ERSHIGS
A Denali company

STOPLINE-G2™

Abrasion Resistant
Pipe & Fittings

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www.ershigs.com

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STOPLINE-G2™ Abrasion-Resistant

If flue gas treatment is your first line of defense in the battle for clean air, then ***Stopline-G2*** abrasion-resistant piping is a powerful ally. Ershigs' newly formulated piping meets increased internal/external abrasion resistance needs in aggressive service applications such as FGD scrubber systems.

Now Seven Times More Abrasion Resistant

A battery of abrasion tests – conducted by an independent test lab simulating typical FGD slurry conditions – resulted in an optimum formulation that is seven times more abrasion resistant than previous Stopline formulation. ***Stopline-G2*** also shows improved abrasion resistance when compared to Alloy 2205 and maintains the flexural and tensile properties you've come to expect from Ershigs' abrasion-resistant piping.

- Independent testing results in new, optimum formulation.
- ***Stopline-G2*** formula is seven times more abrasion resistant than previous Stopline formulation.
- ***Stopline-G2*** shows improved abrasion resistance compared to Alloy 2205.
- Flexural and tensile properties are maintained in new ***Stopline-G2*** formulation.

Stopline-G2 is the cost effective solution for aggressive applications:

Internal FGD Spray Header Piping
External FGD Recycle Piping
Slurry Transfer Lines
Drain Lines
Mist Eliminator Piping
Oxidation Air Spargers

Make *Stopline-G2™* from Ershigs, Inc. your Solution for Aggressive Power Plant Piping Applications!

For more information, contact:

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Table of Contents

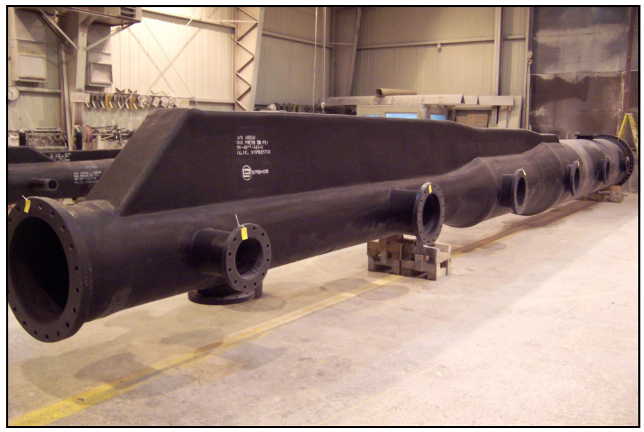
This catalog describes the construction and dimensions of Ershigs' Stopline-G2™ Fiberglass Reinforced Plastic pipe and fittings. It also provides general guidelines for design and installation to aid the user in the proper application of the products described. All information provided herein is subject to change without notice. Ershigs' Engineering Department should be contacted for specific application and design recommendations.

Section 1: Introduction

Stopline-G2™ Features and Benefits

Why use Ershigs Stopline-G2™ AR FRP Pipe & Fittings?

Ershigs Stopline-G2™ is more corrosion resistant than either stainless steel or rubber lined (RL) steel in most industrial systems that utilize corrosive chemicals and processes. It can be used in the chemical environments associated with flue gas desulphurization (FGD) systems, fume scrubber systems for base metal production and metal finishing, waste water and solids handling systems, pulp and paper process systems, and most chemical processing systems.



Ershigs Stopline-G2™ is very cost effective on an installed cost basis against RL steel and many of the stainless steel types, and is generally less costly than 316 SS and higher alloy steels.

Ershigs Stopline-G2™ is lighter weight than metal piping which can save on support steel, installation time, and rigging costs. Typically, FRP piping systems are 1/6 the weight of steel and about 1/20 the weight of concrete.

Ershigs Stopline-G2™ has excellent flow characteristics. The smooth, seamless interiors save pumping costs and reduce maintenance. These surfaces resist sludge and mineral deposit build-up and provide a Williams and Hazen C factor of 150.

Ershigs Stopline-G2™ is available in standard sizes and lengths. However, due to the ease of molding FRP into complex shapes, special sizes and configurations can be manufactured. Layers of the laminates can also be colored to provide good indications of the laminate wear during routine inspections.

Ershigs Stopline-G2™ can be manufactured utilizing a variety of available polyester and vinyl ester based resins that are chosen for their chemical resistance, flexibility, and strength for the service conditions. Each of these resins is then modified to yield an abrasion resistant matrix. Materials are carefully selected for each specific application requirement.

Ershigs Stopline-G2™ spray headers can be supplied as self-supporting to minimize costly tower support beams.

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, chemical and abrasion resistant properties. In general, the glass reinforcing provides the strength to the laminate and the resin binder provides the chemical and abrasion resistance. All laminates are designed to meet the specific application requirements.

Laminate Construction

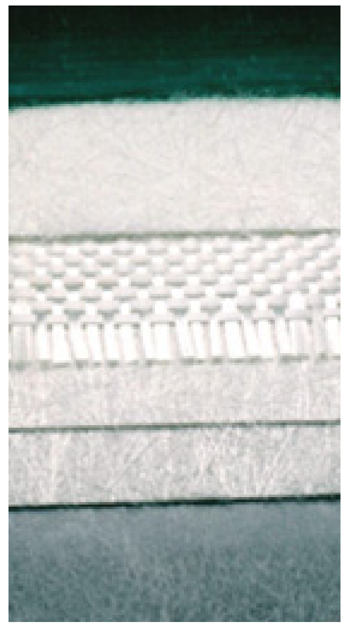
Ershigs manufactures pipe and fitting laminates with a variety of liner and structural wall constructions. In order to achieve optimum chemical and abrasion resistance, all laminates are composed of an **Inner Surface,** an **Interior Layer**, a **Structural Layer** and **an Outer Surface Layer**. The combination of Inner Surface and Interior Layer is often referred to as the **Abrasion Resistant Liner.**

Inner Surface - This surface is exposed to the abrasive and corrosive environment and is composed of Ershigs' abrasion resistant resin formulation 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.

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 Ershigs' abrasion resistant resin formulation and produces a thickness of 85 to 95 mils with a 22% to 32% glass content. Custom liner thicknesses greater than 100 mils are available. The abrasion resistant liner should be considered sacrificial and non-structural.

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 an abrasive environment, an abrasion resistant liner will be added over the structural layer for exterior protection.

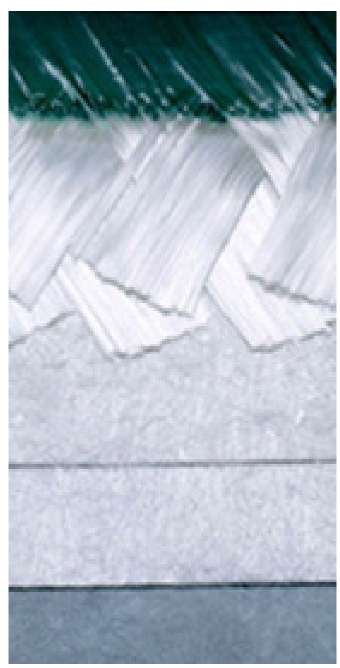


1½ oz.
Chopped Strand

24 oz.
Woven Roving

2 layers 1½ oz.
Chopped Strand

"C" Glass Veil



Bi-directional
Filament Wound
Strand

2 layers 1½ oz.
Chopped Strand

"C" Glass Veil

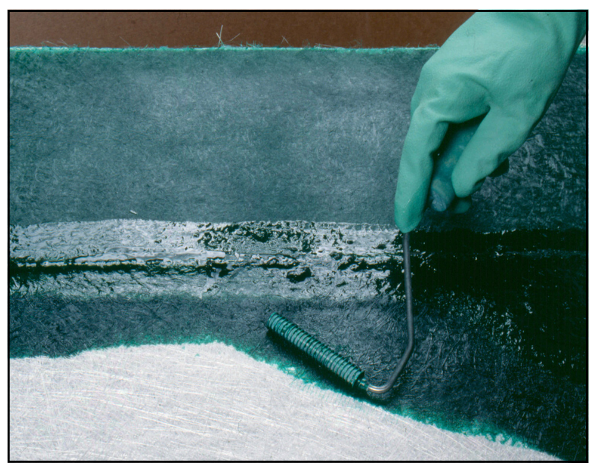
Section 2: Laminates

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 presaturated 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 55^0 winding angle, which provides the theoretical optimum 2 to 1 hoop to axial strength ratio required for pressure piping. Vacuum piping, duct and 0-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 laid 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 Laminates

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	8,000 – 18,000	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	$0.7 – 1.0 \times 10^6$	$1.8 – 3.2 \times 10^6$ (Hoop)
Tensile Modulus of Elasticity, psi	$0.8 – 1.1 \times 10^6$	$2.0 – 3.5 \times 10^6$ (Hoop) $0.9 – 1.4 \times 10^6$ (Axial)
Poisson's Ratio	0.33	Varies by 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	$15 – 20 \times 10^{-6}$	$12 – 16 \times 10^{-6}$
Heat Distortion Temperature (Resin), °F @ 264 psi	170 – 300	170 - 300
Barcol Hardness	27 – 45	27 – 45

Section 3: Pipe, Fitting & Flange Thickness

Stopline A – Pipe, Fittings & Flange Thickness Chart

STOPLINE 150A: 150 PSIG Rating with 100 Mil AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.27	1.3	FULL	11/16”
3	N/A	N/A	N/A		0.27	1.9	FULL	13/16”
4	N/A	N/A	N/A		0.30	2.8	FULL	15/16”
6	0.23	3.6	13.2		0.33	4.6	FULL	1 1/16”
8	0.27	5.7	12.2		0.41	7.7	FULL	1 1/4”
10	0.32	8.4	13.3		0.45	10.5	FULL	1 7/16”
12	0.36	11.4	12.6		0.50	14.0	FULL	1 3/4”
14	0.40	14.8	12.1		0.57	18.6	FULL	1 7/8”
16	0.45	19.0	12.8		0.64	23.9	FULL	2 1/16”
18	0.49	23.3	12.4		0.69	29.0	FULL	2 1/4”
20	0.54	28.5	12.9		0.77	36.0	FULL	2 7/16”
24	0.58	36.7	9.7		0.91	51.0	FULL	2 13/16”
28	0.67	49.5	10.2		1.03	67.4	FULL	3 3/16”
30	0.71	56.2	10.1		1.07	75.0	FULL	3 3/8”
36	0.84	79.8	10.4		1.27	106.8	FULL	4”
42	0.93	103.0	9.3		1.49	146.2	FULL	4 3/8”
48	1.06	134.2	9.6		1.66	186.1	FULL	4 7/8”

STOPLINE 125A: 125 PSIG Rating with 100 Mil AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.27	1.3	FULL	5/8”
3	N/A	N/A	N/A		0.27	1.9	FULL	3/4”
4	N/A	N/A	N/A		0.27	2.5	FULL	7/8”
6	0.23	3.6	13.2		0.30	4.2	12.1	1”
8	0.27	5.7	12.2		0.38	7.1	FULL	1 1/8”
10	0.27	7.1	6.2		0.41	9.6	12.3	1 5/16”
12	0.32	10.1	7.7		0.49	13.7	FULL	1 5/8”
14	0.36	13.3	7.9		0.49	16.0	9.8	1 3/4”
16	0.40	16.9	8.1		0.53	19.8	8.8	1 7/8”
18	0.40	19.0	5.7		0.61	25.7	10.2	2”
20	0.45	23.7	6.6		0.65	30.4	9.4	2 1/8”
24	0.54	34.2	7.5		0.77	43.2	9.7	2 1/2”
28	0.58	42.8	6.1		0.88	57.6	9.7	2 7/8”
30	0.62	49.1	6.3		0.91	63.8	8.8	3 1/16”
36	0.71	67.4	5.9		1.07	90.0	8.7	3 5/8”
42	0.80	88.6	5.6		1.26	123.6	9.4	4”
48	0.93	117.7	6.2		1.42	159.2	9.2	4 1/2”

STOPLINE 100A: 100 PSIG Rating with 100 Mil AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.27	1.3	FULL	9/16”
3	N/A	N/A	N/A		0.27	1.9	FULL	11/16”
4	N/A	N/A	N/A		0.27	2.5	FULL	13/16”
6	0.18	2.8	3.2		0.30	4.2	12.1	7/8”
8	0.23	4.9	5.6		0.33	6.2	7.7	1”
10	0.27	7.1	6.2		0.38	8.9	8.1	1 3/16”
12	0.27	8.5	3.6		0.41	11.5	7.1	1 7/16”
14	0.32	11.8	4.8		0.45	14.7	6.4	1 1/2”
16	0.32	13.5	3.2		0.49	18.3	6.6	1 5/8”
18	0.36	17.1	3.7		0.49	20.6	4.6	1 3/4”
20	0.40	21.1	4.2		0.53	24.8	4.5	1 7/8”
24	0.45	28.5	3.8		0.61	34.2	4.3	2 1/8”
28	0.49	36.2	3.3		0.72	47.1	4.9	2 3/8”
30	0.49	38.8	2.7		0.76	53.3	4.8	2 1/2”
36	0.58	55.1	2.9		0.88	74.0	4.5	2 13/16”
42	0.67	74.2	3.0		1.03	101.1	4.8	3 1/8”
48	0.76	96.2	3.1		1.15	129.0	4.7	3 7/16”

Pipe 6” diameter and larger, use filament wound thickness.
Pipe 4” diameter and less and all fittings, use hand lay-up thickness.

Section 3: Pipe, Fitting & Flange Thickness

Stopline A – Pipe, Fittings & Flange Thickness Chart

STOPLINE 75A: 75 PSIG Rating with 100 Mil AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.27	1.3	FULL	1/2”
3	N/A	N/A	N/A		0.27	1.9	FULL	5/8”
4	N/A	N/A	N/A		0.27	2.5	FULL	11/16”
6	0.18	2.8	3.2		0.27	3.8	7.5	3/4”
8	0.23	4.9	5.6		0.30	5.6	5.1	7/8”
10	0.23	6.1	2.8		0.30	7.0	2.6	1 1/16”
12	0.23	7.3	1.6		0.38	10.7	4.7	1 1/4”
14	0.27	10.0	2.3		0.41	13.4	4.5	1 5/16”
16	0.27	11.4	1.5		0.41	15.3	3.0	1 7/16”
18	0.32	15.2	2.3		0.45	18.9	3.0	1 1/2”
20	0.32	16.9	1.7		0.49	22.9	3.4	1 5/8”
24	0.36	22.8	1.6		0.49	27.5	1.9	1 7/8”
28	0.40	29.5	1.5		0.56	36.6	2.0	2 1/8”
30	0.40	31.7	1.2		0.61	42.8	2.2	2 1/4”
36	0.49	46.5	1.6		0.68	57.2	1.9	2 9/16”
42	0.54	59.8	1.4		0.80	78.5	2.1	2 7/8”
48	0.58	73.4	1.2		0.88	98.7	1.9	3 1/4”

STOPLINE 50A: 50 PSIG Rating with 100 Mil AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.27	1.3	FULL	1/2”
3	N/A	N/A	N/A		0.27	1.9	FULL	1/2”
4	N/A	N/A	N/A		0.27	2.5	FULL	9/16”
6	0.18	2.8	3.2		0.27	3.8	7.5	5/8”
8	0.18	4.9	5.6		0.27	5.0	3.2	3/4”
10	0.18	4.7	0.7		0.30	7.0	2.6	7/8”
12	0.23	7.3	1.6		0.30	8.4	1.5	1”
14	0.23	8.5	1.0		0.33	10.8	1.4	1 1/16”
16	0.23	9.7	0.7		0.33	12.3	1.0	1 3/16”
18	0.23	10.9	0.5		0.38	16.0	1.4	1 1/4”
20	0.27	14.2	0.8		0.38	17.8	1.0	1 5/16”
24	0.27	17.1	0.5		0.41	23.0	0.9	1 1/2”
28	0.32	23.6	0.6		0.45	29.4	0.8	1 3/4”
30	0.32	25.3	0.5		0.49	34.3	1.0	1 7/8”
36	0.36	34.2	0.5		0.53	44.6	0.8	2 3/16”
42	0.40	44.3	0.4		0.56	54.9	0.6	2 1/2”
48	0.45	57.0	0.5		0.64	71.8	0.6	2 3/4”

STOPLINE 25A: 25 PSIG Rating with 100 Mil AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.27	1.3	FULL	1/2”
3	N/A	N/A	N/A		0.27	1.9	FULL	1/2”
4	N/A	N/A	N/A		0.27	2.5	FULL	1/2”
6	0.18	2.8	3.2		0.27	3.8	7.5	1/2”
8	0.18	3.8	1.4		0.27	5.0	3.2	9/16”
10	0.18	4.7	0.7		0.27	6.3	1.6	11/16”
12	0.18	5.7	0.4		0.27	7.6	0.9	3/4”
14	0.18	6.6	0.3		0.27	8.8	0.6	13/16”
16	0.18	7.6	0.2		0.27	10.1	0.4	7/8”
18	0.18	8.5	0.1		0.27	11.4	0.3	15/16”
20	0.18	9.5	0.1		0.30	14.0	0.3	1”
24	0.23	14.6	0.2		0.33	18.5	0.3	1 1/8”
28	0.23	17.0	0.1		0.37	24.2	0.3	1 1/4”
30	0.23	18.2	0.1		0.37	25.9	0.3	1 3/8”
36	0.23	21.8	0.1		0.37	31.1	0.2	1 3/4”
42	0.27	29.9	0.1		0.41	40.2	0.2	2”
48	0.32	40.5	0.1		0.45	50.5	0.2	2 3/8”

Pipe 6” diameter and larger, use filament wound thickness.
Pipe 4” diameter and less and all fittings, use hand lay-up thickness.

Stopline AA – Pipe, Fittings & Flange Thickness Chart

STOPLINE 150AA: 150 PSIG Rating with 100 Mil Internal and 100 Mil External AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.36	1.7	FULL	11/16”
3	N/A	N/A	N/A		0.36	2.5	FULL	13/16”
4	N/A	N/A	N/A		0.40	3.7	FULL	15/16”
6	0.32	5.1	13.2		0.43	6.0	FULL	1 1/16”
8	0.37	7.8	12.2		0.51	9.5	FULL	1 1/4”
10	0.41	10.8	13.3		0.55	12.8	FULL	1 7/16”
12	0.46	14.6	12.6		0.59	16.5	FULL	1 3/4”
14	0.50	18.5	12.1		0.67	21.9	FULL	1 7/8”
16	0.54	22.8	12.8		0.73	27.3	FULL	2 1/16”
18	0.59	28.0	12.4		0.79	33.2	FULL	2 1/4”
20	0.63	33.2	12.9		0.86	40.2	FULL	2 7/16”
24	0.68	43.0	9.7		1.01	56.6	FULL	2 13/16”
28	0.76	56.1	10.2		1.12	73.3	FULL	3 3/16”
30	0.81	64.1	10.1		1.17	82.0	FULL	3 3/8”
36	0.94	89.3	10.4		1.36	114.4	FULL	4”
42	1.03	114.1	9.3		1.59	156.0	FULL	4 3/8”
48	1.16	146.9	9.6		1.75	196.2	FULL	4 7/8”

STOPLINE 125AA: 125 PSIG Rating with 100 Mil Internal and 100 Mil External AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.36	1.7	FULL	5/8”
3	N/A	N/A	N/A		0.36	2.5	FULL	3/4”
4	N/A	N/A	N/A		0.36	3.4	FULL	7/8”
6	0.32	5.1	13.2		0.40	5.6	12.1	1”
8	0.37	7.8	12.2		0.47	8.8	FULL	1 1/8”
10	0.37	9.8	6.2		0.51	11.9	12.3	1 5/16”
12	0.41	13.0	7.7		0.58	16.3	FULL	1 5/8”
14	0.46	17.0	7.9		0.58	19.0	9.8	1 3/4”
16	0.50	21.1	8.1		0.63	23.5	8.8	1 7/8”
18	0.50	23.7	5.7		0.70	29.4	10.2	2”
20	0.54	28.5	6.6		0.74	34.6	9.4	2 1/8”
24	0.63	39.9	7.5		0.86	48.2	9.7	2 1/2”
28	0.68	50.2	6.1		0.97	63.5	9.7	2 7/8”
30	0.72	57.0	6.3		1.01	70.8	8.8	3 1/16”
36	0.81	76.9	5.9		1.17	98.5	8.7	3 5/8”
42	0.90	99.7	5.6		1.35	132.5	9.4	4”
48	1.03	130.4	6.2		1.51	169.3	9.2	4 1/2”

STOPLINE 100AA: 100 PSIG Rating with 100 Mil Internal and 100 Mil External AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.36	1.7	FULL	9/16”
3	N/A	N/A	N/A		0.36	2.5	FULL	11/16”
4	N/A	N/A	N/A		0.36	3.4	FULL	13/16”
6	0.28	4.4	3.2		0.40	5.6	12.1	7/8”
8	0.32	6.8	5.6		0.43	8.0	7.7	1”
10	0.37	9.8	6.2		0.47	11.0	8.1	1 3/16”
12	0.37	11.7	3.6		0.51	14.3	7.1	1 7/16”
14	0.41	15.1	4.8		0.55	18.0	6.4	1 1/2”
16	0.41	17.3	3.2		0.58	21.7	6.6	1 5/8”
18	0.46	21.8	3.7		0.58	24.4	4.6	1 3/4”
20	0.50	26.4	4.2		0.63	29.4	4.5	1 7/8”
24	0.54	34.2	3.8		0.71	39.8	4.3	2 1/8”
28	0.59	43.6	3.3		0.82	53.6	4.9	2 3/8”
30	0.59	46.7	2.7		0.85	59.6	4.8	2 1/2”
36	0.,68	64.6	2.9		0.97	81.6	4.5	2 13/16”
42	0.76	84.2	3.0		1.12	109.9	4.8	3 1/8”
48	0.85	107.6	3.1		1.24	139.0	4.7	3 7/16”

Pipe 6” diameter and larger, use filament wound thickness.
Pipe 4” diameter and less and all fittings, use hand lay-up thickness.

Section 3: Pipe, Fitting & Flange Thickness

Stopline AA – Pipe, Fittings & Flange Thickness Chart

STOPLINE 75AA: 75 PSIG Rating with 100 Mil Internal and 100 Mil External AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.36	1.7	FULL	1/2”
3	N/A	N/A	N/A		0.36	2.5	FULL	5/8”
4	N/A	N/A	N/A		0.36	3.4	FULL	11/16”
6	0.28	4.4	3.2		0.36	5.0	7.5	3/4”
8	0.32	6.8	5.6		0.40	7.5	5.1	7/8”
10	0.32	8.4	2.8		0.40	9.3	2.6	1 1/16”
12	0.32	10.1	1.6		0.47	13.2	4.7	1 1/4”
14	0.37	13.7	2.3		0.51	16.7	4.5	1 5/16”
16	0.37	15.6	1.5		0.51	19.1	3.0	1 7/16”
18	0.41	19.5	2.3		0.55	23.1	3.0	1 1/2”
20	0.41	21.6	1.7		0.58	27.1	3.4	1 5/8”
24	0.46	29.1	1.6		0.58	32.5	1.9	1 7/8”
28	0.50	36.9	1.5		0.66	43.2	2.0	2 1/8”
30	0.50	39.6	1.2		0.70	49.1	2.2	2 1/4”
36	0.59	56.0	1.6		0.78	65.6	1.9	2 9/16”
42	0.63	69.8	1.4		0.90	88.3	2.1	2 7/8”
48	0.68	86.1	1.2		0.97	108.8	1.9	3 1/4”

STOPLINE 50AA: 50 PSIG Rating with 100 Mil Internal and 100 Mil External AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.36	1.7	FULL	1/2”
3	N/A	N/A	N/A		0.36	2.5	FULL	1/2”
4	N/A	N/A	N/A		0.36	3.4	FULL	9/16”
6	0.28	4.4	3.2		0.36	5.0	7.5	5/8”
8	0.28	5.9	5.6		0.36	6.7	3.2	3/4”
10	0.28	7.4	0.7		0.40	9.3	2.6	7/8”
12	0.32	10.1	1.6		0.40	11.2	1.5	1”
14	0.32	11.8	1.0		0.43	14.1	1.4	1 1/16”
16	0.32	13.5	0.7		0.43	16.1	1.0	1 3/16”
18	0.32	15.2	0.5		0.47	19.8	1.4	1 1/4”
20	0.37	19.5	0.8		0.47	22.0	1.0	1 5/16”
24	0.37	23.4	0.5		0.51	28.6	0.9	1 1/2”
28	0.41	30.3	0.6		0.55	36.0	0.8	1 3/4”
30	0.41	32.4	0.5		0.58	40.6	1.0	1 7/8”
36	0.46	43.7	0.5		0.63	53.0	0.8	2 3/16”
42	0.50	55.4	0.4		0.66	64.8	0.6	2 1/2”
48	0.,54	68.4	0.5		0.73	81.9	0.6	2 3/4”

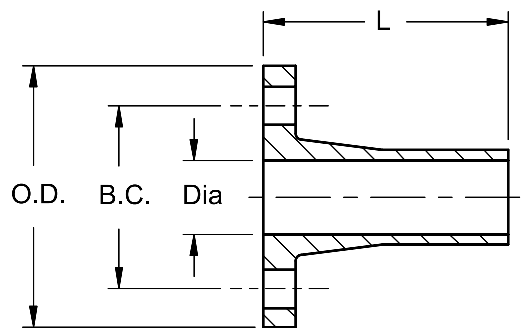
STOPLINE 25AA: 25 PSIG Rating with 100 Mil Internal and 100 Mil External AR Liner								
DIA. (in)	FILAMENT WOUND THK. (in)	FILAMENT WOUND WT. (lb/ft)	VAC (psi)		HAND LAY-UP THK. (in)	HAND LAY-UP WT. (lb/ft)	VAC (psi)	FLANGE THK. (in)
2	N/A	N/A	N/A		0.36	1.7	FULL	1/2”
3	N/A	N/A	N/A		0.36	2.5	FULL	1/2”
4	N/A	N/A	N/A		0.36	3.4	FULL	1/2”
6	0.28	4.4	3.2		0.36	5.0	7.5	1/2”
8	0.28	5.9	1.4		0.36	6.7	3.2	9/16”
10	0.28	7.4	0.7		0.36	8.4	1.6	11/16”
12	0.28	8.9	0.4		0.36	10.1	0.9	3/4”
14	0.28	10.3	0.3		0.36	11.8	0.6	13/16”
16	0.28	11.8	0.2		0.36	13.5	0.4	7/8”
18	0.28	13.3	0.1		0.36	15.1	0.3	15/16”
20	0.28	14.8	0.1		0.40	18.7	0.3	1”
24	0.32	20.3	0.2		0.43	24.1	0.3	1 1/8”
28	0.32	23.6	0.1		0.46	30.1	0.3	1 1/4”
30	0.32	25.3	0.1		0.46	32.2	0.3	1 3/8”
36	0.32	30.4	0.1		0.46	38.7	0.2	1 3/4”
42	0.37	41.0	0.1		0.51	50.0	0.2	2”
48	0.41	51.9	0.1		0.55	61.7	0.2	2 3/8”

Pipe 6” diameter and larger, use filament wound thickness.
Pipe 4” diameter and less and all fittings, use hand lay-up thickness.

Section 4: Fittings 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.
- Ershigs' proprietary filament wound pipe flanges are available in selected sizes.
- 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 ⅜	6	3 ⅛	4	⅝	½
1 ½	5 ½	6	3 ⅞	4	⅝	½
2	6 ½	6	4 ¾	4	¾	⅝
2 ½	7 ½	6	5 ½	4	¾	⅝
3	8	6	6	4	¾	⅝
4	9 ½	6	7 ½	8	¾	⅝
6	11 ½	8	9 ½	8	⅞	¾
8	14	8	11 ¾	8	⅞	¾
10	16 ½	10	14 ¼	12	1	⅞
12	19 ½	10	17	12	1	⅞
14	21 ½	12	18 ¾	12	1 ⅛	1
16	24	12	21 ¼	16	1 ⅛	1
18	25 ½	12	22 ¾	16	1 ¼	1 ⅛
20	28	12	25	20	1 ¼	1 ⅛
24	32 ½	12	29 ½	20	1 ⅜	1 ¼
26	34 ¾	12	31 ¾	24	1 ⅜	1 ¼
28	37	12	34	28	1 ⅜	1 ¼
30	39 ¼	15	36	28	1 ⅜	1 ¼
36	46 ½	15	42 ¾	32	1 ⅝	1 ½
42	53 ½	15	49 ½	36	1 ⅝	1 ½
48	60	15	56	44	1 ⅝	1 ½
54	66 ¾	18	62 ¾	44	2	1 ¾
60	73 ½	18	69 ¼	52	2	1 ¾
66	80 ⅛	18	76	52	2	1 ¾
72	87	22	82 ½	60	2	1 ¾
84	100 ¼	22	95 ½	64	2 ¼	2
96	113 ¾	22	108 ½	68	2 ½	2 ¼

Dimensions are in inches.

Section 4: Fittings Dimensions

Elbows

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

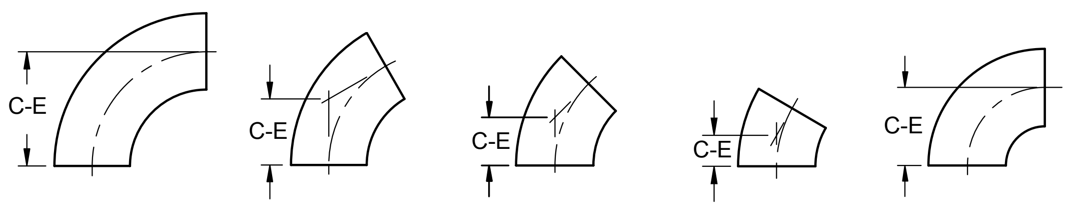
  2 in. and 3 in. have centerline radius two times the inside diameter.

  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.



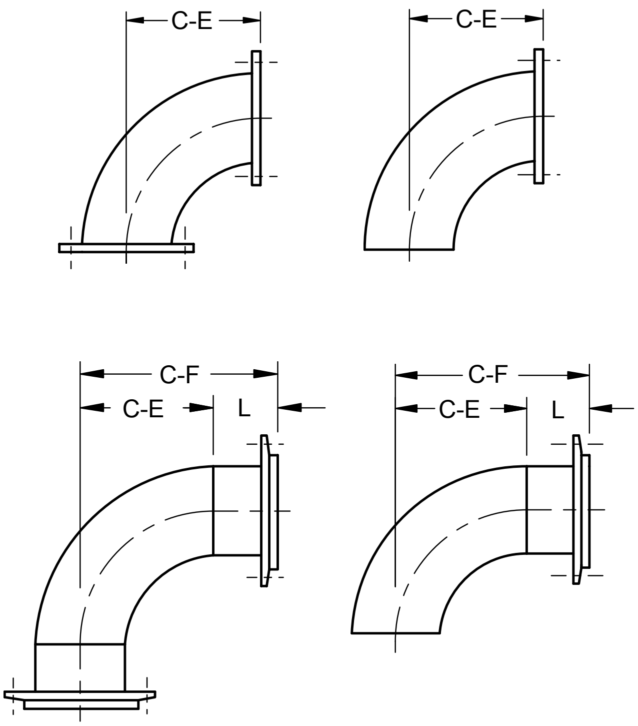
Dia	Long Radius 90° Elbow C-E	Long Radius 60° Elbow C-E	Long Radius 45° Elbow C-E	Long Radius 30° Elbow C-E	Short Radius 90° Elbow C-E
2	4	2 5/16	1 11/16		
3	6	3 7/16	2 1/2		
4	6	3 7/16	2 1/2		
6	9	5 3/16	3 3/4	2 7/16	6
8	12	6 15/16	5	3 3/16	8
10	15	8 11/16	6 3/16	4	10
12	18	10 3/16	7 7/16	4 13/16	12
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

Dimensions are in inches.
*Standard construction is a mitered elbow.

Section 4: Fittings Dimensions

Flanged Elbows

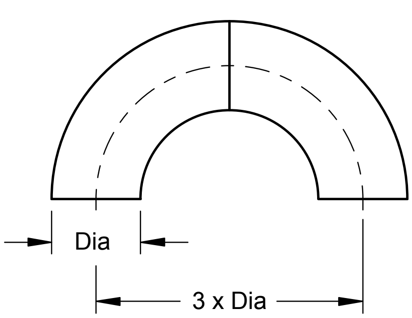
- Flanged elbows can be provided in the configurations shown below.
- All long radius elbows, 45° thru 90°, are suitable for flat face flanges at both ends.
- When backing flanges are used, a stub end must be attached to elbow.



Special Elbows and Bends

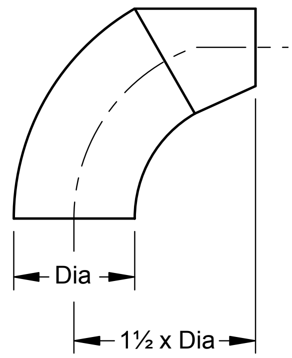
180° Return Bend

Available in long and short radius configurations.



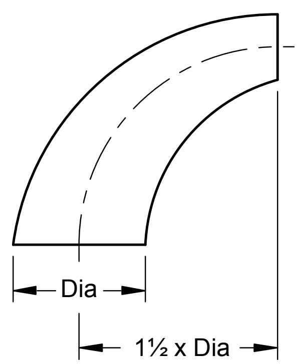
Cut-Back Transition Reducing Elbow

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.



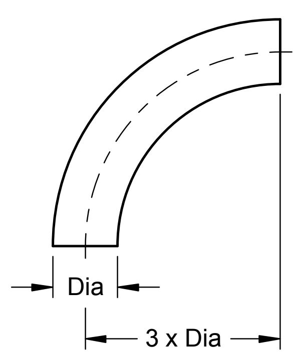
Smooth Flow Reducing Elbow

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 (Bellingham Plant) with a centerline radius of three times the inside diameter. Mitered construction available in all diameters and any centerline radius.

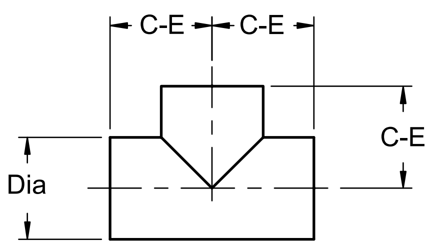


Section 4: Fittings Dimensions

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.
- 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.
- 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.

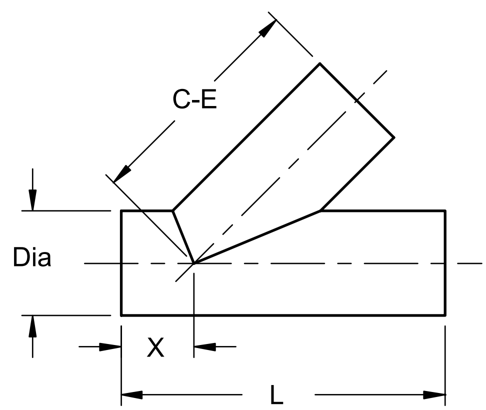
Tee



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

Dimenions 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

Dimenions are in inches.

Section 4: Fittings Dimensions

Reducers

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

$$L = 2\tfrac{1}{2}\,(D_1 - D_2)$$

- Centerline offset of eccentric reducers is calculated as follows:

$$E = \tfrac{1}{2}\,(D_1 - D_2)$$

- Special dimensions are available

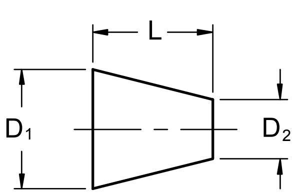
D_1 X D_2	L
3 x 2	2 ½
3 x 1.5	3 ¾
4 x 3	2 ½
4 x 2	5
6 x 4	5
6 x 3	7 ½
6 x 2	10
8 x 6	5
8 x 4	10
8 x 3	12 ½
10 x 8	5
10 x 6	10
10 x 4	15
12 x 10	5
12 x 8	10
12 x 6	15
14 x 12	5
14 x 10	10
14 x 8	15
16 x 14	5
16 x 12	10
16 x 10	15
18 x 16	5
18 x 14	10
18 x 12	15
18 x 10	20

Dimenions are in inches.

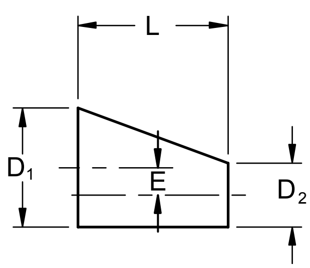
D_1 X D_2	L
20 x 18	5
20 x 16	10
20 x 14	15
24 x 20	10
24 x 18	15
24 x 16	20
26 x 24	5
26 x 20	15
26 x 18	20
28 x 26	5
28 x 26	10
28 x 20	20
30 x 24	15
30 x 20	25
30 x 18	30
30 x 16	35
36 x 30	15
36 x 24	30
42 x 36	15
42 x 30	30
48 x 42	15
48 x 36	30
54 x 48	15
54 x 42	30
60 x 54	15
60 x 48	30

Dimenions are in inches.

Concentric Reducer

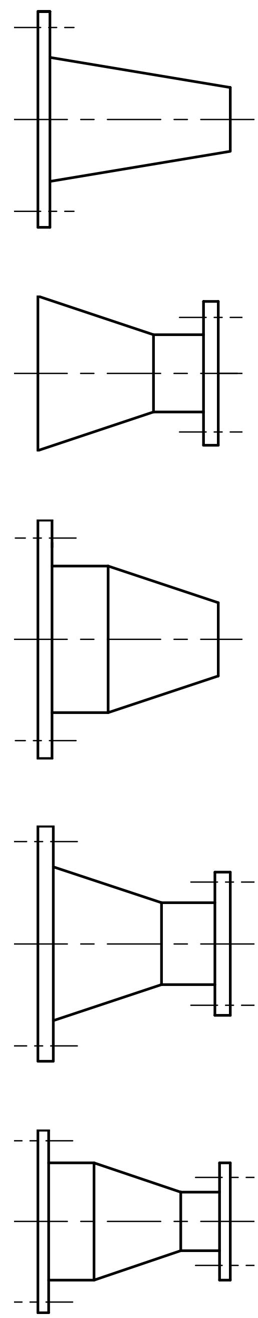


Eccentric Reducer



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.

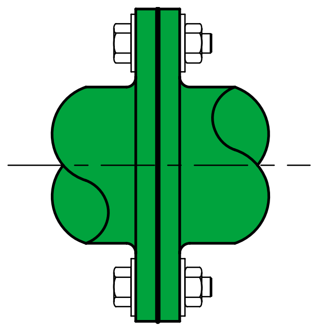


Section 5: Joining Systems

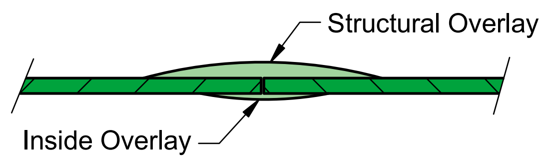
Ershigs' FRP piping systems may be assembled with a variety of joint types. Rigid connections such as bolted flanges and butt joints as well as more flexible bell and spigot joints and mechanical couplings may be used to suit most installation requirements.

Flat Face Drilled Flange

- 125/150 lb ANSI Standard Drilling

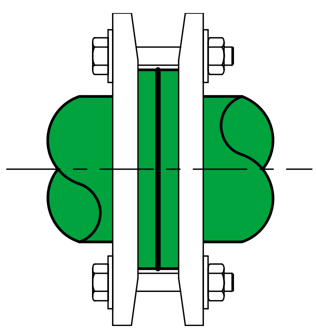


Butt Joint



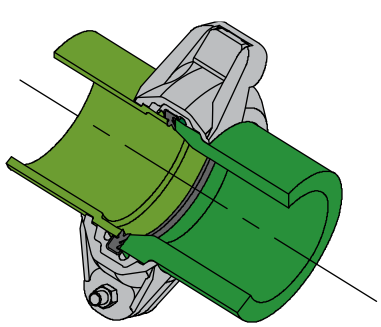
Stub End with Steel Backing Flange

- 125/150 lb ANSI Standard Drilling



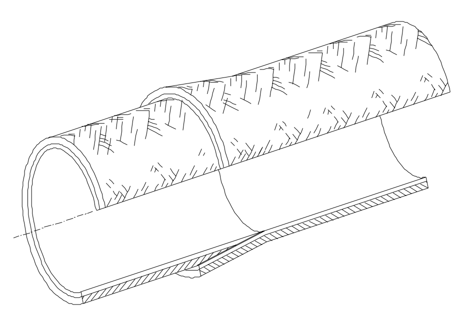
FRP Victualic Style Connection

- Spray Header to Spray Nozzle Connection Applications



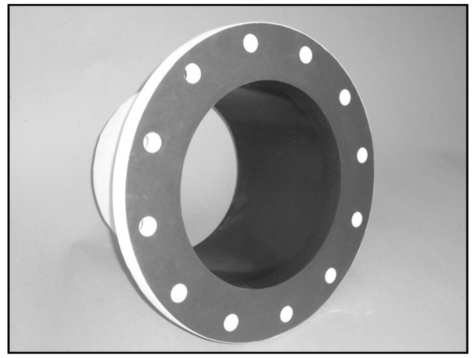
Bell & Spigot Tapered Adhesive Joints

The bell & spigot tapered adhesive joint is a joining option typically used for small diameter piping systems in which field routing is preferred over shop assembled spools. The adhesive joint is available for pipe and fittings from 1 ½" through 12" diameter. Tapered ends can be prepared at the plant or in the field. Field tapering will require the rental of our manual and/or powered tapering machines which are specifically designed to cut a precise taper. The two part adhesive system is available in pre-measured kits. Completion of each joint will require proper tapering, trial-fit, application of adhesive to both male and female ends, seating the joint and clamping to prevent movement. Immediately after clamping, the application of a heat collar is required over the joint area to allow for proper cure.



Section 5: Joining Systems

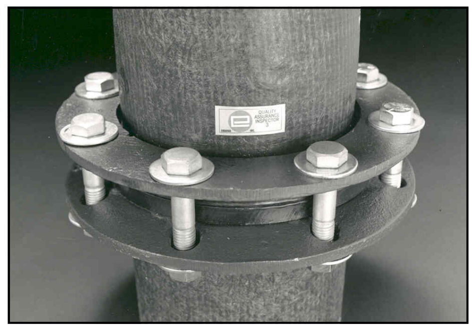
Flanged Joints



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 page 9.

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 cast steel backing flanges are available from Ershigs. They provide an economical alternative to drilled flanges in sizes from 1 ½ 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.

Butt Joints

The most common method of assembling and joining custom manufactured FRP piping is with the butt joint. This system provides a strong, leak proof 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. 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.

WET-OUT

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.

ROLL-OUT

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

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

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' Stopline 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 sacrificial element of the laminate and is not included in wall thickness calculations.

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

Contact molded pipe and fitting designs are based on Ultimate Strengths listed on page 4 with a 6.5:1 safety factor applied. The formula for all thickness is:

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

P = pressure, psig

r = pipe radius, in.

s = ultimate tensile strength

SF = safety factor of 6.5

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

Section 6: Piping System Design

Ershigs' Stopline filament wound pressure piping is manufactured with a 55° (± 3°) winding angle using an allowable strain of .0014 in./in.

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 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:

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

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.
Kn = 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:

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

E_a = 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 Δ T of 100°F.

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

$$\text{Force} = 1{,}800 \times \frac{\pi}{4} (25^2 — 24^2) = 69{,}237 \text{ lb.}$$

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 that 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:

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

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 ½	2 ½	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	Content 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.

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.

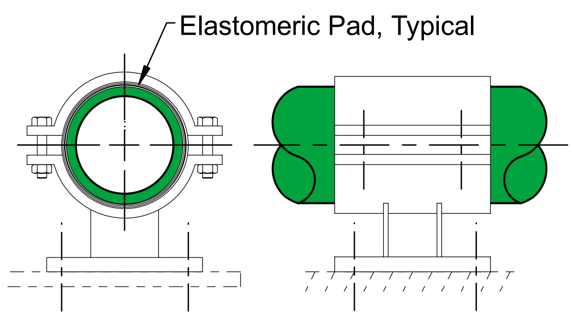
Pipe Supports and Hangers

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.

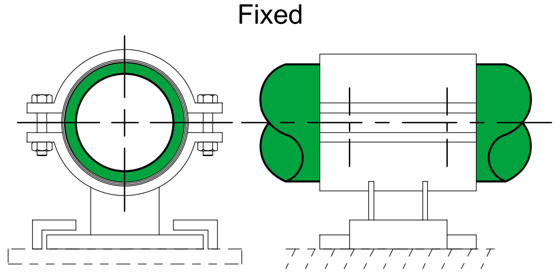
It is essential that each installation be reviewed to ensure the proper location and fit of all supporting elements. Maximum recommended support spacing for Ershigs' FRP pipe is shown on page 21. For specific applications, contact Ershigs' Engineering Department for a custom design.

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.

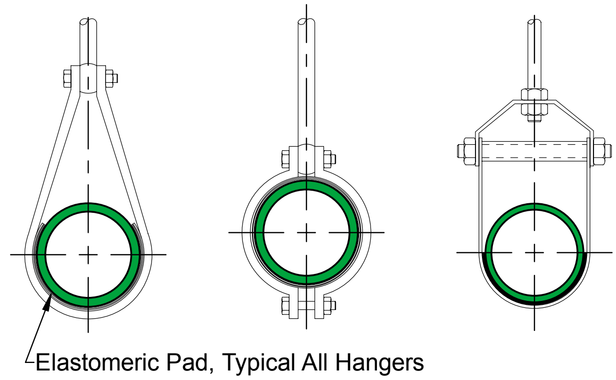


Fixed



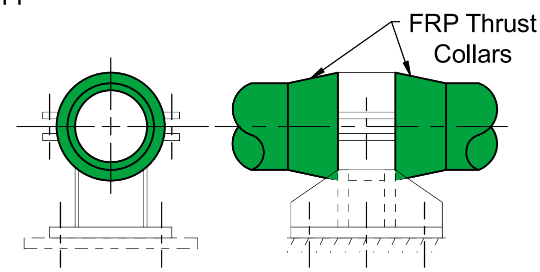
Guided

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



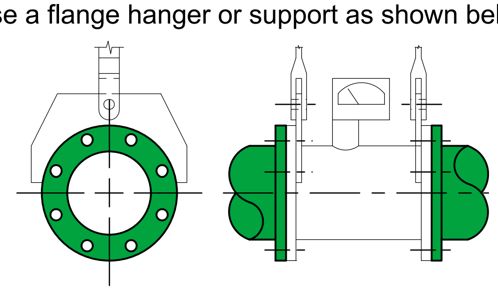
Anchors and Guides

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

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 = ¼ Dia.
  - Saddle width = $^{1}/_{3}$ Dia.
  - Contact Ershigs for saddle width design.

- Maximum deflection = span / 360.
- Simple support conditions.
- 180° 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.

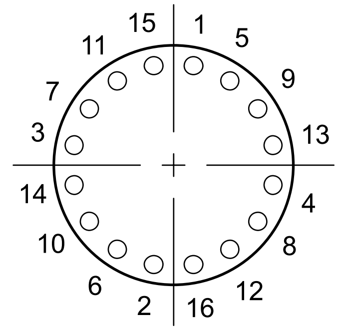
Section 7: Installation

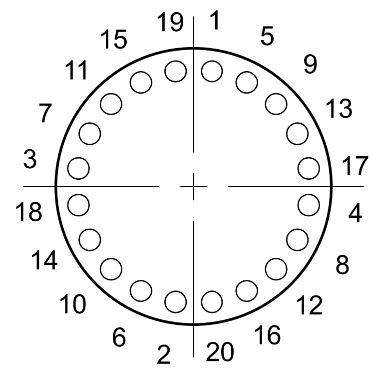
Bolt Torque

Maximum Bolt Torque for Pressure Piping

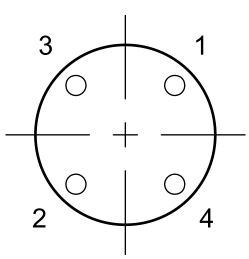
Bolt Size In.	Torque Ft - lb
½	15
⅝	25
¾	40
⅞	65
1	100
1 ⅛	140
1 ¼	200
1 ½	320
1 ¾	600
2	880

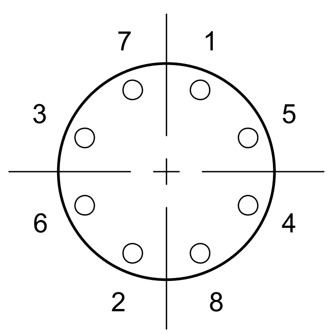
Torques result in a bolt stress of 12,000 psi.
ANSI Type B Regular Series washers are recommended.
Threads & bearing surfaces are to be well lubricated.

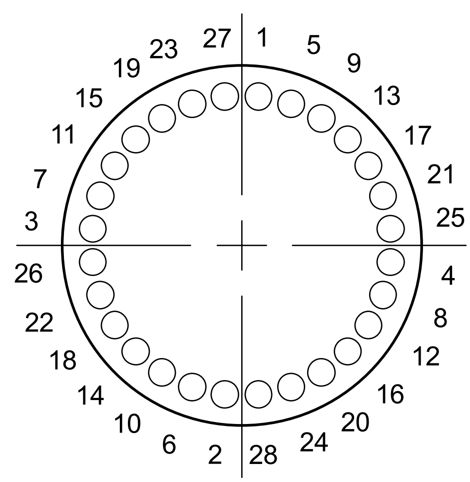


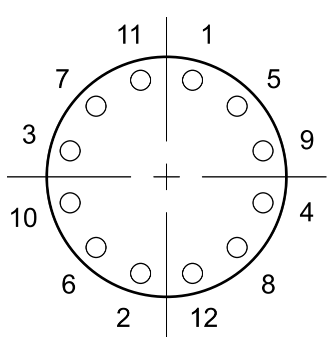


Bolt Tightening Sequence









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 torque is reached.

Maximum torque is not required for low pressure systems.

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 ± ⅛ in. for size 10 in. and under, ± $^{3}/_{16}$ in. for sizes 12 in. through 24 in., and ± ¼ in. for sizes 26 in. through 36. in.

Linear tolerances on "A" for sizes over 36 in. are subject to tolerances of ± ¼ 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.)

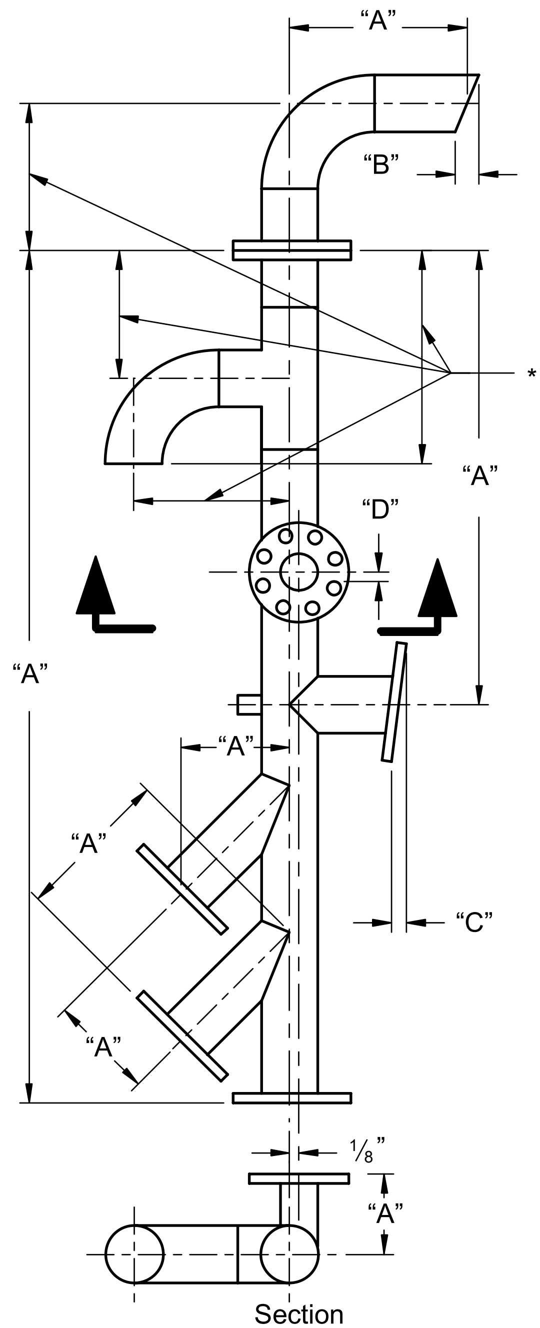
Squareness Tolerance

Squareness of end cuts, "B", shall not deviate more than ± ⅛ 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.



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