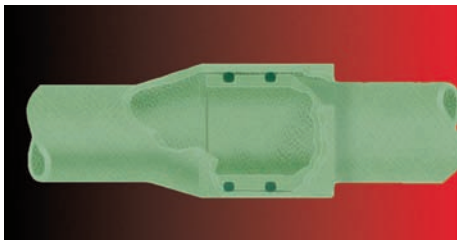
Flanged

Available for all piping systems and diameters; factory assembled or shipped loose for assembly in the field.



Butt & Wrap

Plain-end pipes or pipe and fittings butted together and wrapped with multiple layers of resin-saturated mat or woven roving. Can be used with all piping systems and diameters.



O-Ring Bell & Spigot

Mechanical, O-ring sealed joint, especially useful for buried installations. Available for 10-inch through 72-inch diameters, with the choice of either single or double O-rings in most sizes.

Fiber Glass Systems Support

To help ensure timely, trouble-free, and above all economical installations of time-tested FGS piping systems, we offer unrivaled customer support to go with our unrivaled product lineup. Call FGS Smith Fibercast for full information about all of the following and more:

- Turn-key design and engineering assistance
- On-site installation training
- Free FGS piping design CD-ROM programs including the *Success by Design* engineering program, complete with pipe specifications and chemical guidelines (also available for download from our web site).
- Factory fabrication services to reduce field joints and installation cost
- The worldwide network of stocking distributors and certified fabricators

Joining Systems

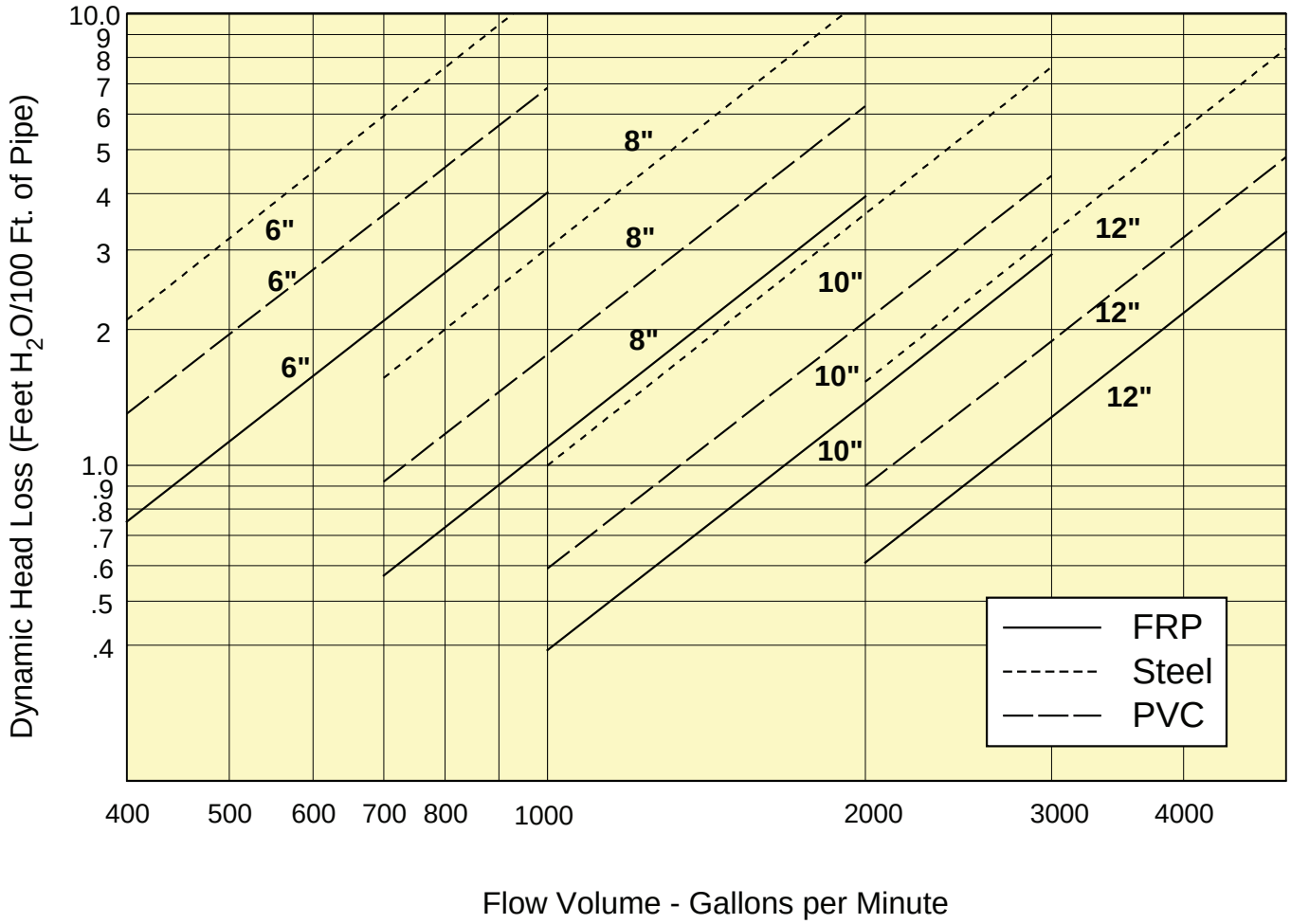
Friction Loss

The absolute roughness of FGS piping systems as determined from flow data is 0.00021 inches. This is equivalent to a Manning value (n) of 0.009 and a Hazen-Williams coefficient of 150. See Figure 1 for comparative head losses between fiberglass, Schedule 40 steel and PVC pipe. This low friction loss coupled with larger flow areas translates into:

- Better flow properties
- Reduced pump pressure
- Less horsepower consumed
- Lower energy cost
- Ability to reduce pipe size

FIGURE 1 • Pressure Loss Curves for Water

FRP & PVC based on Darcy-Weisbach & Colebrook Equations
Sch. 40 Used Steel based on Hazen-Williams Equation "C" Factor 100

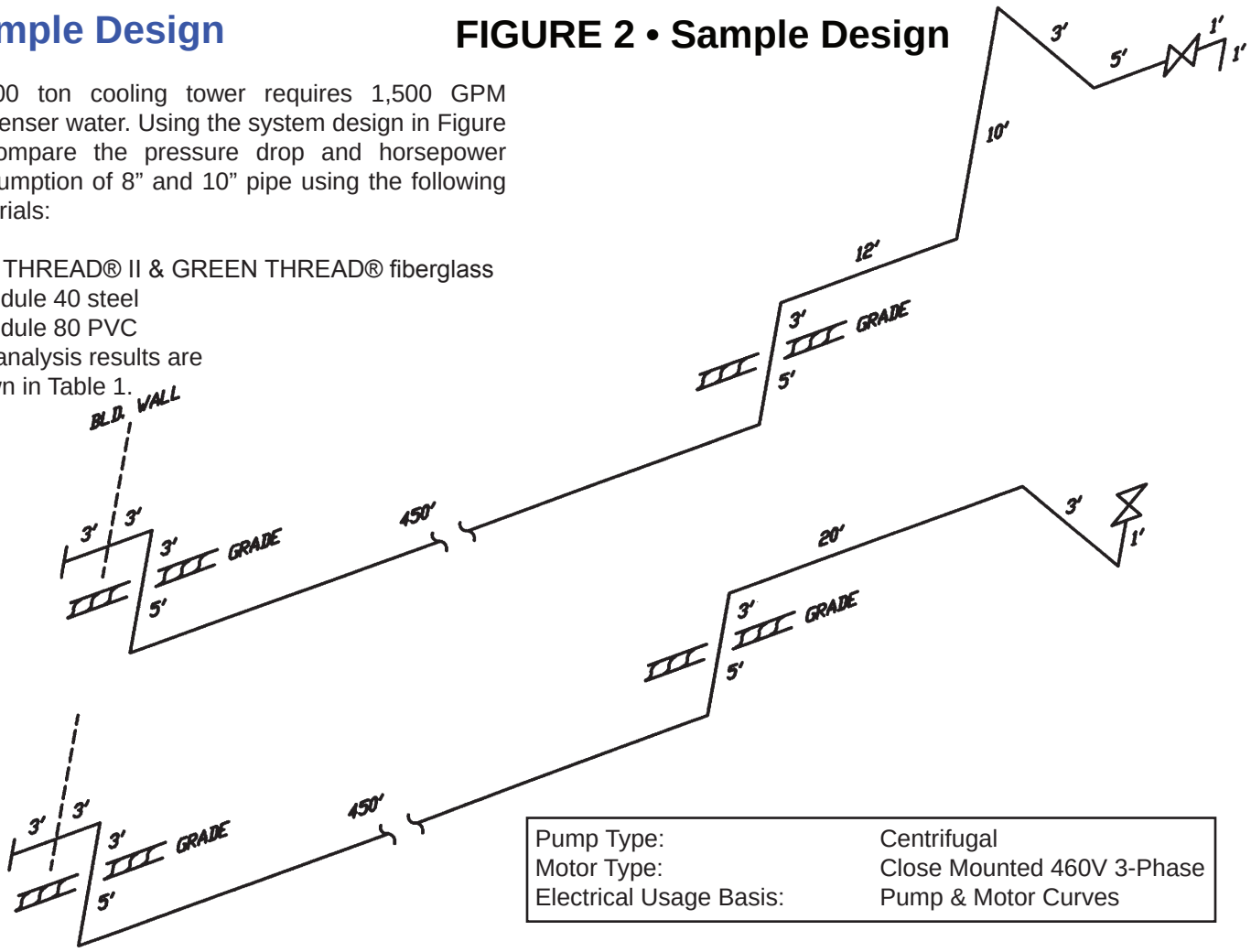


Sample Design

A 500 ton cooling tower requires 1,500 GPM condenser water. Using the system design in Figure 2, compare the pressure drop and horsepower consumption of 8" and 10" pipe using the following materials:

RED THREAD® II & GREEN THREAD® fiberglass
Schedule 40 steel
Schedule 80 PVC
The analysis results are shown in Table 1.

FIGURE 2 • Sample Design



Pump Type:	Centrifugal
Motor Type:	Close Mounted 460V 3-Phase
Electrical Usage Basis:	Pump & Motor Curves

TABLE 1 • Pressure Drop and Horsepower Consumption

	8" Sch 40 Steel	8" Sch 80 PVC	8" RTII & GT	10" Sch 40 Steel	10" Sch 80 Steel	10" RTII & GT
Design						
Flow Rate (gpm)	1500	1500	1500	1500	1500	1500
Flow Area (in.^{2})	50.0	44.9	54.9	78.9	70.8	84.3
Velocity (ft./sec.)	9.63	10.72*	8.78	6.11	6.81*	5.72
Pressure Drop (ft. H_2O/100 ft. pipe)	6.33	3.88	2.39	2.09	1.29	0.84
Equivalent Feet of Pipe						
Pipe Length (ft.)	1000	1000	1000	1000	1000	1000
14 Elbows (equivalent length/unit)	280 (20)	280 (20)	476 (34)	350 (25)	350 (25)	588 (42)
2 Valves (equivalent length/unit)	60 (30)	60 (30)	60 (30)	58 (29)	58 (29)	58 (29)
Total	1340	1340	1536	1408	1408	1646
Total Head (ft. H_2O)						
Dynamic Head	85	52	37	29	18	14
Static Head	10	10	10	10	10	10
Total Head	95	62	47	39	28	24
Pump Horsepower Rating						
Pump Horsepower Rating	60	40	25	20	15	15
Actual Horsepower Usage	59.5	30.5	23.5	19.0	14.8	13.0
Electric Power Usage						
Actual Power Usage (kw)	47.7	24.4	19.0	15.5	12.2	10.8

* Exceeds manufacturer's maximum recommended velocity.

Life Cycle Cost Comparison

Life cycle cost for the sample design can be found in Table 2. This comparison does not take into account the cost reductions for fiberglass piping systems due to:

- Elimination of cathodlc protaction needed with steel pipe
- Reduced usage of water treatment chemicals
- Lighter load rated pipe support systems
- Fewer pipe supports needed that with PVC pipe
- Lower maintenance cost

Fiberglass has a long corrosion-free service life and requires no coating or cathodic protection.

Project Life:	**20 Years**
Annual System Usage Time:	**75%**
Electrical Cost:	**4 cents/Kwh**
Discount Rate:	**8%**

TABLE 2 • Pipe Size & Type vs. Life Cycle Cost

Cost Description	8" Sch 40 Steel	8" Sch 80 PVC	8" GT	8" RTII	10" Sch 40 Steel	10" Sch 80 PVC	10" GT	10" RTII
Year Zero Cost								
Pump, Motor & Combination Starter	$12,577	$11,777	$8,829	$8,829	$8,813	$8,226	$8,226	$8,226
Pipe Installed Cost	$42,095	$19,755	$40,730	$33,730	$54,135	$30,710	$55,285	$48,285
Year Zero Total	$54,672	$31,532	$49,559	$42,559	$62,948	$38,936	$63,511	$56,511
Year 1 - 20 Annual Electrical Cost	$12,536	$6,412	$4,993	$4,993	$4,073	$3,206	$2,838	$2,838
20 Year Discounted Life Cycle Cost	$674,238	$348,432	$296,328	$289,328	$264,248	$197,386	$203,773	$196,773

Contact Fiber Glass Systems for life cycle cost equations. Based on pricing in effect in 2004.

Thermal Expansion Comparison

Fiber Glass Systems' fiberglass reinforced thermoset resin (FRP) piping systems have relatively low rates of thermal expansion when compared to other materials commonly used in water systems. While PVC expands at 5 times the rate of carbon steel, Smith Fibercast pipe only expands 1 1/2 to 2 times (see Figure 3).

The low rates of expansion and flexibility of fiberglass allow for easy anchor, guide and support design (reference Fiber Glass Systems Engineering and Piping Design Manual No. E5000).

Combining the low rate of expansion with a low compressive modulus of elasticity results in piping systems that create very low restrained thermal end loads. Only 2-4% as much as Schedule 40 steel, about one-half that of PVC. These low end loads not only protect the pipe and fittings from failure, but also adjoining equipment such as sumps, heat exchangers and pumps. Fiberglass piping systems provide a generous margin of safety when restrained at elevated temperatures (see Figures 4-6).

Figure 3 - Thermal Expansion Based on Installation @ 70° F

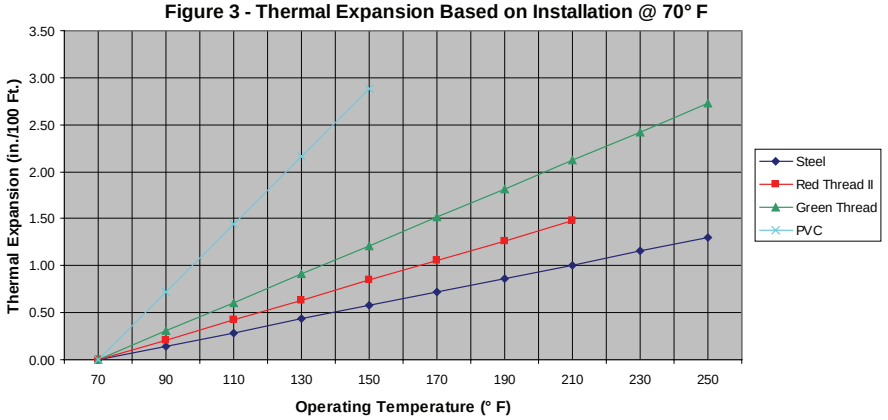


Figure 4 - FRP Pipe Restrained Thermal End Load Stress
Based on 70° F Installation Temperature

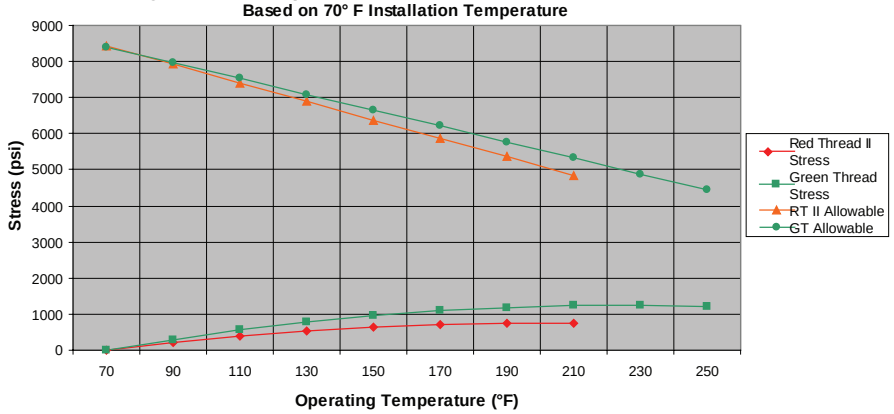


Figure 5 - PVC Pipe Restrained Thermal End Load Stress
Based on 70° F Installation Temperature

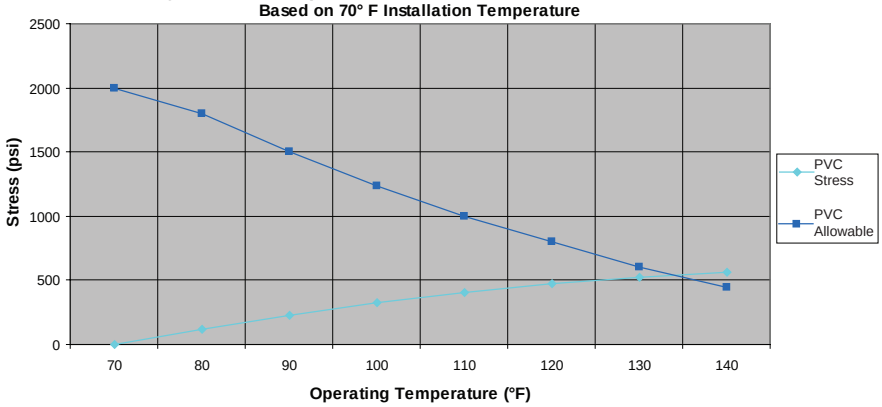
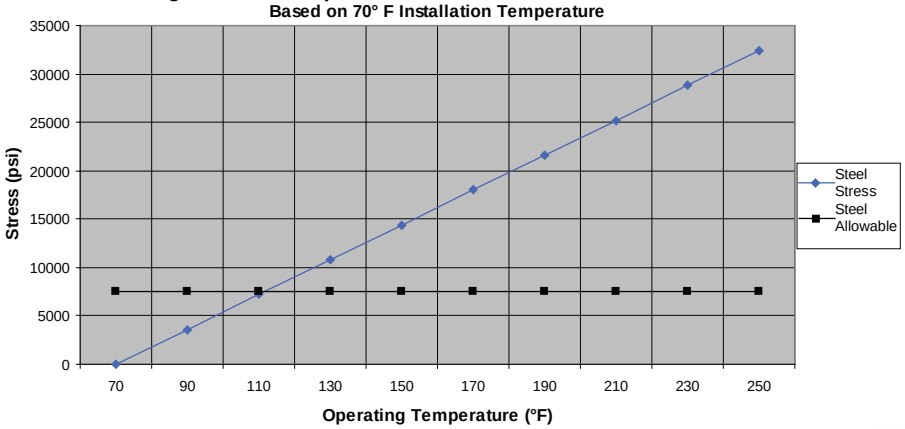


Figure 6 - Steel Pipe Restrained Thermal End Load Stress
Based on 70° F Installation Temperature



Pipe Support Comparison

FGS FRP piping systems combination of high strength and light weight result in support span spacing which typically meets or exceeds those recommended for Schedule 40 steel pipe. PVC will require about three times the number of supports as required for fiberglass piping (see Table 3). Fiberglass pipe retains support span spacing even at elevated temperatures. And fiberglass pipe is typically one-eighth the weight of steel (see Table 4). Water filled weights of fiberglass pipe are 40% - 50% less than Schedule 40 steel resulting in greatly reduced support requirements and building loads (see Table 5).

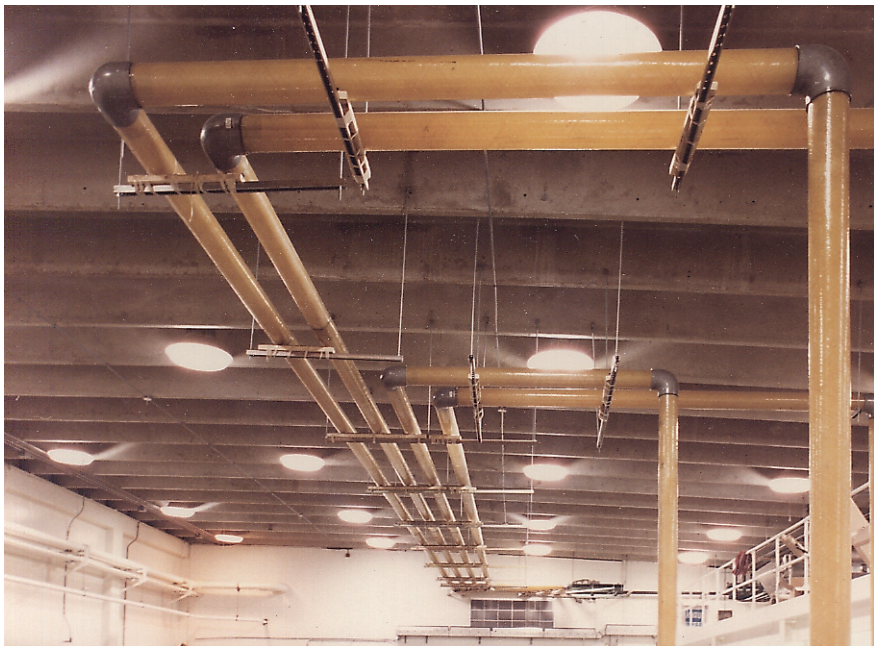


TABLE 3 • Water Filled Pipe Support Spacing versus Operating Temperature (ft.)

Nominal Diameter	Pipe Material	Temperature (ft.)							
		75	100	125	150	175	200	210	225
6”	Sch. 40 Steel	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
	Green Thread	20.4	20.0	19.6	19.0	18.6	18.0	17.5	17.1
	Red Thread II	20.9	20.5	20.1	19.6	19.2	18.6	18.4	NR
	Sch. 80 PVC	9.4	8.5	7.3	NR	NR	NR	NR	NR
8”	Sch. 40 Steel	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
	Green Thread	23.0	22.5	22.1	21.4	20.9	20.2	19.8	19.3
	Red Thread II	22.8	22.3	21.9	21.4	21.0	20.3	20.1	NR
	Sch. 80 PVC	10.4	9.5	8.2	NR	NR	NR	NR	NR
10”	Sch. 40 Steel	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
	Green Thread	25.5	25.0	24.5	23.7	23.2	22.4	21.9	21.4
	Red Thread II	25.4	24.9	24.4	23.9	23.4	22.6	22.4	NR
	Sch. 80 PVC	11.2	10.2	8.8	NR	NR	NR	NR	NR
12”	Sch. 40 Steel	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
	Green Thread	27.8	27.2	26.7	25.9	25.3	24.5	23.9	23.4
	Red Thread II	27.7	27.1	26.6	26.0	25.5	24.7	24.4	NR
	Sch. 80 PVC	12.3	11.3	9.8	NR	NR	NR	NR	NR

FRP based on 1/2” max. mid-span deflection Steel & PVC based published data
NR = Not Recommended

TABLE 4 • Pipe Weight per Foot (lbs.)

Nominal Diameter	6”	8”	10”	12”
Sch. 40 Steel	18.9	28.5	40.8	53.5
Green Thread	2.4	3.9	5.9	7.7
Red Thread II	2.4	3.3	5.3	7.2
Sch. 80 PVC	5.5	8.3	12.2	16.9

TABLE 5 • Weight Per 20 Foot Joint filled with Water (lbs.)

Nominal Diameter	6”	8”	10”	12”
Sch. 40 Steel	630	1005	1500	2041
Green Thread	323	544	831	1169
Red Thread II	327	540	827	1161
Sch. 80 PVC	331	556	859	1206

Pressure Ratings Comparison

Fiber Glass Systems' FRP piping systems have excellent internal pressure ratings at ambient and elevated temperatures. Schedule 80 PVC has comparable 70°F internal pressure ratings, but have a 50% reduction in the ratings at 110°F (see Figure 7).

When flow suddenly starts or stops, by pump startup or by a quick closing valve, a high pressure surge can be created (see Tables 6 & 7).

While high pressure surges should be avoided, FRP piping system's low modulus of elasticity creates 60% less surge pressure than Schedule 40 steel. This not only protects the piping from fast acting valves and pump startup, but also protects adjoining equipment such as valves, expansion joints and instrumentation. Fluid hammer can be significantly reduced in FRP piping systems by controlling pump startup and valve closure rates.

Figure 7 - Static System Pressure Ratings vs. Operating Temperature

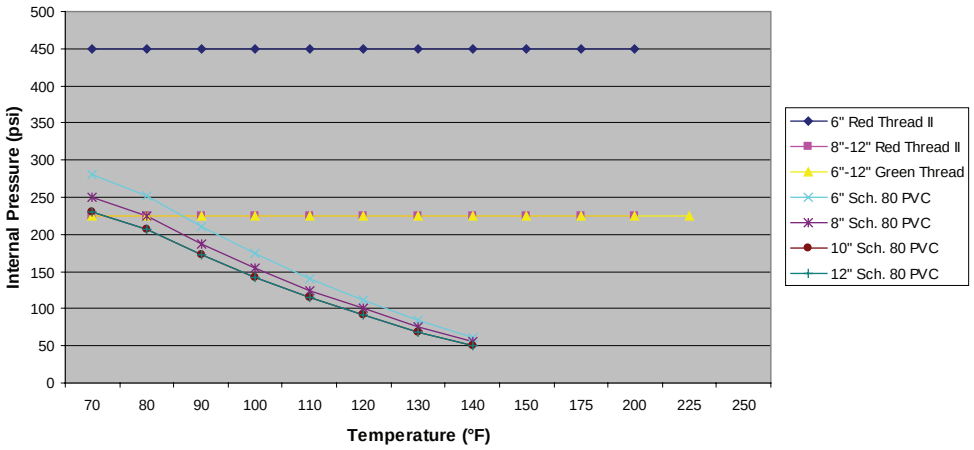


TABLE 6 • Fluid Water Hammer Constants

	Nominal Pipe Size			
Piping Material	**6"**	**8"**	**10"**	**12"**
Sch. 40 Steel	57.6	56.9	56.3	55.9
Red Thread II	22.4	20.2	20.0	20.0
Green Thread	23.2	21.3	20.9	20.7
Sch. 80 PVC	20.2	18.8	18.3	18.0

TABLE 7 • Surge Pressure for Water Service (psi)

Nominal Diameter	Pipe Material	Flow Rate (gal./min.)						
		500	**1000**	**1500**	**2000**	**3000**	**4000**	**5000**
6"	Sch. 40 Steel	320	641	961				
	Red Thread II	118	235	353				
	Green Thread	112	223	335				
	Sch. 80 PVC	127	253	380				
8"	Sch. 40 Steel	183	365	548	731			
	Red Thread II	62	125	187	249			
	Green Thread	59	118	177	236			
	Sch. 80 PVC	67	134	202	269			
10"	Sch. 40 Steel		229	344	459	688	917	
	Red Thread II		80	119	159	239	318	
	Green Thread		76	114	152	229	305	
	Sch. 80 PVC		83	125	166	249	332	
12"	Sch. 40 Steel			240	321	481	641	802
	Red Thread II			84	112	168	224	280
	Green Thread			81	108	163	217	271
	Sch. 80 PVC			87	115	173	231	289

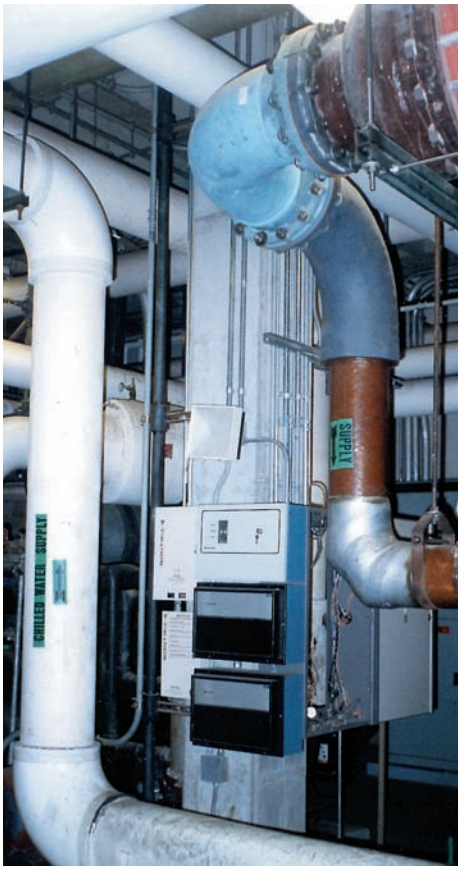
Case Histories

Deionized water lines in service since 1969 at a South Texas Semi-Conductor Plant

- Exposed piping on the building rooftop still in excellent shape after 30 years
- Results of strength retention testing in 1995 shows the piping system should last at least another 20 years

Cooling water lines at Jollyville Pump Station installed in 1988

- System designed to give 40 to 50 years of service life.
- Metal piping could corrode and cause extensive damage to the 600 hp turbines and to the coils for building's air conditioning equipment.
- Better flow capacity with RED THREAD II compared to steel.



Heating and cooling system update in a 43-year Old Building

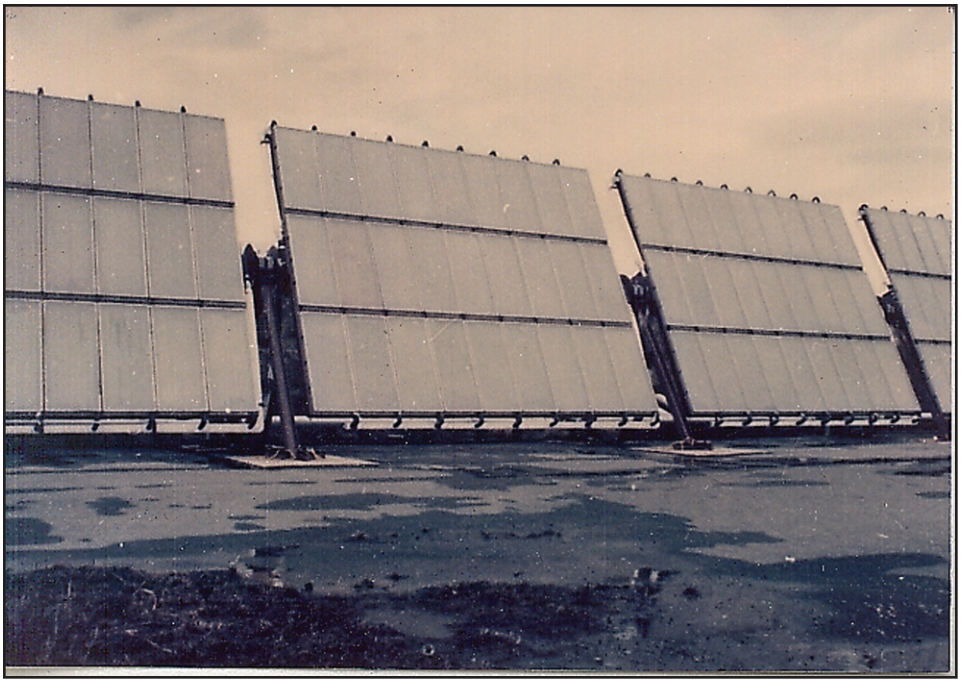
- GREEN THREAD pipe, with its temperature rating to 225°F, was ideal for chilled/hot water lines because it resists the corrosion occurring in condensate return lines and also handles hot water without loss of strength.
- The highly flexible piping was easily installed in building columns through access doors using small crews and minimal handling equipment.

Hot/chilled water lines provide Tulsa Fairgrounds Exposition Center with air conditioning since 1976

- The light weight fiberglass was ideal for the 8-foot square, 1,200 foot long utility tunnels.
- Water ranging from 40° to 160°F traveled through utility tunnels and up to six fan rooms. More than 40,000 gallons of water are contained within the system and 4,536 gallons of water per minute through the various pipe lines.

Fiberglass pipe puts a quick stop to costly steam loss at the East River Housing Corp.

- Corrosion resistance of underground fiberglass piping was essential for return lines.
- Engineers required a pipe with long-term service life, high temperature performance and easy installation.
- Cost savings in Installation and excavation were over 75% of the contractors bid to excavate and lay new pipe.



Colleges, universities and hospitals are common installation sites for fiberglass piping.

Contact your FGS representative for these and other installations.

New Jersey Plant is being heated and cooled by solar energy

- Piping system handles temperature ranges of 35°F to 195°F. More than 6,000 feet of FRP piping from Fiber Glass Systems transported heated and chilled liquid throughout the 40,000 sq. ft. office and manufacturing facility.
- Substantial weight savings was attained with FRP since 4,000 feet was suspended from the ceiling. Copper pipe weighs 2 to 4 times that of FRP pipe in the sizes considered.

FRP Steels School Project for chilled water and return lines

- Flow characteristics of FRP are superior to steel.
- Lighter weight at only 11 pounds per foot, the RED THREAD II piping provided installation benefits over steel pipe at 54 pounds per foot. Existing supports on ten-foot centers was more than sufficient for FRP piping.

FGS helped cool the outdoors in Texas

- Resistance to the area's notoriously corrosive soil conditions was required for the underground chilled water system.
- Installed cost saving with the fiberglass was a key factor in the selection of RED THREAD II piping, especially since no cathodic protection was required.

Design & Installation Considerations

Refer to Fiber Glass Systems' Engineering & Piping Design Manual No. E5000 for the following design considerations:

- Supports, anchors and guides
- Thermal Design
- Burial

Refer to Fiber Glass Systems' Pipe Installation Handbooks - F6000 for Matched Tapered Bell & Spigot Joints or F6080 for Butt & Wrap Joints for:

- Pipe assembly
- Connecting to other systems and equipment

Consult product Bulletins for specific information pertaining to physical properties, support spacing and thermal end loads.

SUCCESS BY DESIGN

Consult *Success by Design* engineering program for design analysis on your system. Available from Fiber Glass Systems or download from our website at www.smithfibercast.com.

Factory Mutual System Approved

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