ERSHIGS

FRP PIPE, DUCT AND FITTINGS
ENGINEERING GUIDE AND SPECIFICATIONS
SIXTH EDITION

Ershigs, Inc. The Leader in FRP Systems

Since 1921, Ershigs, Inc. has been providing industry with quality metal products and dependable service. Since 1960, Ershigs' dedication to quality and service has provided industry with dependable Fiberglass Reinforced Plastic products and services. Ershigs' products are expertly designed by professional engineers and carefully manufactured by skilled craftsmen. Experienced construction personnel are available to install the products at your plant, providing you with a single point of responsibility for a turn-key system.

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This catalog describes the construction and dimensions of Ershigs' Fiberglass Reinforced Plastic pipe, duct and fittings. It also provides general guidelines for design and installation to aid the user in the proper application of the products described. All information provided herein is subject to change without notice. Ershigs' Engineering Department should be contacted for specific application and design recommendations.

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Section 1: Introduction

Ershigs' Fiberglass Reinforced Plastic (FRP) piping and ductwork has been serving industry since 1960. This composite material is carefully manufactured using appropriate polyester or vinyl ester thermosetting resins and fibrous glass reinforcements. Ershigs' FRP is the logical construction material of choice for handling a wide variety of fluids and gases.

ADVANTAGES OF ERSHIGS' FRP

- **Economical** – FRP systems are less expensive than most stainless steel alloys. In larger sizes, FRP is less expensive than traditional materials of construction on an installed basis.
- **Corrosion Resistant** – The ability of FRP to resist a wide variety of corrosives is a principal benefit. FRP is custom designed to resist your particular environment.
- **Strong** – Pound for pound, fiberglass is stronger than steel and Ershigs' FRP products have exceptional strengths and impact resistance.
- **Lightweight** – Ershigs' FRP piping products weigh as little as $^1/_6$ the weight of steel and $^1/_{20}$ the weight of concrete.
- **Temperature Stable** – Ershigs' FRP piping is made with thermosetting resins which do not soften with heat and can be used over a wide range of temperatures. Proper resin selection permits Ershigs' FRP systems to operate at temperatures up to 350° with excursions to 400°F.
- **Excellent Flow Characteristics** – The smooth seamless interiors of Ershigs' FRP pipe and duct saves pumping costs and reduces maintenance. These surfaces resist sludge and mineral deposit build-up and provide a Williams and Hazen C factor of 150.
- **Size Variety** – Ershigs' FRP pipe and duct is available in standard diameters from 2 inches through 144 inches. Pipe lengths to 40 feet are standard with specials available to suit specific applications.
- **Custom Manufactured** – FRP products are custom molded and assembled into virtually any size and shape and are not limited to specific sheet, shape or die sizes.
- **Abrasion Resistant** – Ershigs' AR piping gives high abrasion resistance in applications where both corrosion and erosion are a consideration. Ershigs' AR piping will operate under the same pressures and temperatures as standard FRP piping.

Contact Ershigs to discuss your Specific Application.

Section 2: Laminates

Ershigs' Fiberglass Reinforced Plastic (FRP) laminates are manufactured with thermosetting polyester or vinyl ester resins and various types of fibrous glass reinforcing. Materials are carefully selected for each specific application. The fiberglass reinforcement is thoroughly saturated with catalyzed resin to form a dense laminate with the required physical and chemical resistant properties. In general, the glass reinforcing provides the strength to the laminate and the resin binder provides the chemical resistance. All laminates are designed to meet the specific application requirements.

Laminate Construction

Ershigs manufactures pipe and fitting laminates with a variety of liner and structural wall constructions. In order to achieve optimum chemical and abrasion resistance, all laminates are composed of an **Inner Surface**, an **Interior Layer**, a **Structural Layer** and an **Outer Surface Layer**. The combination of Inner Surface and Interior Layer is often referred to as the **Liner** or **Corrosion Barrier** and is generally considered to contribute structural strength as well as corrosion resistance to the laminate.

Inner Surface - This surface is exposed to the corrosive environment and is composed of resin reinforced with "C" glass veil or a synthetic veil such as Nexus. This layer is 10 to 20 mils thick and has an approximate 90/10 resin to glass ratio by weight for maximum corrosion resistance.

Interior Layer - This portion of the laminate is composed of multiple layers of chopped strand fiberglass reinforcement. Standard construction utilizes two layers of 1 ½ ounce per square foot chopped strand fiberglass saturated with resin and produces a thickness of 85 to 95 mils with a 22% to 32% glass content. In some mild environments a single layer of chopped strand may be used, while aggressive environments may dictate the use of more than the standard two layers. Additional liner thickness can be specified for equipment which may see extreme chemical or abrasive service.

Structural Layer - This layer is the primary structural portion of the laminate and is designed to withstand the loads caused by pressure, wind, seismic and other conditions. It consists of alternating layers of chopped strand and 24 ounce per square yard woven roving to the required thickness. The glass content in these layers will be 30-45% depending on the amount of woven roving used. This layer may also be composed of filament wound continuous strand fiberglass reinforcement which is typically helically wound onto the mandrel and has a glass content of 55-70% by weight.

Outer Surface Layer - This surface is a resin coating formulated to be non air-inhibited and fully cured. When exposed to the environment, this coating contains ultraviolet absorbers or pigments to minimize ultraviolet degradation. If the outer surface of a laminate is to be exposed to a corrosive environment, a veil layer or a chopped strand layer may be added over the structural layer for exterior protection.

Section 2: Laminates

Manufacturing Methods

Ershigs, Inc. offers two standard types of FRP laminate construction for piping and duct systems: **Filament Wound**, and **Contact Molded** (hand lay-up).

Filament Wound Construction - This process utilizes continuous glass strand roving that is pre-saturated in a resin bath and is then helically wound around a rotating mandrel at a specified winding angle. The winding process is continued in bi-directional layers until the desired wall thickness is achieved. Ershigs' pressure piping is typically made with a 55° winding angle, which provides the theoretical optimum 2 to 1 hoop to axial strength ratio required for pressure piping. Vacuum piping, duct and O-ring gasketed joint piping will normally be wound at greater winding angles, such as 65°, to increase the hoop strength.

Contact Molded Construction - This method of laminate construction uses multiple layers of fiberglass chopped strand, woven roving and non-woven glass fabrics saturated with resin and built up to the desired thickness. Each glass layer is layed on the mold and resin is applied. Hand pressure rolling saturates the glass and removes entrapped air to provide a strong, dense laminate. Physical properties will vary with the amount of woven roving, unidirectional roving and/or fabric used.

Spray-up - This method is a variant of the contact molding described above in which a spray gun equipped with a chopper cuts glass strand into short lengths and ejects the chopped glass into the resin spray. The resin and glass are deposited onto the mold and hand rolled as described above. This chopped glass is used in lieu of chopped strand mat in many contact molded products.

Section 2: Laminates

Physical Properties

Laminate properties will vary with the type and orientation of reinforcement and resin content. The data listed below is based on industry standards as well as research and testing conducted by Ershigs, Inc. This information may be used as a general guide for system design.

For more specific design information, contact Ershigs' Engineering Department.

Nominal Properties of FRP Laminate

Property	Contact Molded	Filament Wound
Laminate Density, lb/in.^{3}	0.05 - 0.06	0.06 - 0.07
Specific Gravity	1.5 – 1.8	1.8 – 2.1
Tensile Strength, psi	9,000 – 25,000	25,000 – 50,000 (Hoop)
Flexural Strength, psi	16,000 – 22,000	20,000 – 40,000 (Hoop)
Compressive Edge Strength, psi	18,000 – 24,000	20,000 – 24,000
Flexural Modulus of Elasticity, psi	0.7 – 1.0 x 10^6	1.8 – 3.2 x 10^6 (Hoop)
Tensile Modulus of Elasticity, psi	0.8 – 1.1 x 10^6	2.0 – 3.5 x 10^6 (Hoop) 0.9 – 1.4 x 10^6 (Axial)
Poisson's Ratio	0.33	Varies with wind angle
Impact Strength, ft-lb Izod	30 – 40	40 – 50
Thermal Conductivity Btu – in./hr – ft^2-°F	1.3 – 1.8	1.3 – 1.8
Linear Coefficient of Expansion in./in./°F	15 – 20 x 10^{-6}	12 – 16 x 10^{-6}
Heat Distortion Temperature (Resin), °F @ 264 psi	170 – 300	170 - 300
Barcol Hardness	27 – 45	27 – 45

Section 3: Pipe and Duct

Ershigs' pipe and duct is manufactured in accordance with project specifications using specified resin systems. Pipe can be furnished in the following standard lengths:

2 in. Dia through 4 in. Dia - 20 ft lengths

6 in. Dia through 54 in. Dia - 40 ft lengths

60 in. Dia and larger - 20 ft, 30 ft, or 40 ft lengths (depending on tooling)

Pipe and duct is available with wall thicknesses listed in the following charts or as required by project specifications.

Filament Wound Pressure Pipe

- All thicknesses are nominal and include a structural corrosion liner.
- Vacuum ratings are based on a 5 to 1 safety factor for unstiffened pipe.
- Ratings are suitable for operating temperatures to 180°F (82°C) with premium resins.
- Pressure ratings are based on the specified strain for each "**Grade**".
- Standard pressure classes are shown. Custom designs can be provided for specific requirements.

Grade A Premium grade pipe that includes a 100 mil structrual liner and a strain limit of .0012 in./in.

Grade B Standard grade pipe that includes a 100 mil structrual liner and a strain limit of .0014 in./in.

Grade C Commercial grade pipe that includes a 50 mil structrual liner and a strain limit of .0017 in./in.

Dia	Thk	Wt	Vac	Pressure / Grade		
				A	B	C
2	.21	1.0	14.7	150	150	150
3	.21	1.6	14.7	150	150	
4	.21	2.1	14.7	150	150	150
6	.21	3.1	14.0	150	150	150
8	.21	4.2	10.0	100	125	150
8	.26	5.2	14.7	150	150	
10	.21	5.3	5.1	75	100	150
10	.26	6.5	9.7	125	150	
10	.31	7.8	14.7	150		
12	.21	6.3	3.0	75	75	125
12	.26	7.8	5.6	100	125	150
12	.31	9.3	9.6	125	150	
12	.36	10.9	14.7	150		
14	.21	7.4	1.9	50	75	125
14	.26	9.1	3.6	75	100	150
14	.31	10.9	6.0	100	125	
14	.36	12.7	9.4	125	150	
14	.41	14.4	14.7	150		

Dia	Thk	Wt	Vac	Pressure / Grade		
				A	B	C
16	.21	8.4	1.2	50	50	100
16	.26	10.5	2.4	75	75	125
16	.31	12.5	4.0	100	125	150
16	.36	14.5	6.3	125	150	
16	.41	16.5	11.3	150		
18	.21	9.5	0.9	50	50	75
18	.26	11.8	1.7	75	75	125
18	.31	14.0	2.8		100	150
18	.36	16.3	4.4	100	125	
18	.41	18.5	8.0	125	150	
18	.46	20.8	11.2	150		
20	.21	10.6	.6	25	50	75
20	.26	13.1	1.2	50	75	100
20	.31	15.6	2.1	75	100	125
20	.36	18.1	3.2	100		150
20	.41	20.6	5.8		125	
20	.46	23.1	8.2	125	150	
20	.52	26.1	11.8	150		

Weights are in lb per ft and are based on a laminate density of .07 lb/in.^{3}.
Dimensions are in inches.
Pressure and vacuum ratings are in psig.

Section 3: Pipe and Duct

Filament Wound Pressure Pipe

Dia	Thk	Wt	Vac	Pressure / Grade		
				A	B	C
24	.26	15.7	.7	50	50	75
24	.31	18.7	1.2		75	100
24	.36	21.7	1.9	75	100	125
24	.41	24.7	3.4	100		150
24	.46	27.7	4.7		125	
24	.52	31.4	6.8	125	150	
24	.62	37.4	11.6	150		
26	.26	17.0	.6	50	50	75
26	.31	20.2	.9		75	100
26	.36	23.6	1.5	75		125
26	.41	26.9	2.6		100	
26	.46	30.2	3.7	100	125	150
26	.57	37.6	7.1	125	150	
26	.67	44.4	11.5	150		
28	.26	18.3	.4		50	75
28	.31	21.9	.8	50		100
28	.36	25.4	1.2		75	
28	.41	29.0	2.1	75	100	125
28	.46	32.5	3.0	100		150
28	.52	36.9	4.3		125	
28	.57	40.5	5.7	125		
28	.62	44.1	7.3		150	
28	.67	47.7	9.2	150		
30	.31	23.4	.6	50	50	75
30	.36	27.1	1.0		75	100
30	.41	30.9	1.7	75		125
30	.46	34.7	2.4		100	
30	.52	39.2	3.5	100		150
30	.57	43.0	4.6		125	
30	.62	46.7	5.9	125	150	
30	.72	55.0	9.3	150		
36	.36	32.6	.6	50	50	75
36	.41	37.1	1.0		75	100
36	.46	41.6	1.4	75		
36	.52	47.0	2.0		100	125
36	.62	56.1	3.4	100	125	150
36	.72	65.1	5.4	125		
36	.78	70.6	7.7		150	
36	.88	80.8	11.0	150		
42	.41	43.3	.6	50	50	75
42	.46	48.6	.9		75	100
42	.52	55.0	1.3	75		
42	.57	60.4	1.7			125
42	.62	65.7	2.2		100	
42	.67	71.1	2.7	100		150
42	.72	76.5	3.4		125	
42	.83	88.5	5.8	125		
42	.88	93.9	6.9		150	

Dia	Thk	Wt	Vac	Pressure / Grade		
				A	B	C
42	.98	104.8	9.5	150		
48	.41	49.4	.4	50	50	75
48	.52	62.8	.9		75	100
48	.62	75.0	1.5	75		
48	.67	81.1	1.8		100	125
48	.78	94.7	3.2	100		150
48	.83	100.8	3.9		125	
48	.93	113.2	5.5	125		
48	.98	119.4	6.4		150	
48	1.14	139.4	10.1	150		
54	.46	62.3	.4	50	50	75
54	.57	77.4	.8		75	
54	.62	84.1	1.0			100
54	.67	90.9	1.3	75		
54	.72	99.1	1.6			125
54	.88	119.4	3.3	100	100	150
54	.98	126.2	3.9		125	
54	1.04	141.1	5.4	125		
54	1.09	147.9	6.2		150	
54	1.24	168.3	9.1	150		
60	.52	78.4	.4	50	50	75
60	.62	93.5	.7		75	
60	.67	101.0	.9			100
60	.72	108.6	1.2	75		
60	.83	125.2	2.0		100	125
60	.93	140.2	2.9	100		
60	.99	149.3	3.3			150
60	1.04	156.8	3.9		125	
60	1.14	171.9	5.2	125		
60	1.19	179.4	5.9		150	
60	1.40	211.1	9.6	150		
66	.57	94.5	.4	50	50	75
66	.67	111.1	.7		75	
66	.73	121.1	.9			100
66	.78	129.4	1.2	75		
66	.88	146.0	1.8		100	125
66	1.04	172.5	2.9	100		150
66	1.09	180.8	3.4		125	
66	1.30	215.6	5.7	125	150	
66	1.50	248.8	8.8	150		
72	.62	112.2	.4	50	50	75
72	.78	141.1	1.0		75	100
72	.88	159.2	1.4	75		
72	.98	177.3	1.9		100	125
72	1.14	206.3	3.0	100		150
72	1.19	215.3	3.4		125	
72	1.40	253.3	5.5	125	150	
72	1.66	300.4	9.2	150		

Weights are in lb per ft and are based on a laminate density of .07 lb/in.^{3}.
Dimensions are in inches.
Pressure and vacuum ratings are in psig.

Contact Molded Pressure Pipe (Hand Lay-Up)

- All contact molded pipe laminates are manufactured in accordance with ASTM C-582.
- Thicknesses are applicable to contact molded pipe, fittings and joints.
- All thicknesses include a 100 mil structural corrosion liner.
- Vacuum ratings are based on a 5 to 1 safety factor for unstiffened pipe.
- Ratings are suitable for operating temperatures to 180°F (82°C) with premium resins.

Dia	Thk	Wt	Vac	Safety Factor	
				6 : 1	10 : 1
2	0.18	0.9	14.7	150	150
3	0.18	1.3	14.7	150	100
3	0.22	1.6	14.7		150
4	0.18	1.7	14.7	125	75
4	0.22	2.1	14.7	150	125
4	0.29	2.8	14.7		150
6	0.18	2.5	7.5	75	50
6	0.22	3.1	14.7	125	75
6	0.29	4.1	14.7	150	125
6	0.37	5.3	14.7		150
8	0.18	3.3	3.2	50	25
8	0.22	4.1	6.6	100	50
8	0.29	5.4	14.7	150	75
8	0.32	6.0	14.7		100
8	0.37	7.0	14.7		125
8	0.41	7.8	14.7		150
10	0.18	4.1	1.6	50	25
10	0.22	5.1	3.4	75	50
10	0.29	6.7	8.7	125	75
10	0.37	8.7	14.7	150	100
10	0.45	10.6	14.7		125
10	0.53	12.6	14.7		150
12	0.18	5.0	0.9	25	25
12	0.22	6.1	2.0	50	
12	0.29	8.1	5.0	100	50
12	0.37	10.4	11.6	150	75
12	0.41	11.5	14.7		100

Dia	Thk	Wt	Vac	Safety Factor	
				6:1	10:1
12	0.53	15.0	14.7		125
12	0.61	17.4	14.7		150
14	0.22	7.1	1.2	50	25
14	0.29	9.4	3.2	75	50
14	0.32	10.4	4.3	100	
14	0.37	12.0	7.3	125	75
14	0.45	14.7	13.1	150	
14	0.49	16.1	14.7		100
14	0.61	20.2	14.7		125
14	0.72	24.0	14.7		150
16	0.22	8.1	0.8	50	25
16	0.29	10.7	2.1	75	
16	0.32	11.8	2.9		50
16	0.37	13.7	4.9	100	
16	0.41	15.2	6.7	125	75
16	0.49	18.3	11.4	150	
16	0.56	21.0	14.7		100
16	0.68	25.7	14.7		125
16	0.80	30.4	14.7		150
18	0.22	9.1	0.6		25
18	0.29	12.0	1.5	50	
18	0.32	13.3	2.0	75	
18	0.37	15.4	3.4	100	50
18	0.45	18.8	6.2	125	75
18	0.56	23.5	11.9	150	
18	0.61	25.7	14.7		100
18	0.76	32.3	14.7		125

Weights are in lb per ft and are based on a laminate density of .06 lb/in.^{3}.
Dimensions are in inches.
Pressure and vacuum ratings are in psig.

Section 3: Pipe and Duct

Contact Molded Pressure Pipe (Hand Lay-Up)

Dia	Thk	Wt	Vac	Safety Factor	
				6 : 1	10 : 1
18	0.91	38.9	14.7		150
20	0.22	10.1	0.4		25
20	0.29	13.3	1.1	50	
20	0.37	17.0	2.5	75	50
20	0.41	18.9	3.4	100	
20	0.53	24.6	7.4	125	75
20	0.61	28.4	11.2	150	
20	0.68	31.8	14.7		100
20	0.88	41.6	14.7		125
20	1.00	47.5	14.7		150
24	0.29	15.9	0.6	50	
24	0.29	15.9	0.6		25
24	0.37	20.4	1.5	75	
24	0.41	22.6	2.0		50
24	0.49	27.1	3.4	100	
24	0.61	34.0	6.5	125	75
24	0.72	40.3	10.7	150	
24	0.80	44.9	14.7		100
24	1.00	56.5	14.7		125
24	1.22	69.6	14.7		150
26	0.29	17.2	0.5	50	25
26	0.41	24.5	1.6	75	
26	0.45	26.9	2.1		50
26	0.53	31.8	3.4	100	
26	0.68	41.0	7.1	125	75
26	0.80	48.5	11.5	150	
26	0.88	53.5	14.7		100
26	1.10	67.4	14.7		125
26	1.34	82.9	14.7		150
28	0.29	18.6	0.4		25
28	0.32	20.5	0.5	50	
28	0.45	29.0	1.6	75	
28	0.49	31.6	2.1		50
28	0.56	36.2	3.2	100	
28	0.72	46.8	6.7	125	75
28	0.88	57.5	12.3	150	
28	0.95	62.2	14.7		100
28	1.18	77.9	14.7		125
28	1.42	94.5	14.7		150

Dia	Thk	Wt	Vac	Safety Factor	
				6 : 1	10 : 1
30	0.29	19.9	0.3		25
30	0.37	25.4	0.7	50	
30	0.45	31.0	1.3	75	
30	0.53	36.6	2.2		50
30	0.61	42.2	3.3	100	
30	0.76	52.9	6.4	125	75
30	0.91	63.6	11.0	150	
30	1.00	70.1	14.7		100
30	1.26	89.1	14.7		125
30	1.53	109.1	14.7		150
36	0.37	30.4	0.4	50	25
36	0.56	46.3	1.5	75	
36	0.61	50.5	1.9		50
36	0.72	59.8	3.2	100	
36	0.91	76.0	6.4	125	75
36	1.10	92.3	11.3	150	
36	1.22	102.7	14.7		100
36	1.53	129.9	14.7		125
36	1.80	153.9	14.7		150
42	0.37	35.5	0.3		25
42	0.45	43.2	0.5	50	
42	0.64	61.7	1.4	75	
42	0.72	69.6	2.0		50
42	0.88	85.4	3.6	100	
42	1.07	104.2	6.5	125	75
42	1.26	123.3	10.7	150	
42	1.42	139.5	14.7		100
42	1.77	175.2	14.7		125
42	2.11	210.5	14.7		150
48	0.41	44.9	0.3		25
48	0.49	53.7	0.4	50	
48	0.72	79.3	1.3	75	
48	0.80	88.3	1.8		50
48	1.00	110.8	3.6	100	
48	1.22	135.8	6.5	125	75
48	1.45	162.2	10.9	150	
48	1.61	180.7	14.7		100
48	2.04	230.9	14.7		125
48	2.47	282.0	14.7		150

Weights are in lb per ft and are based on a laminate density of .06 lb/in.^{3} .
Dimensions are in inches.
Pressure and vacuum ratings are in psig.

Section 3: Pipe and Duct

Duct

- Ershigs' FRP duct can be provided with contact molded or filament wound construction.
- Thicknesses shown include a 100 mil structural corrosion liner.
- Pressure ratings for contact molded duct are based on a 10 to 1 safety factor.
- Pressure ratings for filament wound duct are based on a strain of .001 in./in.
- Vacuum ratings are based on a 5 to 1 safety factor.
- Thicknesses shown are recommended minimums. Systems should be designed for actual operating conditions.

Contact Molded Duct

Dia	Thk	Wt	Vac	Press
4	.14	1.3	329	1744
6	.14	1.9	97	1162
8	.14	2.6	41	872
10	.14	3.2	21	697
12	.14	3.8	12	581
14	.14	4.5	7	498
16	.14	5.1	5	436
Stiffeners on 10 ft centers are placed on 18 in. dia and larger duct.				
18	.14	5.7	6	732
20	.14	6.4	5	658
24	.18	9.8	7	705
26	.18	10.7	7	651
28	.18	11.5	6	605
30	.18	12.3	5	564
36	.18	14.7	5	470
42	.22	21.0	6	493
48	.22	24.0	5	431
54	.22	27.0	4	383
60	.22	30.0	3	345

Dimensions are in inches.
Pressure and vacuum ratings are in inches water gauge.
Weights are in lb per ft and are based on a laminate density of .06 lb/in.^{3}.

Filament Wound Duct

Dia	Thk	Wt	Vac	Press
4	.21	2.3	3394	4941
6	.21	3.4	1005	3294
8	.21	4.5	424	2470
10	.21	5.7	217	1976
12	.21	6.8	125	1647
14	.21	7.9	79	1411
16	.21	9.0	53	1235
Stiffeners on 10 ft centers are placed on 18 in. dia and larger duct.				
18	.21	10.1	54	1098
20	.21	11.2	46	988
24	.21	13.4	35	823
26	.21	14.5	31	760
28	.21	15.6	28	705
30	.21	16.7	25	658
36	.21	20.1	19	549
42	.26	29.0	26	582
48	.26	33.1	21	585
54	.26	37.2	18	453
60	.26	41.3	15	407

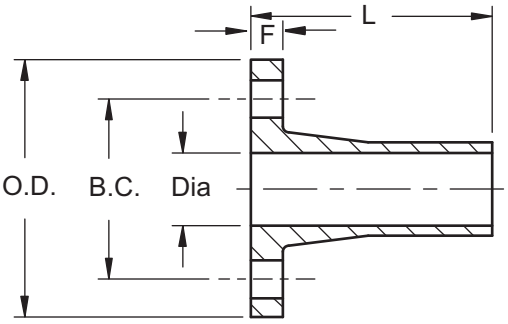
Dimensions are in inches.
Pressure and vacuum ratings are in inches water gauge.
Weights are in lb per ft and are based on a laminate density of .07 lb/in.^{3}.

Section 4: Fitting Dimensions

Ershigs offers a full line of fittings to complete your pipe or duct system. Our high quality fittings are designed and manufactured to specific pressure ratings up to 150 psi and are available with flanged or plain ends. Bell and spigot O-ring joints are available for underground piping systems.

Drilled Duct Flanges

- Duct flanges are manufactured by contact molding in accordance with ASTM D-3982.
- Thickness dimensions shown are minimums and may be increased to withstand more severe operating conditions.



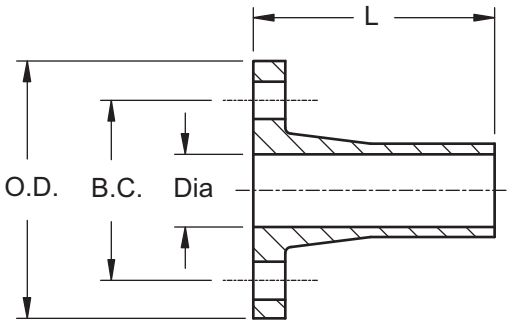
Dia	O.D.	Wall Thickness	F	L	B.C.	No. Holes	Hole Size	Allowable Pressure
2	6 3/8	.14	3/8	6	5	4	1/2	1000
3	7 3/8	.14	3/8	6	6	4	1/2	1000
4	8 3/8	.14	3/8	6	7	4	1/2	1000
6	10 3/8	.14	3/8	6	9	8	1/2	812
8	12 3/8	.14	3/8	6	11	8	1/2	581
10	14 3/8	.14	3/8	6	13	12	1/2	463
12	16 3/8	.14	3/8	6	15	12	1/2	384
14	18 3/8	.14	3/8	6	17	12	1/2	327
16	20 3/8	.14	1/2	6	19	16	1/2	450
18	22 3/8	.14	1/2	6	21	16	1/2	395
20	24 3/8	.14	1/2	6	23	20	1/2	351
24	28 3/8	.18	1/2	8	27	20	1/2	390
26	30 3/8	.18	1/2	8	29	24	1/2	360
28	32 3/8	.18	1/2	8	31	28	1/2	335
30	34 3/8	.18	1/2	8	33	28	1/2	309
36	40 3/8	.18	1/2	8	39	32	1/2	255
42	46 3/8	.25	5/8	10	45	36	1/2	368
48	54 3/8	.25	5/8	10	52	44	5/8	233
54	60 3/8	.25	5/8	10	58	44	5/8	206
60	66 3/8	.25	5/8	10	64	52	5/8	185
66	72 3/8	.32	5/8	10	70	56	5/8	160
72	78 3/8	.32	3/4	10	76	60	5/8	240
78	84 3/8	.32	3/4	10	82	68	5/8	220
84	90 3/8	.32	3/4	10	88	72	5/8	205
96	102 3/8	.32	3/4	12	100	80	5/8	178
108	114 3/8	.37	3/4	12	112	92	5/8	169
120	126 3/8	.37	3/4	12	124	100	5/8	152
132	139	.41	7/8	12	137	112	3/4	150
144	151	.41	7/8	12	149	120	3/4	125

Dimensions are in inches.
Pressure is in inches water gauge.
Bolt diameter is hole size minus 1/8 inch.

Section 4: Fitting Dimensions

Flat Face Flanges

- Ershigs' flat face flanges are manufactured by contact molding (hand lay-up). Laminates are manufactured in accordance with ASTM C-582.
- Drilled hole patterns per ANSI B16.1, Class 125 (identical to ANSI B16.5, Class 150 thru 24 in.).
- L is a standard dimension. Special lengths are available.
- 26 in. and 28 in. are not covered by ANSI Stds.



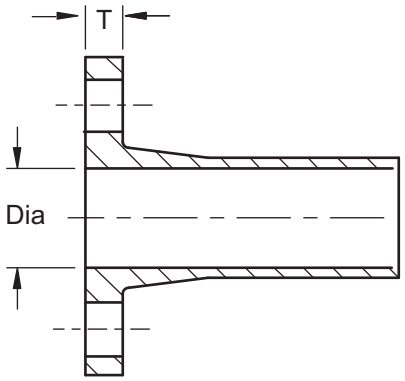
Dia	O.D.	L	B.C.	No. Holes	Hole Size	Bolt Size
1	4 1/4	6	3 1/8	4	5/8	1/2
1 1/2	5	6	3 7/8	4	5/8	1/2
2	6	6	4 3/4	4	3/4	5/8
2 1/2	7	6	5 1/2	4	3/4	5/8
3	7 1/2	6	6	4	3/4	5/8
4	9	6	7 1/2	8	3/4	5/8
6	11	8	9 1/2	8	7/8	3/4
8	13 1/2	8	11 3/4	8	7/8	3/4
10	16	10	14 1/4	12	1	7/8
12	19	10	17	12	1	7/8
14	21	12	18 3/4	12	1 1/8	1
16	23 1/2	12	21 1/4	16	1 1/8	1
18	25	12	22 3/4	16	1 1/4	1 1/8
20	27 1/2	15	25	20	1 1/4	1 1/8
24	32	15	29 1/2	20	1 3/8	1 1/4
26	34 1/4	15	31 3/4	24	1 3/8	1 1/4
28	36 1/2	15	34	28	1 3/8	1 1/4
30	38 3/4	18	36	28	1 3/8	1 1/4
36	46	18	42 3/4	32	1 3/4	1 1/2
42	53	24	49 1/2	36	1 3/4	1 1/2
48	59 1/2	24	56	44	1 3/4	1 1/2
54	66 1/4	24	62 3/4	44	2	1 3/4
60	73	24	69 1/4	52	2	1 3/4
66	80	custom	76	52	2	1 3/4
72	86 1/2	custom	82 1/2	60	2	1 3/4
84	99 3/4	custom	95 1/2	64	2 1/4	2
96	113 1/4	custom	108 1/2	68	2 1/2	2 1/4

Dimensions are in inches.

Section 4: Fitting Dimensions

Flat Face Flange Thickness

- Flanges are back faced or spot faced to accommodate ANSI Type A plain washers, narrow series.
- Larger sizes are designed to suit specific applications.
- Flange thicknesses, T, are minimums at design pressures.



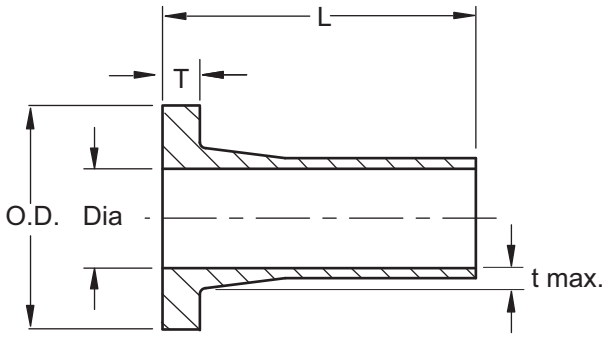
Dia	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi
1 1/2	1/2	1/2	1/2	9/16	5/8	11/16
2	1/2	1/2	1/2	9/16	5/8	11/16
2 1/2	1/2	1/2	9/16	5/8	11/16	3/4
3	1/2	1/2	5/8	11/16	3/4	13/16
4	1/2	9/16	11/16	13/16	7/8	15/16
6	1/2	5/8	3/4	7/8	1	1 1/16
8	9/16	3/4	7/8	1	1 1/8	1 1/4
10	11/16	7/8	1 1/16	1 3/16	1 5/16	1 7/16
12	3/4	1	1 1/4	1 7/16	1 5/8	1 3/4
14	13/16	1 1/16	1 5/16	1 1/2	1 3/4	1 7/8
16	7/8	1 3/16	1 7/16	1 5/8	1 7/8	2 1/16
18	15/16	1 1/4	1 1/2	1 3/4	2	2 1/4
20	1	1 5/16	1 5/8	1 7/8	2 1/8	2 7/16
24	1 1/8	1 1/2	1 7/8	2 1/8	2 1/2	2 13/16
26	1 1/4	1 5/8	2	2 1/4	2 11/16	3
28	1 1/4	1 3/4	2 1/8	2 3/8	2 7/8	3 3/16
30	1 3/8	1 7/8	2 1/4	2 1/2	3 1/16	3 3/8
36	1 3/4	2 3/16	2 9/16	2 13/16	3 5/8	4
42	2	2 1/2	2 7/8	3 1/8	4	4 3/8
48	2 3/8	2 3/4	3 1/4	3 7/16	4 1/2	4 7/8
54	2 1/2	3 3/8	4 1/8	4 5/8	5 1/8	5 1/2

Dimensions are in inches.

Section 4: Fitting Dimensions

Stub End Flanges

- Ershigs' stub end flanges are designed for use with steel backing flanges, pg. 14.
- L is a standard dimension. Special lengths are available.
- Flange thickness dimensions are suitable for 150 psig through 24 in. dia and 125 psig through 48 in. dia.



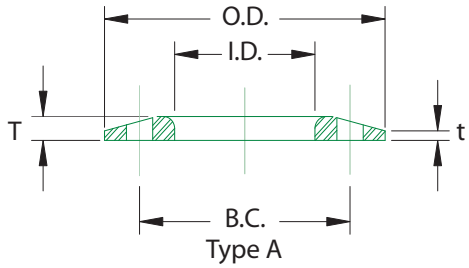
Dia	O.D.	T	L	t max
1 1/2	3 1/4	1/2	6	.25
2	4	1/2	6	.31
2 1/2	4 3/4	1/2	6	.31
3	5 1/4	9/16	6	.37
4	6 3/4	5/8	6	.37
6	8 5/8	3/4	8	.43
8	10 7/8	7/8	8	.43
10	13 1/4	1	10	.62
12	16	1 5/16	10	.68
14	17 5/8	1 3/8	12	.80
16	20 1/8	1 1/2	12	.91
18	21 1/2	1 5/8	12	.91
20	23 3/4	1 5/8	15	1.00
24	28 1/8	1 3/4	15	1.22
26	30 3/8	1 7/8	15	1.10
28	32 5/8	2 1/8	15	1.18
30	34 5/8	2 5/16	18	1.26
36	41 1/8	2 11/16	18	1.53
42	47 7/8	3 1/4	24	1.77
48	54 3/8	3 1/2	24	2.04

Dimensions are in inches.

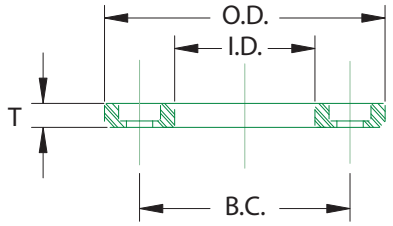
Section 4: Fitting Dimensions

Steel Backing Flanges

- Steel backing flanges are to be used with FRP stub end flanges, pg. 13.
- Type A cast steel flanges are available in sizes through 12 in. Type B cast steel flanges are available in sizes 14 in. through 48 in.
- Machines A-36 steel plate flanges with a constant thickness, T, are also available.
- Flanges are galvanized. Specialty coatings are available upon request.
- Cast stainless steel flanges are available on special order.
- Drilled hole patterns per ANSI B16.1, Class 125 (identical to ANSI B16.5, Class 150 thru 24 in.).



Type A



Type B

Pipe Dia	I.D.	O.D.	B.C.	T	t	No. Holes	Hole Size	Max Press	Approx. Wt.
1 1/2	2 1/4	5	3 7/8	1/2	3/8	4	5/8	150	3
2	3	6	4 3/4	5/8	3/8	4	3/4	150	4
2 1/2	3 1/2	7	5 1/2	5/8	3/8	4	3/4	150	5
3	4 1/8	7 1/2	6	5/8	3/8	4	3/4	150	6
4	5 1/8	9	7 1/2	5/8	3/8	8	3/4	150	7
6	7 3/8	11	9 1/2	3/4	3/8	8	7/8	150	10
8	9 3/8	13 1/2	11 3/4	3/4	3/8	8	7/8	150	15
10	11 1/2	16	14 1/4	7/8	1/2	12	1	150	20
12	13 5/8	19	17	7/8	1/2	12	1	150	29
14	15 7/8	21	18 3/4	1 3/8		12	1 1/8	150	32
16	18 1/8	23 1/2	21 1/4	1 7/16		16	1 1/8	150	43
18	20 1/8	25	22 3/4	1 9/16		16	1 1/4	150	45
20	22 5/16	27 1/2	25	1 11/16		20	1 1/4	150	47
24	26 11/16	32	29 1/2	1 7/8		20	1 3/8	150	63
26	28 1/2	34 1/4	31 3/4	2		24	1 3/8	125	83
28	30 5/8	36 1/2	34	2 1/16		28	1 3/8	125	102
30	32 3/4	38 3/4	36	2 1/8		28	1 3/8	125	111
36	39 5/16	46	42 3/4	2 3/8		32	1 5/8	125	156
42	45 13/16	53	49 1/2	2 5/8		36	1 5/8	125	208
48	52 3/8	59 1/2	56	2 3/4		44	1 5/8	125	263

Dimensions are in inches.
Weights are in pounds.
Bolt diameter is hole size minus 1/8 inch.
Pressure is in psig.

Section 4: Fitting Dimensions

Elbows

- Ershigs' smooth turn elbows are contact molded in sizes from 2 in. through 36 in.

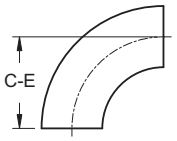
  2 in. and 3 in. have a centerline radius two times the inside diameter.

  4 in. through 36 in. Long Radius elbows have a centerline radius 1.5 times the inside diameter.

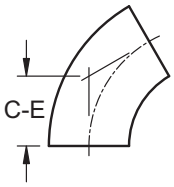
  6 in. through 24 in. Short Radius elbows are also available with a centerline radius equal to the inside diameter.

- Mitered elbows are fabricated from segmented pipe sections and are available in long and short radius configurations. Elbows 42 in. diameter and larger are supplied in mitered construction unless otherwise specified.

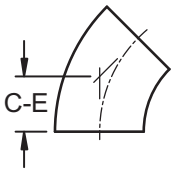
- Bends less than 45° are supplied in standard two piece mitered construction.



Long Radius 90° Elbow

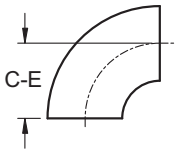


Long Radius 60° Elbow



Long Radius 45° Elbow

Long Radius 30° Elbow



Short Radius 90° Elbow

Dia	C-E	C-E	C-E	C-E	C-E
2	4	2 5/16	1 11/16		
3	6	3 7/16	2 1/2		
4	6	3 7/16	2 1/2		
6	9	5 3/16	3 3/4	2 7/16	6
8	12	6 15/16	5	3 3/16	8
10	15	8 11/16	6 3/16	4	10
12	18	10 3/8	7 7/16	4 13/16	12
14	21	12 1/8	8 11/16	5 5/8	14
16	24	13 7/8	9 15/16	6 7/16	16
18	27	15 9/16	11 3/16	7 1/4	18
20	30	17 5/16	12 7/16	8 1/16	20
24	36	20 13/16	14 15/16	9 5/8	24
26	39	22 1/2	16 1/8	10 7/16	26
28	42	24 1/4	17 3/8	11 1/4	28
30	45	26	18 5/8	12 1/16	30
36	54	31 3/16	22 3/8	14 1/2	36
42	63	36 3/8	26 1/8	16 7/8	42
48	72	41 9/16	29 13/16	19 5/16	48
54	81	46 3/4	33 9/16	21 11/16	54
60*	90	51 15/16	37 1/4	24 1/8	60
66*	99	57 1/8	41	26 1/2	66
72*	108	62 3/8	44 3/4	28 15/16	72

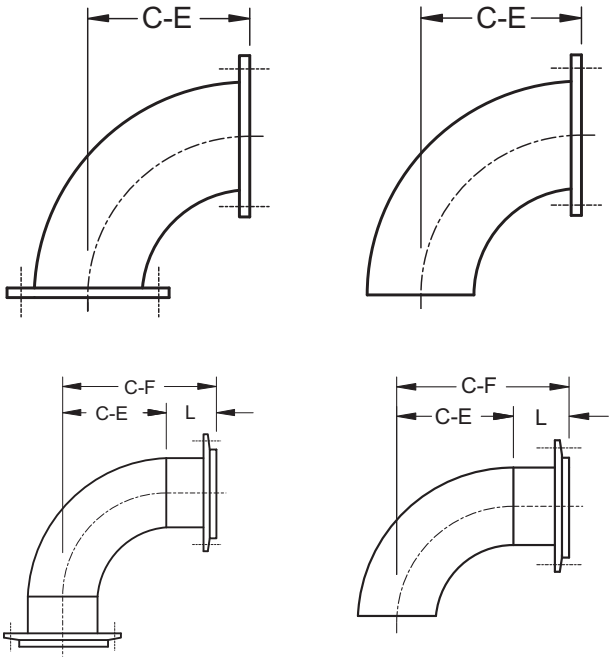
*Standard construction is a mitered elbow.

Dimensions are in inches.

Section 4: Fitting Dimensions

Flanged Elbows

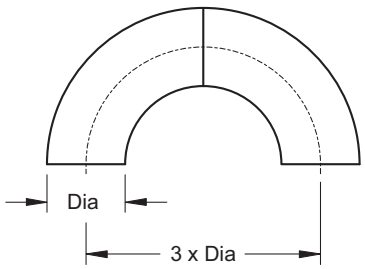
- Flanged elbows can be provided in the configurations shown below.
- All long radius elbows, 45° thru 90° are suitable for flat face flanges, at both ends.
- When backing flanges are used, a stub end, pg. 13, must be attached to elbow.



Special Elbows and Bends

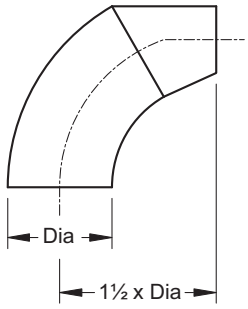
180° Return Bend

Available in long and short radius configurations.



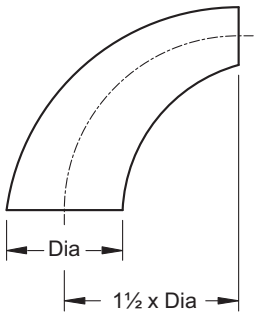
Cut-Back Transition Reducing Elbow

An economical reducing elbow is available in standard long radius smooth turn configurations through 36 in. diameter (large end). Elbows can also be supplied in nonstandard degrees of bend.



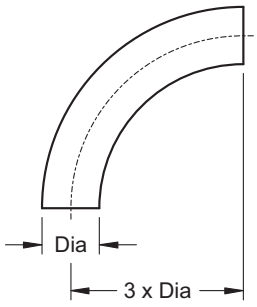
Smooth Flow Reducing Elbow

Available in long radius configurations through 24 in. diameter (large end). Reducing elbows are also available in mitered construction.



Special Radius Bend

Smooth turn available in 8 in., 10 in., and 12 in. sizes with a centerline radius of three times the inside diameter. Mitered construction available in all diameters and any centerline radius.

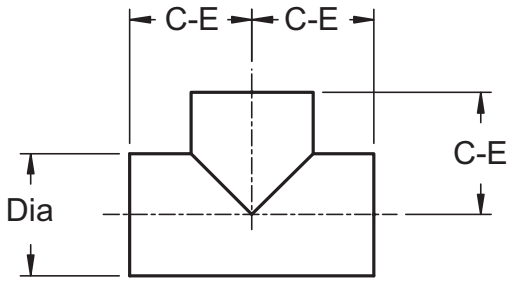


Section 4: Fitting Dimensions

Tees and Laterals

- Fabricated tees and laterals are available in all diameters.
- These fittings **must be heavily reinforced** when used in pressure service.
- Dimensions shown are suitable for flanging.
- Fabricated reducing tees and laterals are available in all diameters.
- Tee and lateral intersections can be fabricated into piping runs, thereby eliminating extra end joints.

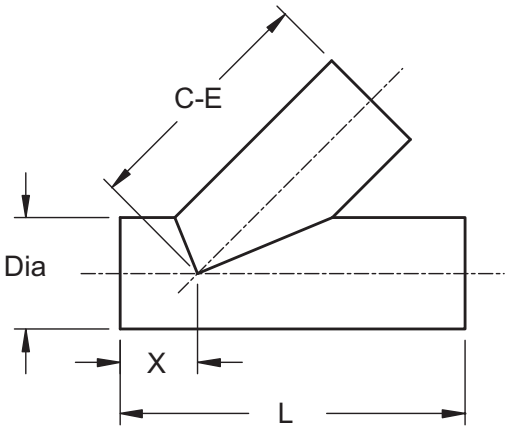
Tee



Dia	C-E
2	6
3	7
4	8
6	10
8	12
10	14
12	16
14	18
16	20
18	21
20	22
24	24
26	26
28	28
30	30
36	33
42	36
48	39

Dimensions are in inches.

45° Lateral



Dia	L	X	C-E
2	16	6	10
3	18	6	12
4	20	6	14
6	24	8	16
8	30	10	20
10	34	10	24
12	38	12	26
14	42	12	30
16	46	14	32
18	50	14	36
20	54	16	38
24	60	18	42
26	64	18	45
28	68	18	48
30	72	20	52
36	84	22	62
42	96	24	72
48	108	26	82

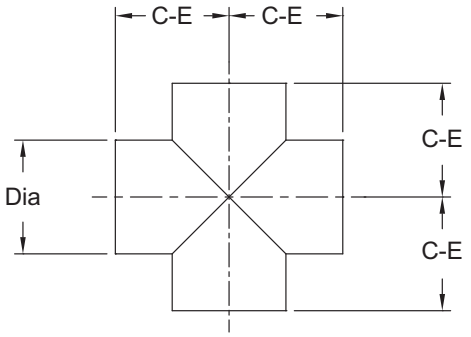
Dimensions are in inches.

Section 4: Fitting Dimensions

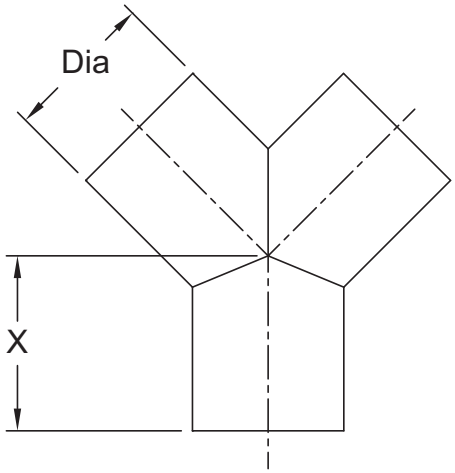
Crosses and Wyes

- Fabricated crosses and wyes are available in all diameters.
- These fittings **must be heavily reinforced** when used in pressure service.
- Cross dimensions are the same as tee fittings, pg. 17.
- True wye fittings have an “X” dimension identical to that of a 45° lateral.

Cross

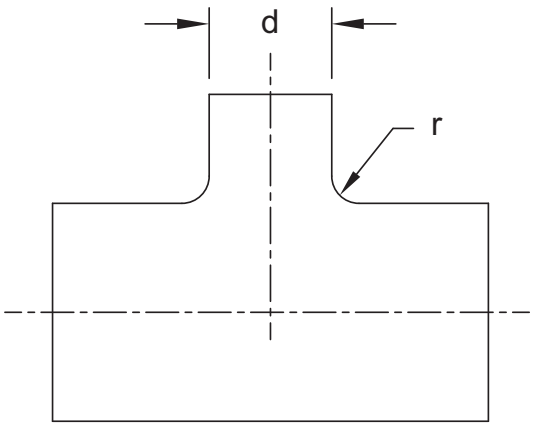


True Wye



Integral Smooth Flow Nozzles

- One piece molded nozzle penetrations or reducing tees are available. The intersection is radiused and molded with a continuous inside surface. These fittings are advantageous in abrasive applications and where pressure drop is a concern. The continuous mold surface also performs better in highly corrosive environments.
- Available in 2 in. through 18 in. outlet sizes.



Section 4: Fitting Dimensions

Reducers

- Tapered reducers are contact molded with a standard slope in concentric or eccentric configurations.
- Length is calculated as follows:

$$L = 2\ ^1/_2\ (D_1 - D_2)$$

- Centerline offset of eccentric reducers is calculated as follows:

$$E = \ ^1/_2\ (D_1 - D_2)$$

- Special dimensions are available.

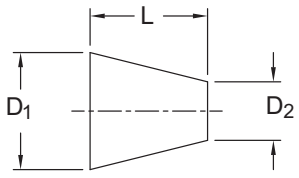
D_1 X D_2	L
3 x 2	2 ½
3 x 1.5	3 ¾
4 x 3	2 ½
4 x 2	5
6 x 4	5
6 x 3	7 ½
6 x 2	10
8 x 6	5
8 x 4	10
8 x 3	12 ½
10 x 8	5
10 x 6	10
10 x 4	15
12 x 10	5
12 x 8	10
12 x 6	15
14 x 12	5
14 x 10	10
14 x 8	15
16 x 14	5
16 x 12	10
16 x 10	15
18 x 16	5
18 x 14	10
18 x 12	15
18 x 10	20

Dimensions are in inches.

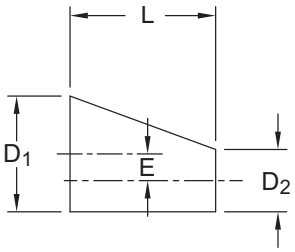
D_1 X D_2	L
20 x 18	5
20 x 16	10
20 x 14	15
24 x 20	10
24 x 18	15
24 x 16	20
26 x 24	5
26 x 20	15
26 x 18	20
28 x 26	5
28 x 24	10
28 x 20	20
30 x 24	15
30 x 20	25
30 x 18	30
30 x 16	35
36 x 30	15
36 x 24	30
42 x 36	15
42 x 30	30
48 x 42	15
48 x 36	30
54 x 48	15
54 x 42	30
60 x 54	15
60 x 48	30

Dimensions are in inches.

Concentric Reducer

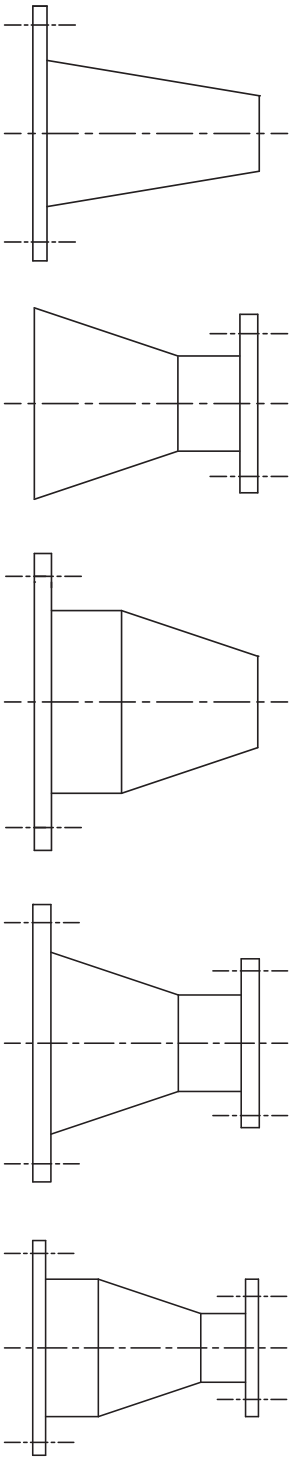


Eccentric Reducer



Flanged Reducers

- Stub end flanges, duct flanges and full face drilled flanges can be provided on the large end of all reducers. An additional flange fitting is required on the small end.
- Flanged reducers can be provided in configurations shown below, with any flange type.

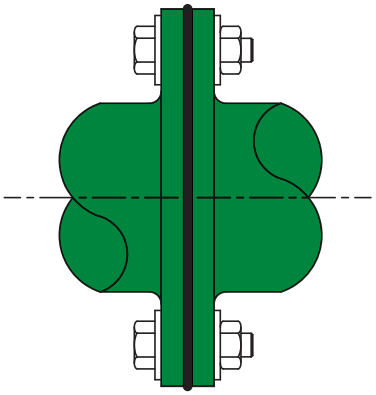


Section 5: Joining Systems

Ershigs' FRP piping systems may be assembled with a variety of joint types. Regid connections such as bolted flanges and butt joints as well as more flexible bell and spigot joints and mechanical couplings may be used to suit most installation requirements.

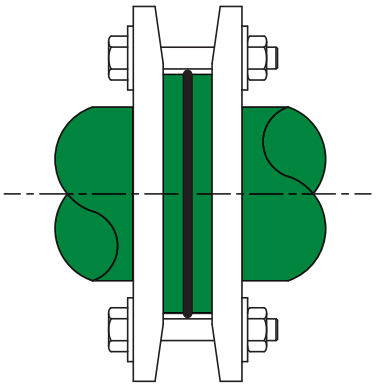
Flat Face Drilled Flange

- 125/150 lb ANSI B16.1/B16.5 Standard Drilling
- Light Weight Duct Flange

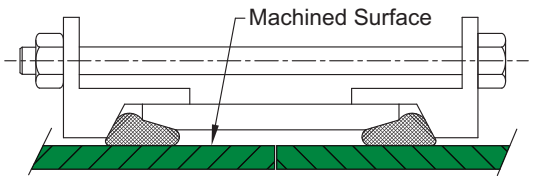


Stub End with Steel Backing Flange

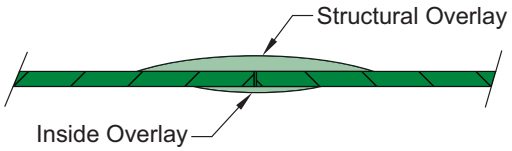
- 125/150 lb ANSI B16.1/B16.5 Standard Drilling



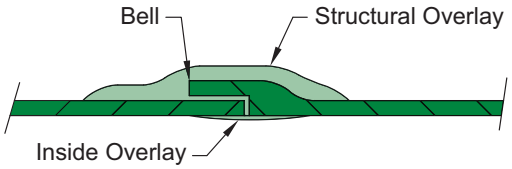
Mechanical Coupling Joints



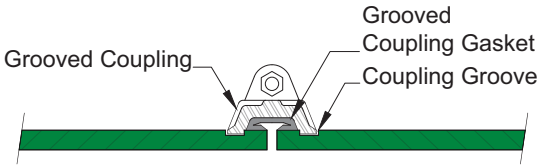
Butt Joint



Alignment Bell Joint

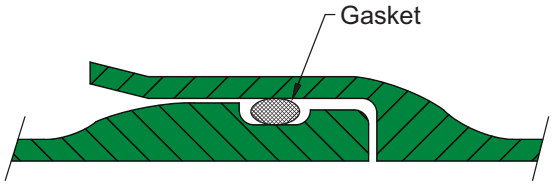


Grooved Coupling Joint

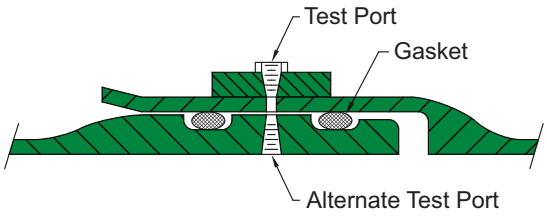


Bell & Spigot with O-Ring Gasket

- Single O-Ring



- Double O-Ring



Section 5: Joining Systems

Flanged Joints

Flanged joints are used in piping systems for ease of installation and connection to equipment. All flanges are designed for the operating pressures specified by the user. Standard dimensions are in tables on pages 10-15.

Ershigs manufactures all flanges with continuous glass reinforcing from the hub into the flange face. Both hand lay-up and filament winding techniques are used.

FRP flat face drilled flanges are provided with standard bolting patterns conforming to ANSI B16.1 class 125 (identical to ANSI B16.5 class 150 through 24 in. size.) **FRP flat face drilled flanges MUST be bolted to flat face companion flanges with full gaskets.** Ershigs' flanges have molded finish faces for proper sealing and machined or spot faced back faces for proper washer seating. Flange face O-ring gasket grooves can be provided upon request.

FRP stub ends with steel backing flanges are available from Ershigs. They provide an economical alternative to drilled flanges in sizes from 1 $^{1}/_{2}$ in. through 48 in. diameter. These flanges conform to ANSI standard bolting patterns, are easy to install, provide rotational flexibility and can be mated to raised face flanges.

FRP drilled duct flanges are provided for ventilation and gas or vapor service where standard ANSI drilling is not required. These flanges conform to dimensions of ASTM D-3982.

Bell and Spigot Gasketed Joints

Ershigs manufactures bell and spigot joints for use with elastomeric O-ring gaskets. These joints are easy to install and allow slight angular deflection to conform to burial conditions.

Buried piping must have thrust blocks at every change of direction to restrain axial thrust loads. Above ground piping must have thrust blocks as well as guides in the straight runs.

Several bell and spigot joint types are manufactured to suit specific requirements. Single O-ring joints are provided with machined spigots or cast spigots. The cast spigot joint is compatible with RPM pipe formerly manufactured by CorBan/Armco and AMOCO.

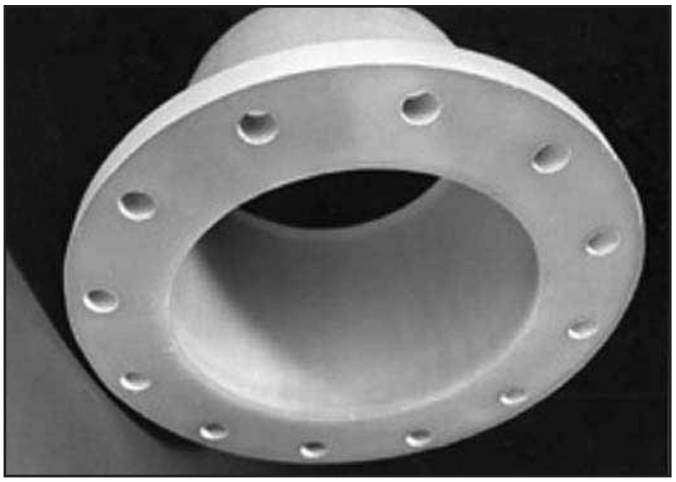
Double O-ring spigots are machined and are normally used with a bell end that has test ports attached for preburial testing. Air or water can be introduced between the O-rings to confirm that the gaskets are properly seated. For a complete description, see the Hydrostatic Testing Section on page 35.

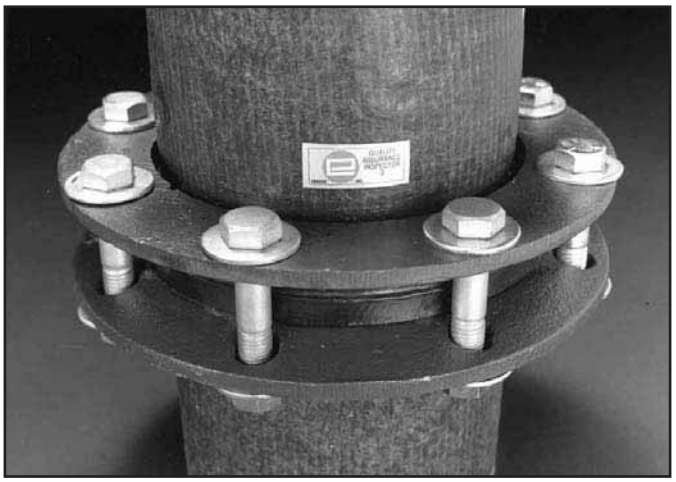
All bell ends are integrally molded with the pipe.

All bell and spigot joint types allow a maximum of one degree of angular misalignment.

Specialty Joints

Mechanical couplings may be used to connect Ershigs' FRP pipe to dissimilar piping. Many of these commercially available couplings allow some degree of flexibility to accommodate expansion and contraction movements and slight angular rotation. These couplings usually require specially machined outside diameter ends on the FRP pipe and thrust blocks or anchor arrangements to provide axial restraint across the joint.





Section 5: Joining Systems

Butt Joints

The most common method of assembling and joining custom manufactured FRP piping is with the butt joint. This system provides a strong, leakproof joint and can be applied either in the shop or in the field. Butt joints are designed for system operating pressures and are contact molded in the same thickness as the equivalent contact molded pipe and fittings. Therefore, the charts on pages 7 and 8 also define joint thickness. Joint reinforcing is supplied in varying widths and is pre-cut for each particular pressure and diameter. The maximum joint thickness occurs at the center and tapers down in thickness toward each side.

Ershigs strongly recommends that all FRP joints be made by trained personnel with experience in this work. Final fit-up and assembly joints should not be made until the system hangers, supports and anchors have been properly located and installed and equipment connections have been made. Because of the high rate of thermal expansion in FRP piping, all measuring, cutting, fitting and joining should be performed at the same ambient temperature.

Standard field joint kits include pre-cut glass reinforcing materials, resin putty, laminating resin, surfacing resin and catalyst.

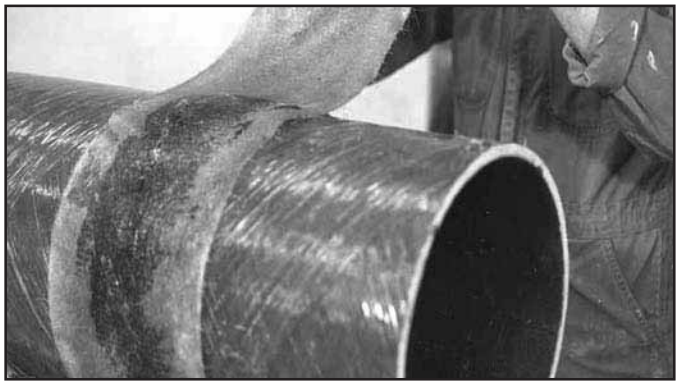
MATERIALS

HAND TOOLS

It is important that all personnel making FRP joints **read and understand the Material Safety Data Sheets** prior to working with these materials.

PREPARATION

WET-OUT



APPLICATION

ROLL-OUT

Section 6: Piping System Design

The design of Fiberglass Reinforced Plastic piping systems should be performed by persons experienced in the fundamentals of piping stress analysis as well as composite materials. Ershigs maintains a complete staff of professional engineers and designers to assist in the design process.

Differences Between FRP and Steel Pipe Design

Yield - FRP composites do not yield. Consequently, plastic deformation cannot be relied upon to distribute loads and relieve stress.

Modulus - FRP structures are much more flexible than steel due to the lower modulus of elasticity. Tensile modulus of FRP ranges from approximately 1 to 4 million psi compared to about 30 million psi for steel.

Temperature - Mechanical properties of FRP decrease at elevated temperatures. Most resins used by Ershigs are suitable for use up to 212° F. Special resins and designs allow FRP to be used up to 400° F. in certain environments. There is little strength reduction or brittleness at low temperatures.

Orthotropic Properties - Most FRP mechanical properties vary directionally and depend on loading conditions. Steel is isotropic and has equal properties in all directions.

Safety Factor - FRP piping is designed with safety factors ranging from 5 to 10. More appropriately called a design factor, these relatively high numbers are used to compensate for:

Strength reduction due to long term chemical exposure.

Discontinuity stresses.

Manufacturing variables.

Product Design

Ershigs' FRP pipe and fittings are designed and custom manufactured for specific applications. The following design criteria are followed:

Contact molded pipe and fitting laminates are designed in accordance with ASTM C-582.

The standard nominal 100 mil inner surface and interior layer is considered a structural element of the laminate and is included in wall thickness calculations.

In certain chemical environments such as hot wet chlorine and chlorine dioxide, additional material is added to the interior layer as a corrosion allowance and is not included in structural calculations.

Filament wound pressure pipe laminates are manufactured with a helical winding angle of 55°. The design is strain limited.

Wall thicknesses are considered suitable for operating temperatures to 180°F with premium grade polyester and vinyl ester resins.

Contact molded pipe and fitting designs are based on Ultimate Strengths listed on page 4 with a safely factor applied. (See pages 7 and 8 for safety factor.) The formula for wall thickness is:

$$t = \frac{Pr}{s/SF}$$

P = pressure, psig

r = pipe radius, in.

s = ultimate tensile strength

SF = safety factor

Wall thicknesses for contact molded pipe, fittings and joints are shown in the table on pages 7 and 8.

Filament Wound Pipe Laminate properties vary with the winding angle. The design of filament wound FRP pressure pipe can be optimized to produce the 2:1 hoop to axial stress ratio needed for a fixed joint pressure pipe system. The winding angle required to produce this ratio is 55° as measured from the pipe axis.

Wall thickness for the filament wound portion of the laminate may be calculated by the following formula:

$$t = \frac{Pr}{E_h Z}$$

P = pressure, psig

r = pipe radius, in.

E_h = hoop tensile modulus

Z = allowable strain

Ershigs' standard filament wound pressure piping is manufactured with a 55° (± 3°) winding angle. Pressure ratings for three types of material are shown in the table on pages 5 and 6.

Grade A Pipe is for severe chemical service and is designed using an allowable strain of .0012 in./in. and a 100 mil structural liner.

Grade B Pipe is for mild chemical service and is designed using an allowable strain of .0014 in./in. and a 100 mil structural liner.

Grade C Pipe is for water service and is designed using an allowable strain of .0017 in./in. and a 50 mil structural liner.

Vacuum conditions must be considered for all FRP pipe installations. Because of the relatively low modulus of FRP materials which makes it more susceptible to collapse, the possibility of vacuum due to planned, as well as unplanned, operating conditions must be analyzed. Since a vertical drop of 34 feet of water (at sea level) will produce a full vacuum within a pipe, care must always be taken to properly drain, vent and valve piping systems.

A 5:1 safety factor is normally applied to collapse or buckling conditions. The winding angle of filament wound piping will affect hoop and axial properties. If a system will operate only under vacuum conditions, either without possibility of internal pressure or with a low internal pressure, the winding angle may be increased to improve hoop properties for buckling resistance. External stiffeners may be manufactured on pipe 18 in. diameter and larger to provide buckling resistance. A large diameter system subjected to both pressure and vacuum conditions will normally be designed with a wall thickness suitable for the internal pressure and with stiffeners sized and spaced to provide necessary buckling resistance.

Collapse Pressure, P_c, for unstiffened pipe may be calculated by the following formula:

$$P_c = 2.2\ E\ R'\ (t/d)^3$$

Collapse Pressure, P_c, for stiffened pipe may be calculated by the following formula:

$$P_c = \frac{.92\ E\ t^{2.5}\ R'}{L\ r^{1.5}}$$

Design Pressure, External = $P_c\ K_n$ / SF

E = hoop flexural modulus, psi

R' = strength retention at temperature

SF = safety factor

r = pipe radius, in.

d = pipe diameter, in.

t = wall thickness, in.

L = length between stiffeners, in.

K_n = 0.9 knockdown factor for unstiffened pipe
0.8 knockdown factor for stiffened pipe

The required moment of inertia for pipe stiffeners may be calculated by the following formula;

$$I = \frac{SF\ Ld^3\ P_c}{24\ E}$$

Expansion

The coefficient of thermal expansion for FRP is between two and three times the rate of steel, depending on glass content and orientation. A design coefficient for contact molded pipe, having a low glass content, is 18 x 10^{-6}, while high glass content filament wound pressure pipe has a design coefficient of 16 x 10^{-6}, for axial expansion.

Internal pressure will also cause FRP pipe to expand as the pipe is strained.

Expansion and contraction of FRP piping must be recognized and taken into account during the design of supports and anchors. However, relatively low modulus of the material makes FRP quite forgiving when good, basic design practice is followed.

When piping is completely restrained by anchors or in underground installations, no movement takes place and the expansion stresses are absorbed in the pipe wall laminate. Stress can be calculated as follows:

$$S = E_a \times \frac{\Delta L}{L} = E_a\ \alpha\ \Delta T$$

Ea = modulus of elasticity, axial

L = length

α = thermal coefficient of expansion

ΔT = temperature differential, °F

Anchor Force can be calculated as follows:

$$F = sA$$

F = Force, lbs

s = Stress, axial

A = Cross-sectional area of pipe, $in.^2$

Example: 24 in. Dia x .5 in. wall contact molded pipe anchored and operating with a ΔT of 100 °F.

$S = (1 \times 10^6) \times (18 \times 10^{-6}) \times 100 = 1{,}800$ psi

$F = 1{,}800 \times \frac{\pi}{4} (25^2 - 24^2) = 69{,}237$ lbs.

The above example illustrates that anchoring pipe to restrain thermal expansion develops stresses less than 10% of the ultimate compressive stress of the FRP laminate. However, the thrust force may be significant, especially with large diameter pipe, in an axially guided system. Even a slight lateral movement, however, will relieve stresses significantly in a lightly guided system. In most systems, supporting and guiding FRP pipe to allow for expansion movement is the simplest and most economical approach. The following guidelines should be followed:

Elbows should be free to move, unless they are close-coupled to a fixed flange connection.

Guides should be a minimum of 10 x pipe diameter away from elbows.

Anchors or fixed connections should be at least 20 x pipe diameter away from free moving elbows.

Each system should be anchored, restrained or guided to insure that it remains in its intended position.

Expansion Joints

Many types of expansion joints can be used with FRP piping systems. Since FRP piping develops lower thermal end forces than steel (approximately 3% to 5% the amount of schedule 40 steel pipe), the expansion joints must be activated by low forces. Various elastomeric bellows type expansion joints are suitable for FRP piping systems.

As a general guideline, an expansion joint thal operates with an activational force of less than F_a should be selected. This will limit axial pipe stress to 1,000 psi which is well within design limits.

$F_a = 1{,}000\ A$

A = Cross-sectional area of pipe, $in.^2$

The expansion joint must be installed to accommodate the amount of expansion and contraction that may be experienced, both axially and laterally. From previous discussions, the total expansion movement can be calculated and an appropriate expansion joint can be selected. At the time of installation, a **preset** must be determined based on installation and operating temperatures. The amount of preset may be calculated as follows:

$$\text{Length of Preset, in.} = \frac{M\,(T_i - T_{min.})}{(T_{max.} - T_{min.})}$$

M = total rated expansion joint movement, in.

T_i = installation temperature

$T_{min.}$ = minimum temperature

$T_{max.}$ = maximum temperature

Guides must be installed to insure that the pipe movement will be directly into the expansion joint. Recommended spacing to the first guide is 4 x pipe diameter with the second guide spaced 10 x pipe diameter beyond the first. This spacing will limit any angular twist on the expansion joint.

Expansion Loops

Expansion loops may be used as a means to accommodate pipe expansion and/or contraction. Design is based on the stress developed in a cantilever beam assuming a concentrated load at the free end. This approach is often too cumbersome for a process piping system and is more suitable for long runs of straight piping where space is not a problem. Two guides must be used on each side of the expansion loop to maintain alignment. Elbows and torsion are also good sources of compliance within a system that may be considered.

Section 6: Piping System Design

Flow Properties

The smooth interior and larger inside diameter of Ershigs' FRP pipe and fittings provide flow capacities greater than steel of the same nominal diameter. The smooth surface resists sludge and mineral build-up as well as material hang-up and minimizes friction loss in the piping system.

The friction of fluid flowing in a pipe causes a drop in pressure which is approximately proportional to the velocity squared, and is directly proportional to the effective length of the pipeline and the friction factor.

In calculating friction loss for FRP pipe, a Manning roughness coefficient of 0.009 and a Williams and Hazen roughness coefficient of 150 is commonly used for water service applications.

The effective length of a pipeline is the total length of straight pipe plus the equivalent length of all fittings and valves which add resistance to the system.

Fitting Friction Loss

Equivalent length of straight pipe for head loss through fittings

Dia	90° Smooth Turn Elbow	45° Smooth Turn Elbow	Tee Entering Run
2	3 1/2	2 1/2	11
3	5	4	16
4	6	5	21
6	10	7	32
8	14	10	42
10	16	12	55
12	20	15	65
14	24	16	75
16	26	19	85
18	30	21	100
20	34	24	110
24	40	30	130
30	50	35	160
36	60	42	200

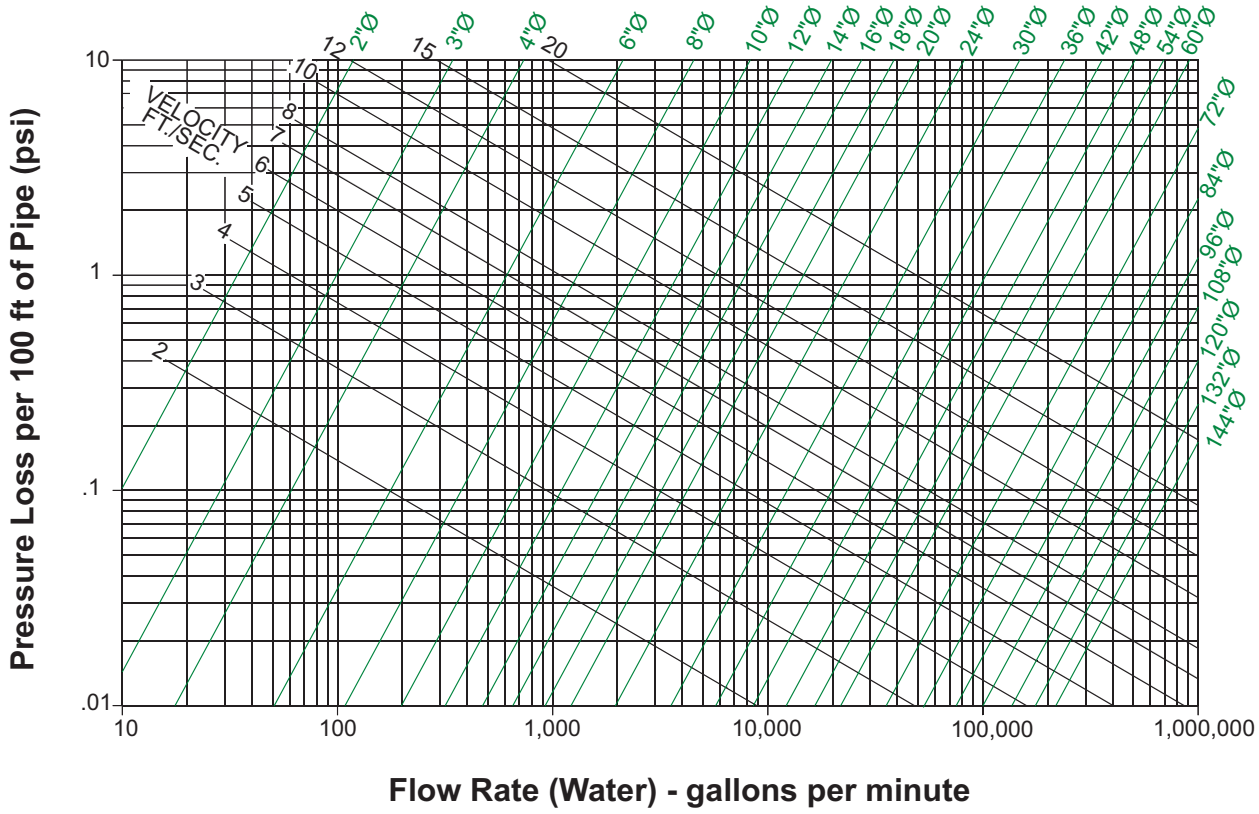
Length is in feet.
Dia is in inches.

Pipe Capacity

Dia	Capacity	Contents Wt
2	0.16	1.30
3	0.37	3.08
4	0.65	5.42
6	1.47	12.25
8	2.61	21.76
10	4.08	34.01
12	5.87	48.93
14	8.00	66.69
16	10.44	87.02
18	13.22	110.20
20	16.32	136.04
24	23.50	195.90
26	27.58	229.91
28	31.99	266.67
30	36.72	306.10
36	52.88	440.81
42	71.97	599.94
48	94.00	783.58
54	118.97	991.97
60	146.88	1,224.39
66	177.72	1,481.47
72	211.51	1,763.15
84	287.88	2,399.77
96	376.01	3,134.42

Dia is in inches.
Weight is in lbs per ft, water.
Capacity is in gal per ft.

Pipe Friction Loss (Williams and Hazen Formula)



- To convert gallons per minute to cubic feet per second, divide by 448.8.
- To convert gallons per minute to millions of gallons per day, divide by 694.4.
- To convert friction loss in psi to feet of head, divide by 0.433.

Section 6: Piping System Design

Underground Piping

Ershigs' FRP underground piping is a flexible conduit and must be analyzed as such when designing for burial.

In an underground installation, the external soil load above the pipe causes a decrease in the vertical diameter of the pipe and a corresponding increase in the horizontal diameter of the pipe. The horizontal movement of the pipe walls into the soil material at the sides of the pipe develops a passive resistance that acts to help support the external load. The resistance of the soil is affected by the type of soil and its density and moisture content. The higher the soil resistance, the less the pipe will deflect. Proper installation techniques are necessary to develop the passive soil resistance required to prevent excessive pipe deflections. Proper bedding support and backfill are required for satisfactory sealing of the bell and spigot joints most commonly used.

The deflection of a buried flexible pipe depends on the soil load above the pipe (which is a function of the depth of burial), live loads over the pipe, the stiffness of the pipe, the passive resistance of the soil at the sides of the pipe, the time consolidation characteristics (deflection lag factor) of the soil, and the degree of support given to the bottom of the pipe (bedding constant).

An initial maximum pipe deflection of 3% is recommended with an allowable long term deflection of 5% maximum. These deflections may be calculated using the Spangler equation.

Ershigs FRP underground piping is designed using the methods given in AWWA M45, except that credit is given for the effect of the trench using the Marston equation for calculating earth loading and live loading on the pipe. Alternate design basis may be used on a case by case basis.

The pipe wall thicknesses are designed giving structural credit to the corrosion liner and design is strain limited using appropriate tensile and flexural moduli. Most underground installations utilize gasketed bell and spigot joints which eliminate axial loads due to internal pressure. Therefore, the winding angle used in manufacturing the pipe can be changed to increase hoop properties and decrease axial properties. In any event, a minimum axial tensile modulus of 500,000 psi should be maintained.

Maximum allowable membrane strain for internal pressure shall be .0017 in./in. and combined hoop strain for sustained loading shall be .0024 in./in. Combined hoop strain for transient loading shall not exceed .0028 in./in.

The safety factor for buckling will be in accordance with AWWA M45. When integral stiffeners are used, a safety factor of 3 will be used for the stiffener section. Stiffener spacing will not exceed two pipe diameters.

The hoop flexural modulus will be used in calculating external loading design and will be determined by test (ASTM D-790 or ASTM D-2412) or developed by laminate theory and supported by tests.

Design Criteria

The following parameters are to be supplied by the owner for consideration by Ershigs, Inc. during the detail design:

Operating temperature of the line fluid.

Operating, surge, vacuum and test pressures.

Live loads (wheel loads).

Max./min. burial depth and trench width.

Description of the soil properties and trench preparation.

Soil Properties

The following soil properties will be used for design of the pipe unless specified otherwise:

Soil density - 120 pcf.

Deflection lag factor - 1.5.

Deflection bedding constant - 0.083.

Soil reaction modulus - 1,000 psi.

Local water table, below bottom of pipe.

Requirements for thrust blocks or anchors shall be considered.

Section 6: Piping System Design

Load Combinations

Ershigs will analyze the following load combinations:

Design pressure at maximum burial depth.

Design pressure plus live loads at minimum and maximum burial.

Burial and live load conditions, plus vacuum (if applicable).

Burial and live loads for empty pipe.

Pre-burial hydrotest requirement.

All structural analysis will include both membrane and hoop bending effects in the pipe wall.

Thrust Blocks

Ershigs' bell and spigot joined FRP piping may require thrust blocks for axial restraint. All changes in direction, including bends, tees and laterals, must be restrained. Cast in place concrete blocks are often used for buried piping and can be used in combination with tie rods and thrust collars for above ground piping.

Hydrostatic thrust loads at a bend can be calculated as follows:

$$T = 2PA \sin \theta/2$$

T = Thrust, lb

P = Pressure, psi

A = Cross sectional pipe area , $in.^2$

θ = Angle of bend in degrees

The need for thrust blocks and their design is the responsibility of the engineering agency designing the piping system.

Hydrodynamic loads are normally small in comparison to hydrostatic loads, however, they must also be considered by the design engineer.

Design of restraints must consider soil strength, stability and location of the water table. Effective thrust blocks must totally encapsulate the pipe fitting and must have:

Adequate bearing area to resist the thrust.

The bearing surface against undisturbed soil.

The resultant thrust vector passing perpendicularly through the center of the bearing surface.

If the soil is unstable or the installation is below the water table, tie rods or other means to insure stability may be required.

Safe Bearing Pressure, S_p, of soils ranges from 0 for quicksand to over 100,000 lbs/ft^2 for solid, hard rock. Hard clay, course sand and gravel range from 8,000 to 10,000 lbs/ft^2. A complete list of these ratings can be found in soils engineering handbooks and in "Marks Mechanical Engineers' Handbook." Actual values should be defined by the Project Geotechnical Engineer.

The soil bearing area required for restraints are calculated as follows:

$$A_b = T/S_p$$

A_b = bearing area, ft^2

T = Thrust, lb

S_p = Allowable soil bearing pressure, lb/ft^2

Restraints must be installed before hydrostatic testing of the pipe.

Section 7: Installation

Ershigs' FRP pipe and duct should be installed in accordance with project specifications and rules of good practice for supporting metal pipe. FRP is strong, lightweight and easy to install. Care must be taken to avoid impact damage, point loads and damage to inner surfaces which may lead to premature failure.

Rigging and handling must be done with nylon slings or padded cable. Cables and chains must not bear directly against the pipe wall. Handle with care to ensure long life and trouble free service.

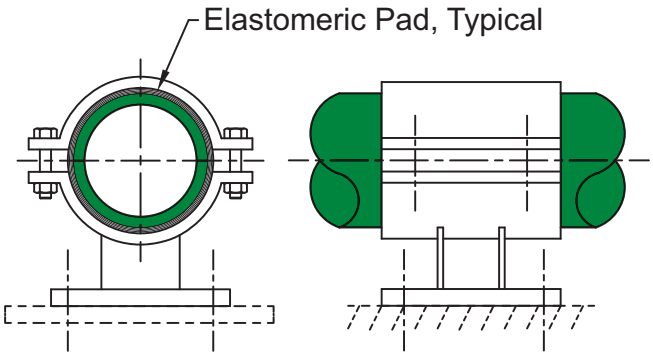
Pipe Supports and Hangers

Fabricated steel hangers and supports should be manufactured to fit the outside diameter of the FRP pipe and duct being used. We recommend that all hangers and supports be lined with an elastomeric pad (Shore 'A' hardness 50-70) to conform to any surface irregularities and to provide uniform bearing support.

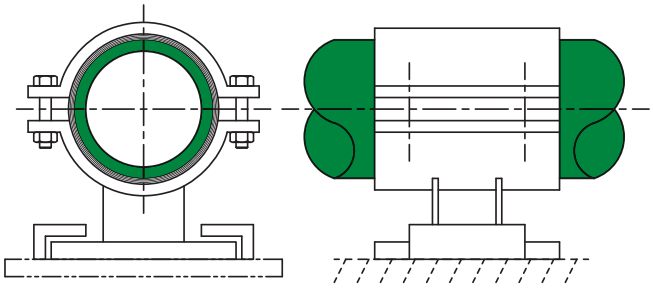
It is essential that each installation be reviewed to ensure the proper location and fit of all supporting elements. Maximum recommended support spacing for Ershigs' FRP pipe is shown on page 31. For specific applications, contact Ershigs' Engineering Department for a custom design.

Ershigs' Metal Fabrication Division can supply all types of hangers. supports, anchors and clamps for your FRP systems. Alloy or mild steel materials are available with prime paint, specialty coatings or galvanized finish to meet project specifications.

Pipe Saddle Supports may be either fixed or guided, as required by the system design. These are normally 180° bottom supports with a 180° retainer band. Guided supports allow slight axial or lateral movement due to thermal expansion.

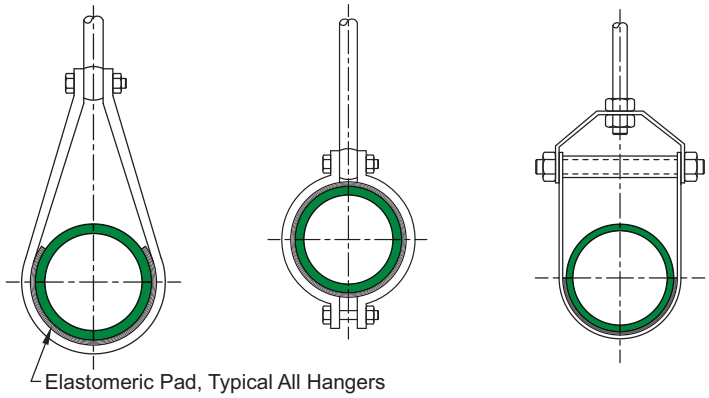


Fixed



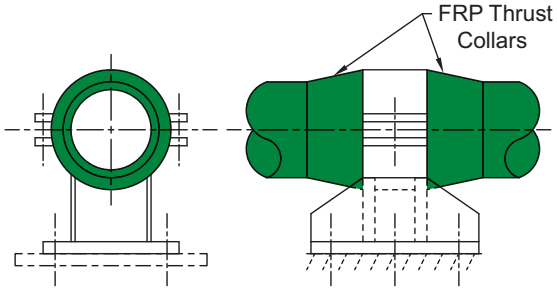
Guided

Three basic configurations of **pipe hangers** are used: Sling, Clamp and Clevis. These hangers do not restrain axial or lateral movement.



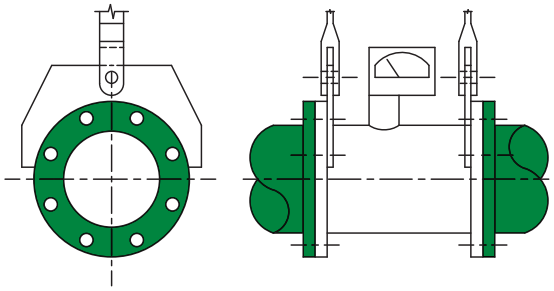
Anchors and Guides

Pipe anchors are used to restrain pipe movement against thrust loads and thermal expansion. 360° FRP thrust collars are laminated to the pipe on either side of an anchor support to restrain the pipe. These collars can be installed in the shop or the field and are also used with riser clamps for vertical support.



Flange/Component Support

All valves, regulators, flow meters or other components used in FRP piping systems should be independently supported to prevent overstressing the FRP pipe and fittings. One common method is to use a flange hanger or support as shown below.



Section 7: Installation

Pipe Support Spacing

Recommended support spacing for filament wound and contact molded pressure pipe is shown in the tables below. Tables are based on the following assumptions:

- 180° support saddle using color coding noted on charts below.
  - Saddle width = $^1/_4$ Dia
  - Saddle width = $^1/_3$ Dia
  - Contact Ershigs for saddle width design.
- Maximum deflection = span / 360.
- Simple support conditions.
- 180° F maximum temperature.
- Wind and seismic effects are not considered.
- Specific gravity of contents, 1.2.
- Correction Factors for weight of contents.

Sp. Gr.	Multiplier
1.0	1.10
1.2	1.00
1.4	0.93
1.6	0.87
1.8	0.81

Filament Wound Pressure Pipe

Dia	Wall Thickness																
	.20	.25	.30	.36	.41	.46	.51	.56	.62	.67	.72	.77	.82	.88	.93	.98	1.03
2	8.0	8.5	9.0	9.5													
3	9.5	10.0	11.0	11.5													
4	10.0	11.0	12.0	12.5	13.0												
6	10.5	11.5	12.5	13.5	14.5												
8	10.5	11.5	13.0	14.0	15.0	15.5											
10	10.5	12.0	13.0	14.0	15.0	16.0	17.0										
12	10.5	12.0	13.0	14.5	15.5	16.0	17.0										
14	10.5	12.0	13.0	14.5	15.5	16.5	17.0	18.0									
16	10.5	12.0	13.0	14.5	15.5	16.5	17.5	18.0	19.0								
18	10.5	12.0	13.5	14.5	15.5	16.5	17.5	18.0	19.0	20.0							
20	11.0	12.0	13.5	14.5	16.0	16.5	17.5	18.5	19.5	20.0							
24	9.5	12.5	13.5	15.0	16.0	17.0	17.5	18.5	19.5	20.0	21.0						
30	**7.5**	**11.0**	13.5	15.0	16.0	17.0	18.0	18.5	19.5	20.5	21.0	22.0					
36		**9.0**	**12.0**	**14.0**	16.0	17.0	18.0	18.5	19.5	20.5	21.5	22.0	23.0	23.5			
42			**10.5**	**12.5**	**14.5**	**16.0**	18.0	18.5	20.0	21.0	21.5	22.0	23.0	23.5	24.5		
48			**9.0**	**11.0**	**12.5**	**14.0**	**15.5**	**17.0**	19.0	20.5	21.5	22.0	23.0	24.0	24.5	25.0	25.0

Dia and thicknesses are in Inches. Span is in feet.

Contact Molded Pressure Pipe

Dia	Wall Thickness																
	.18	.25	.29	.37	.41	.49	.56	.64	.68	.76	.80	.88	.95	1.00	1.10	1.26	1.38
2	7.0	9.0	9.5	11.0													
3	8.0	10.5	11.0	12.5													
4	8.0	11.5	12.5	14.0	14.5												
6	8.5	12.0	13.0	15.5	16.0	17.5											
8	8.5	12.0	13.0	16.0	16.5	18.0											
10	8.5	12.0	13.0	16.0	17.0	18.0	19.5										
12	9.0	12.0	13.5	16.0	17.0	18.5	19.5	20.0									
14	9.0	12.0	13.5	16.0	17.0	18.5	19.5	21.0	21.5								
16	9.0	12.0	13.5	16.0	17.0	18.5	20.0	21.0	21.5	23.0	23.0						
18	8.0	12.0	13.5	16.5	17.0	18.5	20.0	21.0	22.0	23.0	23.5	24.0					
20		10.0	13.0	16.5	17.0	19.0	20.0	21.0	22.0	23.0	23.5	24.0	25.5	26.0			
24		8.5	11.0	15.0	17.0	19.0	20.0	21.5	22.0	23.0	25.0	25.0	26.0	27.5	29.0		
30			8.5	12.0	14.5	17.0	20.0	21.5	22.0	23.0	24.0	25.0	26.0	26.5	27.5	29.0	30.0
36				10.0	11.0	14.5	17.5	20.0	22.0	23.5	24.0	25.0	26.0	26.5	27.5	30.0	30.0
42					10.0	12.5	14.5	16.5	18.0	20.0	21.0	22.5	24.0	25.5	26.5	28.0	30.0
48					9.0	10.5	12.0	14.0	15.5	17.0	18.5	19.5	20.0	21.5	22.5	24.0	25.5

Dia and thicknesses are In Inches. Span is in feet.

Flange Assembly

Flange assembly should be done in accordance with standard rules of good practice. Proper alignment and fit up must be maintained in order to avoid undue stress on the flange. Flat face FRP flanges and duct flanges **MUST be bolted to flat face companion flanges, with full gaskets**. If raised face flanged equipment is connected to FRP flanges, a hard plastic or metal spacer ring must be added to provide a flat connection surface.

FRP stub ends with steel backing flanges may be connected directly to raised face or flat face steel flanges but must not be connected to flat face FRP flanges. Ring gaskets should be used with FRP stub ends.

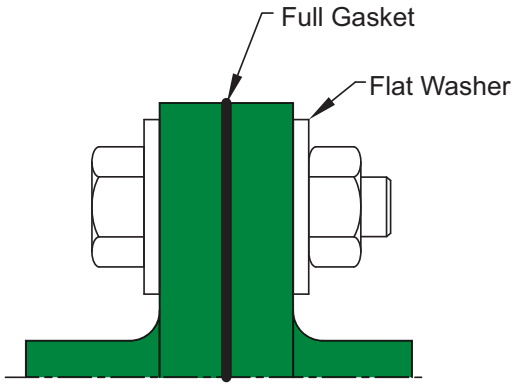
Bolting material should be specified by the user in accordance with plant practice. Thread lubricants should be applied to all bolts, except Teflon coated bolts, used on pressure piping. ANSI Type A, plain washers, narrow series must be used against FRP and cast steel flanges.

Gaskets should be made of elastomeric material having a Shore A Durometer of 50-60. Minimum thickness should be as follows:

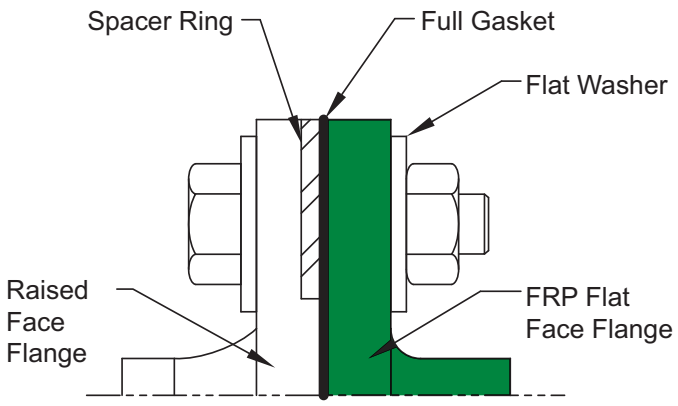
- $^{1}/_{8}$ in. through 20 in. diameter
- $^{3}/_{16}$ in. for 24 in. diameter through 36 in. diameter
- $^{1}/_{4}$ in. for 42 in. diameter and larger

Systems to be operated or tested over 100 psig should use reinforced gasket material to prevent extrusion of gasket caused by high bolt torque.

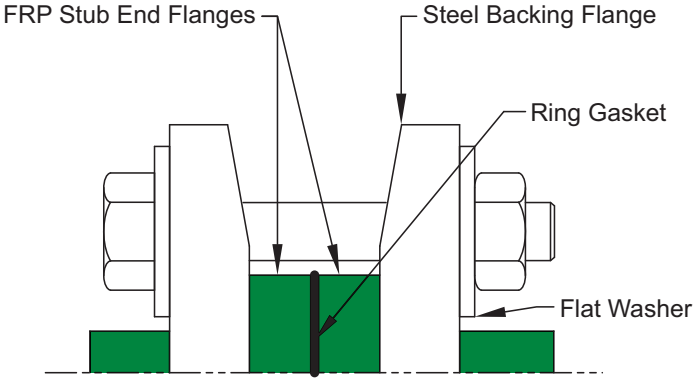
Flat Face Flange Connection



Raised Face to Flat Face Flange Connection



Stub Ends with Backing Flanges



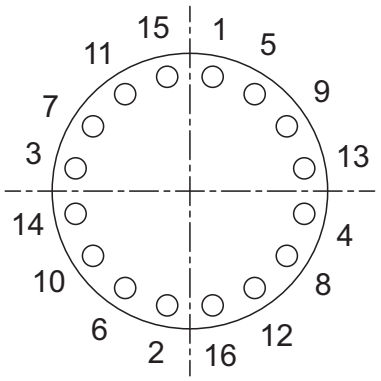
Section 7: Installation

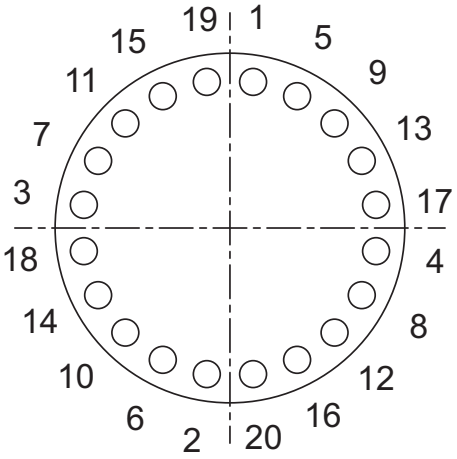
Bolt Torque

Maximum Bolt Torque for Pressure Piping

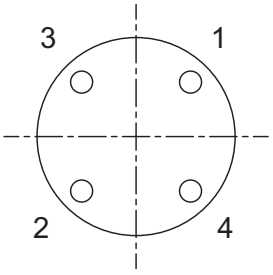
Bolt Size in.	Torque ft - lb
1/2	15
5/8	25
3/4	40
7/8	65
1	100
1 1/8	140
1 1/4	200
1 1/2	320
1 3/4	600
2	880

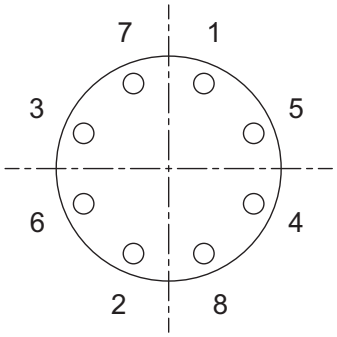
Torques result in a bolt stress of 12,000 psi.
ANSI Type A Narrow Series washers are recommended.
Threads & bearing surfaces are to be well lubricated.
Bolts 1" and larger are 8-thread series.

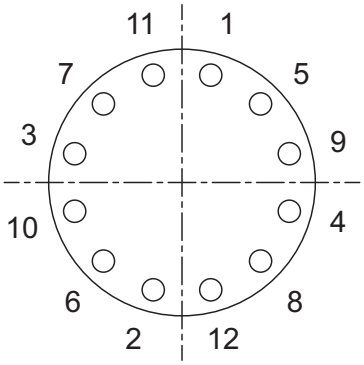


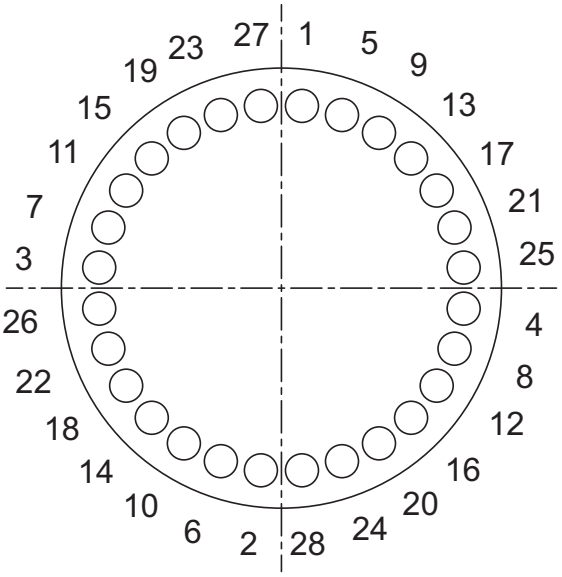


Bolt Tightening Sequence









Follow similar patterns for flanges with a greater number of bolts.

Tighten bolts to 50% of required torque in sequence shown. Repeat tightening in the same sequence until required torgue is reached.

Maximum torque is not required for low pressure systems.

Section 7: Installation

Buried Pipe Installation

Ershigs' FRP pipe is a flexible conduit. Procedures for site preparation and placement are similar to those used for other types of flexible materials. The light weight and long laying lengths of Ershigs' FRP pipe are definite advantages which generally permit installation cost savings over other materials.

The following guidelines should be followed when installing FRP pipe:

Investigate soil conditions along the proposed pipe line route. Due to the wide variation of soil types and conditions, a qualified geotechnical engineer should be consulted to ensure the soil and backfill meet the design specifications.

Excavate pipe trench to 6 in. below pipe invert with a width of 1.5 dia to 1.6 dia. Clearance at sides of pipe should not exceed 20 in. and proper trench conditions must be maintained.

Grade and compact trench bottom, maintaining the elevation 6 in. below pipe invert.

Keep trench free from water.

Place and shape a 6 in. thick layer of specified bedding material. Crushed stone or crushed gravel per ASTM C33, gradation 67 (grain size 3/4 in. to 3/16 in.) is often used. Coarse, well-graded sand containing less than 10% fines may also be used.

Provide bell holes at each joint location for bell and spigot pipe. Provide access holes at joint locations for all field joints.

Place pipe sections on bedding and align with survey instruments. Stabilize pipe with small amounts of backfill under the haunches and complete joining.

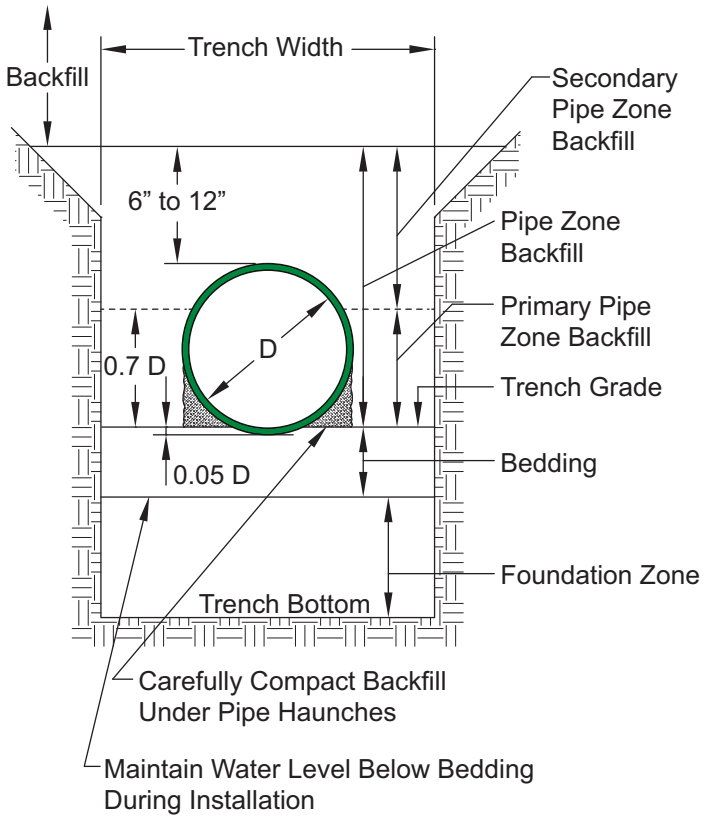
Carefully backfill and compact any voids or pockets.

Continue backfilling and compacting in 6 in. to 12 in. layers to an elevation at least 6 in. above top of pipe. All bedding and backfill material is to be thoroughly compacted to at least 95% Standard Proctor, ASTM D-698. Do not operate compacting equipment over pipe.

Four feet of native backfill above specified backfill is generally required for traffic loads (HS-20). **Installation under highways and railways requires special consideration.**

After installation, deflection or elongation of pipe should be less than 3% of the inside diameter.

Follow all state, local, and Federal safety regulations. Shore, sheet, brace, or otherwise support trench walls as required for safety of personnel working in the trench.



Proper installation procedures are required to develop the passive soil resistance necessary to prevent excessive pipe deflectons.

Section 7: Installation

O-Ring Gasketed Joints

Ershigs' bell and spigot gasketed joints use round elastomeric O-ring gaskets made of Neoprene, Isoprene or Buna-N. These gaskets are packaged separately for field assembly and should be kept in a cool, dry area out of direct sunlight.

Bell and spigot pipe must be installed by a skilled and experienced contractor.

Preparation

Wipe the bell and spigot clean with a cloth. Lubricate the O-ring with a vegetable oil based lubricant and stretch it into the groove. Once the O-ring is properly seated, grasp it, lift it out of the groove a few inches and release it so it snaps back into place. This procedure should be done at three points approximately 120^0 apart to equalize the tension in the O-ring.

Setting The Joint

Lift the section being joined from two lift points. Tilt it slightly and push the spigot into the bell as the pipe is lowered into final position. It may be necessary to move the free end of the pipe up and down or from side to side to seal the spigot and O-ring into the bell. The spigot should not contact the shoulder of the bell. A gap of approximately $^3/_4$ in. between the spigot end and the bell shoulder should be maintained.

Do not apply excessive longitudinal force to the free end of the pipe through the use of backhoe buckets, blades, winches or other powered equipment in such a manner as to point load a pipe end. Damage to either the bell or spigot will prevent the joint from sealing and will render the pipe useless.

Hydrostatic Testing

Hydrostatic testing, as required by project specifications, may be accomplished either as a shop test, or preferably as a field test of the assembled system. Testing procedures must not induce loads into the pipe for which it was not designed. The maximum test pressure shall be approved by Ershigs, Inc. All anchors and supports must be in place before testing.

The sealing integrity of each double O-ring bell and spigot joint should be confirmed before burial and before filling the pipe with water. The $^1/_4$ in. FPT test ports located between O-rings may be pressurized with air and/or water to 40 psig to confirm that the primary O-ring is properly seated.

The line must be filled with water in such a way so as to insure that all air is vented prior to pressurization. Limit initial pressure to 50% of design pressure for 10 minutes to seal all gaskets and O-rings. Some minor leakage is acceptable during this period.

The pressure should be gradually increased to the specified test pressure, blanked off and observed for a period of 30 minutes. During this time the line pressure must not drop by more than 5 psig and no significant leakage should occur.

Following the pressure test, the line should be emptied and thoroughly inspected.

Section 8: Fabricated (Spooled) Piping

Ershigs' pipe, duct and fittings are easily fabricated on the job site and assembled with the various joint types previously described. However, it is much more efficient and cost effective to prefabricate the components into spool pieces in our shop thereby minimizing higher cost field labor.

Ershigs' Engineering Department can easily work from plans and elevations or isometrics to develop individual spool drawings. During this process, standard FRP components and joints are located and identified to provide clear assembly information to Ershigs' Manufacturing Department and to minimize the total cost of the spool section.

Dimensional Tolerances

Ershigs' general pipe fabricating tolerances for prefabricated FRP piping assemblies through 36 in. diameter are as follows:

Linear Tolerance

The tolerances on linear dimensions (intermediate or overall) apply to the face to face, face to end, and end to end measurements of fabricated straight pipe and headers; center to end or center to face of nozzles or other attachments. These tolerances are not cumulative.

Linear tolerances on “A” are ± $^{1}/_{8}$ in. for sizes 10 in. and under, ± $^{3}/_{16}$ in. for sizes 12 in. through 24 in., and ± $^{1}/_{4}$ in. for sizes 26 in. through 36 in.

Linear tolerances on "A” for sizes over 36 in. are subject to tolerances of ± $^{1}/_{4}$ in., increasing by ± $^{1}/_{16}$ in. for each 12 in. in diameter over 36 in.

Due to the cumulative effects of tolerances on fittings or flanges, when joined without intervening pipe segments, deviations in excess of those specified above may occur. Tolerances on these dimensions are to be based on tolerances of the fittings or flanges involved.

(See *on drawing to the right.)

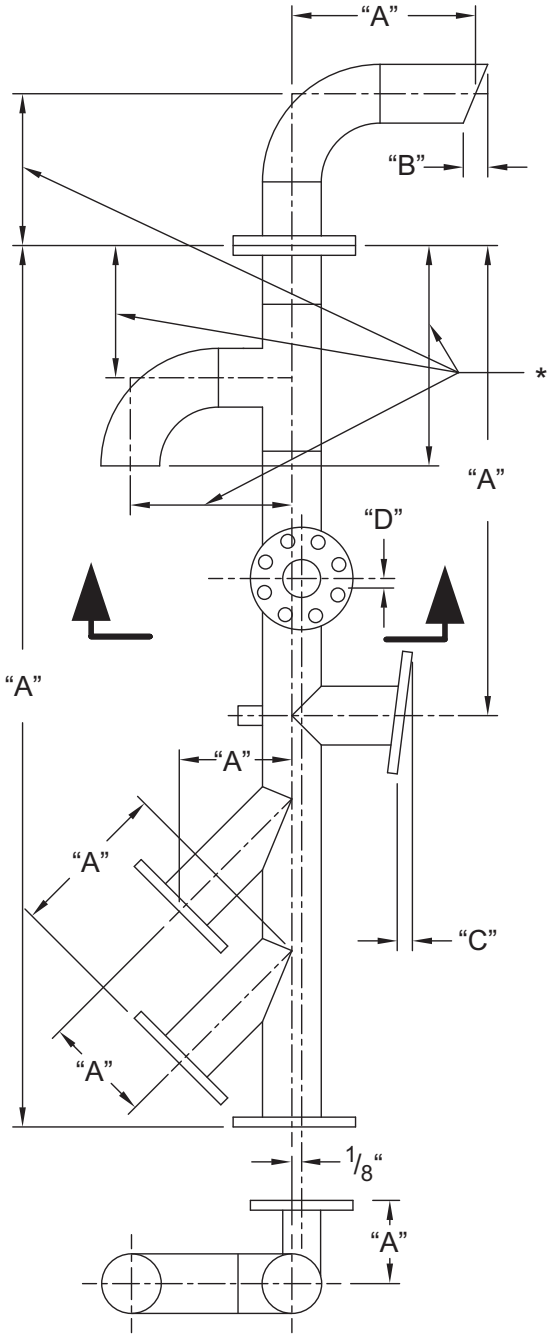
Squareness Tolerance

Squareness of end cuts, “B,” shall not deviate more than ± $^{1}/_{8}$ in. up to and including 24 in. Dia and $^{3}/_{16}$ in. for all diameters above 24 in.

Angularity and Rotational Tolerance

Alignment of facings, “C," or ends shall not deviate from the indicated position measured across any diameter more than $^{3}/_{64}$ in. per ft.

Rotation of flanges, "D,” from the indicated position measured as shown shall be a maximum of $^{1}/_{16}$ in.



Section

Section 9: Accessories

Ershigs provides special FRP custom designed components for all types of pipe and duct systems. Items such as manholes, filters, spectacle blinds, butterfly valves and transitions are available to suit your specific needs and meet your system requirements.

FRP Manholes

Large diameter underground piping systems require access manholes for periodic inspection, clean out, bends or junctions. FRP manholes can be fabricated in any configuration to withstand earth loads, live loads and groundwater loads. Bottoms can be contoured to direct flow and act as bends or junction boxes for several process streams. Special fittings are available for attachment of a variety of piping materials. Internal corrosion resistant ladders can be provided for easy access.

Filters and Separators

FRP filters, strainers and separators are manufactured for specific applications.

FRP Valves and Dampers

Valves and balancing dampers are available for gas and vapor service to 65 in. WG pressure in sizes from 6 in. dia to 144 in. dia. These FRP corrosion resistant valves can be manually operated or controlled with pneumatic, hydraulic or electric actuators.

Spectacle blind flanges are available for positive shut off of gas and vapor systems. These are inserted between a pair of companion flanges with the open end in the gas stream during normal operation and then rotated with the closed end in the gas stream for shut off. These blinds can be provided with Ershigs' standard duct drilling or ANSI 125/150 lb drilling, or without drilling for use with stub ends and backing flanges.

Special Fittings

Ershigs' custom fabricated special fittings are contact molded on precision tooling. Rectangular to round transitions for equipment connections (fans, pumps, etc.), hoods for fume removal, chutes, and flumes are just a few of the many specially made items supplied by Ershigs to complete your system requirements.

Section 10: Specifications

The following standards are published by nationally recognized organizations:

ASTM

C582	Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) laminates for Corrosion-Resisitant Equipment
D3299	Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
D3839	Standard Practice for Underground Installation of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
D3982	Standard Specification for Contact-Molded “Fiberglass” (Glass-Flber-Reinforced Thermosetting-Resin) Duct and Hoods
D4097	Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermosetting Resin Corrosion- Resistant Tanks

ANSI/ASME

RTP-1	Reinforced Thermoset Plastic Corrosion Resistant Equipment
B31.3	Process Piping

AWWA

M45	Fiberglass Pipe Design

Section 11: Quality Assurance

Ershigs, Inc. has been providing industry with quality products and dependable service since 1921.

From the first metal products to components for Navy minesweepers to corrosion resistant FRP equipment, Ershigs' quality has been its hallmark.

Ershigs' Quality Assurance and Quality Control Procedures are thoroughly outlined in our Manual ES-601. This document describes the organization, administration and responsibilities of the Quality Assurance Program. It provides management and our customers with the assurance that company products and services are meeting required standards on a continuing basis.

It is the policy of Ershigs, Inc. that all products and services shall comply with established company standards, recognized industry standards and specific customer requirements.

Glass Content Burn Test

Barcol Hardness Test

Burn Test Calculations

Angularity and Rotational Tolerance

Ultrasonic Thickness Test

The Ershigs label is your best guarantee

Corrosion Resistant FRP Products

ERSHIGS

Ershigs, Inc. manufactures a complete line of storage tanks, process vessels, scrubbers, and towers. Shop manufactured vessels are provided in diameters to 14 ft.

Ershigs' patented on-site manufacturing process provides users with quality FRP vessels in diameters to 65 ft. Storage tanks, neutralization tanks, bleach towers and absorber towers are in service in many industries.

Tall FRP stacks can be provided with guy-wire support or structural steel cage support, depending on customer requirements.

Ershigs' FRP chimney liners to 42 ft., 6” in Dia and over 1200 ft in height have been operating in power plants, pulp mills and smelters since 1974.

Fume hoods and ventilation systems can be designed, manufactured, and installed by **Ershigs, Inc.**

FRP and dual-laminate scrubbers provide chemical recovery and pollution control for a variety of industries.

EPS-07 ERSHIGS, INC. 2013