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SYSTEM COMPOSITION

Dual Tech is a composite, or dual laminate, piping system consisting of Polypropylene (PP), PVDF, PFA, CPVC or a PVC liner that is strengthened with a fiber glass reinforced thermoset resin system.

Thermoplastics, particularly Polypropylene (PP) and Polyvinylidiene Fluoride (PVDF), have excellent chemical resistance to most process chemicals and wastes. However, they suffer a significant loss of physical properties (tensile strength, beam strength, etc.) when subjected to elevated temperature applications. FRP systems possess physical properties which far exceed thermoplastics but are decidedly inferior to thermoplastic's chemical resistance.

The objective of the Dual Tech System is to achieve a reliable and effective combination of these dissimilar plastic materials that enhances the performance of each component while minimizing the individual weaknesses. By successfully bonding the FRP Laminate onto the thermoplastic liner Simtech has created a piping product with capabilities which far exceed the potential of either piping component.

*DUAL TECH PP- Reinforced Polypropylene Piping: 1" - 16"**

*DUAL TECH VF - Reinforced Polyvinylidiene Fluoride Piping: 1" - 16"**

*DUAL TECH PF - Reinforced PFA Piping: 1" - 16"**

*DUAL TECH PV - Reinforced PVC Piping: 1" - 16"**

*DUAL TECH CV - Reinforced CPVC Piping: 1" - 16"**

*LARGER SIZES AVAILABLE ON REQUEST.

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DUAL TECH PIPE LINERS

POLYVINYLIDIENE FLUORIDE (PVDF) -
The PVDF liner used in Dual Tech is extruded (seamless) from natural unpigmented 100% pure Polyvinylidiene Fluoride polymer. There are no additives or fillers which could be leached from the liner to contaminate the media. After extrusion the liner is annealed to relieve inherent stresses caused by the extrusion process.

Chemical Compatibility - PVDF possesses outstanding resistance to most inorganic chemicals, acids, salts, aromatic and aliphatic hydrocarbons, halogens, organic acids and alcohols.

PVDF is not suitable for certain polar solvents, hot concentrated alkalies, fuming sulfuric, amines or pyridine.

Consult our Chemical Resistance Guide for specific applications.

Temperature Range - PVDF can be subjected to continuous operating temperatures as high as 280^{0}F.

Permeability - PVDF has one of the lowest permeation coefficients of all the fluorocarbon resins. It is particularly superior to PTFE and FEP.

See page 6 & 7 of our Chemical Resistance Guide for further information.

POLYPROPYLENE (PP) -
The PP liner used in Dual Tech is, in fact, 150 psi rated through 2" diameter and 90 psi rated 2 1/2" - 12" diameter. The liner is seamless, extruded and stress relieved. Produced from Isotatic Homopolymer the material has temperature stabilizers added to provide enhanced resistance to aggressive media at elevated temperatures.

Chemical Compatibility - Polypropylene is particularly suited for handling dilute acids, some strong acids, alkalie and organic solvents. PP should not be used for halogens, halogenated hydrocarbons, aromatics or highly concentrated oxidizing acids.

Consult our Chemical Resistance Guide for specific applications.

Temperature Range - Polypropylene can be subjected to continuous operating temperatures as high as 210^{0}F.

Permeability - When compared to PVC and other more amorphous thermoplastics, polypropylene possesses a relatively high gas permeation coefficient. It is important to incorporate thick liners in PP lined composite systems. Any increase in the thickness produces a reduction in permeability disproportionately greater than the increase in thickness.

DUAL TECH FITTING LINERS

The fitting liners used in Dual Tech PP and VF are injection molded fittings fully pressure rated before reinforcement.

PP Fitting Liner

1" - 2"	Rated at 150 psig @ 68^{0}F
2 1/2" - 12"	Rated at 90 psig @ 68^{0}F

PVDF Fitting Liner

1" - 4"	Rated at 232 psig @ 68^{0}F
6" - 12"	Rated at 150 psig @ 68^{0}F

Fittings after reinforcement are rated:

PP	Rated at 150 psig @ 200^{0}F
PVDF	Rated at 150 psig @ 250^{0}F*

As a consequence of this design feature, reliability in vacuum service is assured.

* *Limitation to only 250^{0}F is due to the thermosetting resin temperature limits.*

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RESIN SYSTEM

The standard resin system employed in the manufacture of Dual Tech is Dow Chemical Company's Derakane 470 Vinylester Resin with UV inhibitors. Derakane 470 provides broader chemical compatibility than other vinylesters and a continuous operating temperature range of 250^0F.

LAMINATE INTERFACE

The surface of the liners are prepared in proprietary processes which provide significant lap shear strength between the liner and the FRP laminate. This is essential to maximizing system service life.

LINER BEHAVIOR

The effects of temperature change play an important role in the life expectancy of the liner in any lined pipe system. This is particularly true in lined steel systems where the liner cannot be effectively bonded or laminated to the steel jacket. As the temperature in the system increases, the liner material wants to expand but cannot because it is totally enclosed by the steel jacket. Consequently the material goes into compression. When the temperature returns to ambient the compressive stress reverts to tensile stress. Each succeeding thermal cycle will result in slightly less compressive stress when the pipe returns to operating temperature and slightly more tensile stress when the pipe returns to ambient (See Figure A). Eventually the material will see only tensile stress due to shrinkage induced by thermal cycling. When the liner reaches this condition all the stresses will be concentrated in the area where the liner has been heated and flared to form the flange face.

In Dual Laminate FRP Pipe Systems the liner will behave in the same manner as with lined steel except that it is possible to create a bond between the liner and the FRP overwrap. (Caution is advised with Dual Laminate pipe because many fabricators do not or cannot create a satisfactory bond between the liner and the structural FRP overwrap.) If a satisfactory bond is achieved the liner will be restrained in a manner which prevents dimensional change until the liner eventually delaminates. Annealing the liner greatly increases the time required for delamination to occur. If delamination should occur, the use of molded fitting liners becomes critical to the continued system integrity.

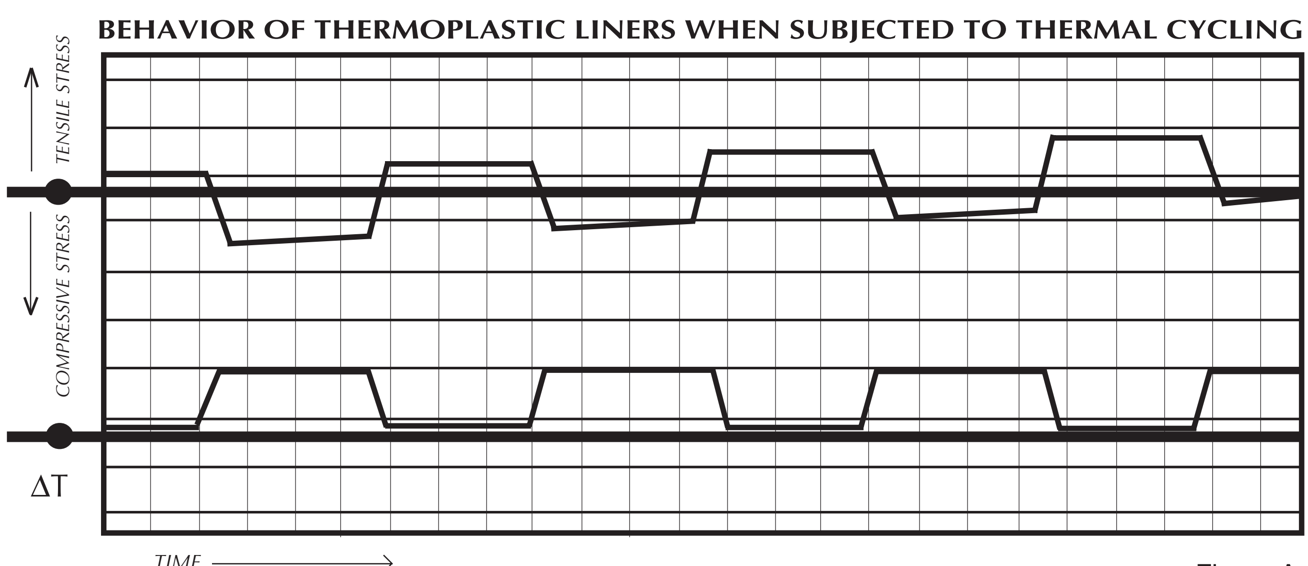

Figure A

PIPE PHYSICAL PROPERTIES

Note: Dual Tech is structurally reinforced (FRP) thermoplastic piping material. The mechanical properties of the thermoplastic liner are customarily ignored when considering the performance capabilities of a dual laminate material. The values shown below are representative of the filament wound structural reinforcing applied to the OD of the pipe. Those values are not representative of the potential of Dual Tech as a System. Reinforcement of Dual Tech fittings and field joints is performed by contact molding in accordance with NBS-PS-15-69. (Typical Properties are not to be interpreted as specifications.)

Table 2: Typical Properties - Pipe	
Tensile - Longitudinal [Accordance with ASTM D2105 (psi)]	7,000 @ 70^0F 4,000 @ 200^0F
Modulus Of Elasticity (10^6 psi) [Accordance with ASTM D2105]	1.4 @ 70^0F 0.60 @ 200^0F
Poisson's Ratio	0.35 @ 70^0F 0.72 @ 200^0F
Hydro-Burst (10^3 psi) [Accordance with ASTM D1599]	44 @ 70^0F 32.1 @ 200^0F
Thermal Expansion [Accordance with ASTM D696]	1.05 x 10^{-5} in / in / ^{0}F
Thermal Conductivity	1.3 BTU / FT^2 / hr / ^{0}F / inch
Flow Coefficient: Hazen-Williams Method	C = 150

Table 3: Typical Properties of Contact Molded Laminate[1] with Derakane 470-36	
Tensile Stress	18,800 psi @ 250^0F
Fluxural Stress	24,100 psi @ 250^0F
Fluxural Modulus	10.6 x 10^5 psi @ 250^0F

[1] Based on 1/4" Laminate w/40% glass content (constructed: V / M / M / WR / M / WR / M).

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SYSTEM PRESSURE RATING

Both Dual Tech PP and Dual Tech VF Systems will require flanges for joining to pumps, tanks valves or other equipment. Only ANSI 150 lb. flanges are available with Dual Tech. Consequently Dual Tech is limited to 150 psig service at the corresponding maximum allowable operating temperature.

Note: The hoop stress rating of the liner is not included in calculations to determine thickness of winding necessary to obtain pressure rating.

Table 4: System Pressure Rating

Nominal Pipe Size	Internal (psig) Pressure Rating @ 200°F PP	280°F PVDF*	Max Allowable External Pressure (psig)	Nominal O.D.+ PP & PVDF	Nominal Weight per foot in lbs. PP	PVDF	Standard Lengths Plain End (ft)
1	150	150	250	1.50	.4	.5	16.4
1 1/2	150	150	230	2.21	.85	.9	16.4
2	150	150	200	2.72	1.4	1.6	16.4
2 1/2	150	150	140	3.19	1.8	2.0	16.4
3	150	150	75	3.78	2.4	2.4	16.4
4	150	150	40	4.65	2.9	3.2	16.4
6	150	150	32	6.70	5.6	5.5	16.4
8	150	150	27	8.36	9.0	8.5	16.4
10	150	150	20	10.33	15.2	14.0	16.4
12	150	150	19	12.96	21.5	20.0	16.4

* PVDF can be used as high as 280°F continuous operating temperatures. Thermal cycled systems should not exceed 210°F.

+ Dimensions may vary slightly due to thickness of resin rich coating.

FLOW CHARACTERISTICS

The surface finish on the ID of Dual Tech PP and Dual Tech VF is considerably smoother than the bore of steel pipe. In addition, since these materials are not subject to corrosion the coefficient of friction does not deteriorate with time and exposure as with steel pipe.

Coefficient of Friction Dual Tech Piping

Hazen-Williams Method: C = 150

Pressure loss for Dual Tech PP is shown in Table 5: Chart PL-1 and Dual Tech VF is shown in Table 6: Chart PL-2. Table 7: Chart PL-3 provides equivalent footage to be added for fittings.

Table 5: PL-1 Pressure Loss for Dual Tech PP Pipe

V = Velocity of water in ft/s; P = Pressure drop in psi/100 ft of pipe based upon the Hazen-Williams method : C = 150.

Flow	1	1	1 1/4	1 1/4	1 1/2	1 1/2	2	2	2 1/2	2 1/2	3	3	4	4	6	6	8	8	10	10	12	12	14	14	16	16	18	18
Rate gpm	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p
1	0.39	0.04	0.24	0.01																								
2	0.78	0.14	0.49	0.04	0.32	0.02																						
5	1.95	0.75	1.22	0.24	0.79	0.08	0.5	0.3	0.35	0.01	0.24	0.01																
7	2.72	1.39	1.71	0.45	1.11	0.16	0.7	0.05	0.49	0.02	0.34	0.02																
10	3.89	2.7	2.45	0.87	1.58	0.3	1	0.1	0.7	0.04	0.49	0.03																
15	5.84	5.72	3.67	1.85	2.37	0.64	1.49	0.21	1.05	0.09	0.73	0.06	0.49	0.01														
20	7.78	9.74	4.9	3.15	3.16	1.09	1.99	0.36	1.41	0.15	0.97	0.1	0.65	0.02														
25	9.73	14.72	6.12	4.77	3.95	1.64	2.49	0.54	1.76	0.23	1.22	0.13	0.81	0.03														
30	11.7	20.63	7.34	6.68	4.74	2.3	2.99	0.75	2.11	0.32	1.46	0.17	0.98	0.05														
35			8.57	8.89	5.53	3.07	3.49	1	2.46	0.43	1.7	0.23	1.14	0.06	0.54	0.01												
40			9.79	11.38	6.32	3.92	3.98	1.27	2.81	0.55	1.94	0.28	1.3	0.08	0.62	0.02												
45			11	14.16	7.11	4.88	4.48	1.59	3.16	0.68	2.19	0.34	1.46	0.1	0.69	0.02												
50					7.9	5.93	4.98	1.93	3.52	0.83	2.43	0.47	1.63	0.13	0.77	0.03												
60					9.48	8.31	5.98	2.71	4.22	1.16	2.92	0.63	1.95	0.18	0.92	0.03	0.59	0.01										
70					11.1	11.1	6.97	3.6	4.92	1.54	3.4	0.81	2.28	0.24	1.08	0.04	0.69	0.02										
80							7.97	4.61	5.62	1.97	3.89	1	2.6	0.3	1.23	0.05	0.79	0.02										
90							8.96	5.73	6.33	2.46	4.38	1.22	2.93	0.38	1.39	0.06	0.89	0.03										
100							9.96	6.97	7.03	2.99	4.86	1.84	3.25	0.46	1.54	0.07	0.98	0.03										
125							12.5	10.5	8.79	4.52	6.08	2.56	4.06	0.69	1.92	0.11	1.23	0.04	0.79	0.01								
150									10.6	6.33	7.29	3.43	4.88	0.07	2.31	0.16	1.48	0.05	0.95	0.02								
175											8.51	4.39	5.69	1.29	2.69	0.21	1.72	0.07	1.1	0.02								
200											9.72	6.64	6.5	1.65	3.08	0.27	1.97	0.09	1.26	0.03								
250											12.2	9.31	8.13	2.49	3.85	0.4	2.46	0.13	1.58	0.05	099	0.01						
300													9.75	3.5	4.62	0.57	2.95	0.19	1.89	0.06	1.19	0.02	0.94	0.01				
350													11.4	4.64	5.39	0.75	3.44	0.26	2.21	0.09	1.39	0.03	1.09	0.02				
400															6.16	0.97	3.94	0.32	2.52	0.11	1.59	0.03	1.25	0.02				
450															6.93	1.2	4.43	0.4	2.84	0.14	1.78	0.04	1.4	0.03	1.11	0.01		
500															7.69	1.46	4.92	0.49	3.15	.16	1.98	0.05	1.56	0.03	1.23	0.02		
600															9.23	2.04	5.9	0.69	3.78	0.23	2.38	0.07	1.87	0.04	1.48	0.02	1.17	0.01
700															10.8	2.72	6.89	0.92	4.41	0.31	2.78	0.1	2.19	0.06	1.72	0.03	1.36	0.02
800																	7.87	1.17	5.04	0.4	3.17	0.13	2.5	0.07	1.97	0.04	1.55	0.02
900																	8.85	1.46	5.67	0.49	3.57	0.16	2.81	0.09	2.21	0.05	1.75	0.03
1000																	9.84	1.78	6.3	0.6	3.97	0.19	3.12	0.11	2.46	0.06	1.94	0.03
2000																			12.6	2.17	7.93	0.7	6.24	0.39	4.92	0.22	3.89	0.13
2500																					9.92	1.07	7.8	0.59	6.15	0.33	4.86	0.19
5000																									12.3	1.2	9.72	0.68
7500																											14.6	1.43

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Table 6: PL-2 Pressure Loss for Dual Tech VF Pipe

V = Velocity of water in ft/s; P = Pressure drop in psi/100 ft of pipe based upon the Hazen-Williams method : C = 150.

Flow	1	1	1 1/4	1 1/4	1 1/2	1 1/2	2	2	2 1/2	2 1/2	3	3	4	4	6	6	8	8	10	10	12	12
Rate gpm	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p	v	p
1	0.36	0.03	0.21	0.01																		
2	0.71	0.11	0.42	0.03	0.27	0.01																
5	1.78	0.06	1.06	0.17	0.67	0.06	0.41	0.02														
7	2.49	1.11	1.49	0.32	0.94	0.1	0.57	0.03	0.38	0.01												
10	.355	2.16	2.12	0.62	1.35	0.2	0.81	0.06	0.54	0.02												
15	5.33	4.57	3.19	1.31	2.02	0.43	1.22	0.13	0.81	0.05	0.4	0.1										
20	7.1	7.79	4.25	2.24	2.69	0.74	1.62	0.21	1.07	0.08	0.6	0.02										
25	8.88	11.8	5.31	3.37	3.37	1.11	2.03	0.32	1.34	0.12	0.79	0.04	0.5	0.01								
30	10.7	16.5	6.37	4.73	4.04	1.46	2.43	0.45	1.61	0.17	0.99	0.06	0.62	0.02								
35			7.43	6.3	4.71	2.08	2.84	0.6	1.88	0.22	1.19	0.08	0.74	0.03								
40			8.5	8.06	5.38	2.66	3.24	0.78	2.15	0.29	1.39	0.11	0.87	0.03								
45			9.56	10	6.06	3.31	3.65	0.96	2.42	0.36	1.59	0.14	0.99	0.04								
50			10.62	12.2	6.73	4.02	4.05	1.17	2.69	0.43	1.79	0.17	1.12	0.05	0.59	0.01						
60					8.08	5.63	4.86	1.64	3.22	0.6	1.99	0.21	1.24	0.06	0.7	0.02						
70					9.42	7.49	5.67	2.18	3.76	0.8	2.38	0.29	1.49	0.09	0.82	0.02						
80					10.8	9.6	6.48	2.79	4.3	1.03	2.78	0.39	1.74	0.12	0.94	0.03						
90							7.29	3.47	4.83	1.28	3.18	0.19	1.99	0.16	1.05	0.03						
100							8.1	4.22	5.37	1.55	3.57	0.61	2.23	0.19	1.17	0.04	0.75	0.01				
125							10.31	6.38	6.71	2.35	4.96	0.74	2.48	0.24	1.46	0.06	0.93	0.02				
150									8.06	3.29	5.96	1.13	3.1	0.36	1.76	0.08	1.12	0.03				
175									9.4	4.37	6.95	1.58	3.72	0.05	2.05	0.01	1.31	0.03	0.96	0.01		
200									10.7	5.6	7.94	2.1	4.34	0.85	2.34	0.14	1.5	0.04	1.2	0.02		
250											11.9	9.06	6.2	1.81	2.39	0.21	1.87	0.07	1.44	0.03		
300													7.44	2.41	3.51	0.29	2.24	0.1	1.68	0.04		
350													9.93	3.09	4.1	0.39	2.62	0.13	1.92	0.06	1.06	0.01
400													11.2	3.84	4.68	0.49	2.99	0.16	2.16	0.07	1.21	0.02
450														4.67	5.27	0.61	3.37	0.2	2.4	0.08	1.36	0.02
500															5.85	0.75	3.74	0.25	2.87	0.12	1.51	0.03
600															7.02	1.05	4.49	0.35	3.35	0.16	1.81	0.03
700															8.19	1.4	5.24	0.47	3.83	0.02	2.11	0.05
800															9.36	1.79	5.98	0.6	4.31	0.26	2.41	0.06
900															10.5	2.23	6.73	0.75	4.79	0.31	2.71	0.08
1000																	7.48	0.91	9.58	1.11	3.02	0.1
2000																	15	3.29	12	1.68	6.03	0.36
2500																					7.54	0.55
5000																					15.1	1.97

Table 7: PL3 Pressure Drop for Fittings in Equivalent Feet of Pipe

Fitting	Nominal Size									
	1	1 1/2	2	2 1/2	3	4	6	8	10	12
90^0 EL	2.75	4.25	5.5	7	8	11	16	20	25	32
45^0 EL	1.25	2	2.5	3	3.8	5	7.5	10	12.5	15
TEE	6	8	12	14	17	21	34	44	55	58

WATER HAMMER

Shock waves or pressure surges commonly referred to as water hammer are caused by rapid or abrupt change in fluid velocity within the pipe system. In some cases the surges can attain a magnitude sufficient to damage the system. The amount of surge experienced is dependant upon the modulus of the pipe material, the density and velocity of the fluid, the line length and the speed at which flow is stopped or started.

Dual Tech pipe is capable of withstanding surges many times its rated pressure, however, it is recommended that the source of hammer be eliminated or reduced in order to insure long term system integrity.

Avoid:

- Valves that close or open instantly
- Starting pumps into empty discharge lines unless a slow opening valve is used to gradually increase flow
- Slow closing check valves

It may also be advisable to employ feedback loops or surge suppressors to eliminate hammer.

SUPPORTING DUAL TECH

Table 8A shows the recommended support spacing for Dual Tech Pipe. Adjustment factors for operating temperature and specific gravity of the media are indicated in 8B and 8C respectively. Multiply Factor 8A by the appropriate factor shown in 8B and then multiply the result by the correction factor in 8C to obtain the recommended support spacing.

Table 8: Recommended Support Spacing

Table 8A

Nominal Size	Span @ 70^{0}F *
1	7.6
1 1/2	9.9
2	11
2 1/2	11.5
3	12.5
4	13.7
6	16.7
8	17
10	17
12	19

Table 8B

Max. Oper. Temp. ^{0}F	Factor
100	.95
125	.90
150	.85
175	.75
200	.65
210	.62
250	.40

Table 8C

Specific Gravity	Factor
.90	1.02
1.00	1.00
1.10	.98
1.25	.95
1.50	.91

* Maximum deflection at Midspan = .5 inches
* Interior (continuous) spans can be increased by 20%

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HANGERS AND SUPPORTS

Most standard pipe supports or hangers are satisfactory for supporting Dual Tech. The most important consideration is that 'point' loading be avoided. Saddles must be used to cradle the pipe in the hanger or support. Saddles should encompass a 120^0 - 180^0 arc on the bottom of the pipe and the length of the saddle should be at least equal to the diameter of the pipe being supported. Saddles can be made of galvanized sheet metal (12 ga.) or from half sections of plastic pipe of a suitable wall thickness.

Figure B: Hanger with Support Saddle Detail

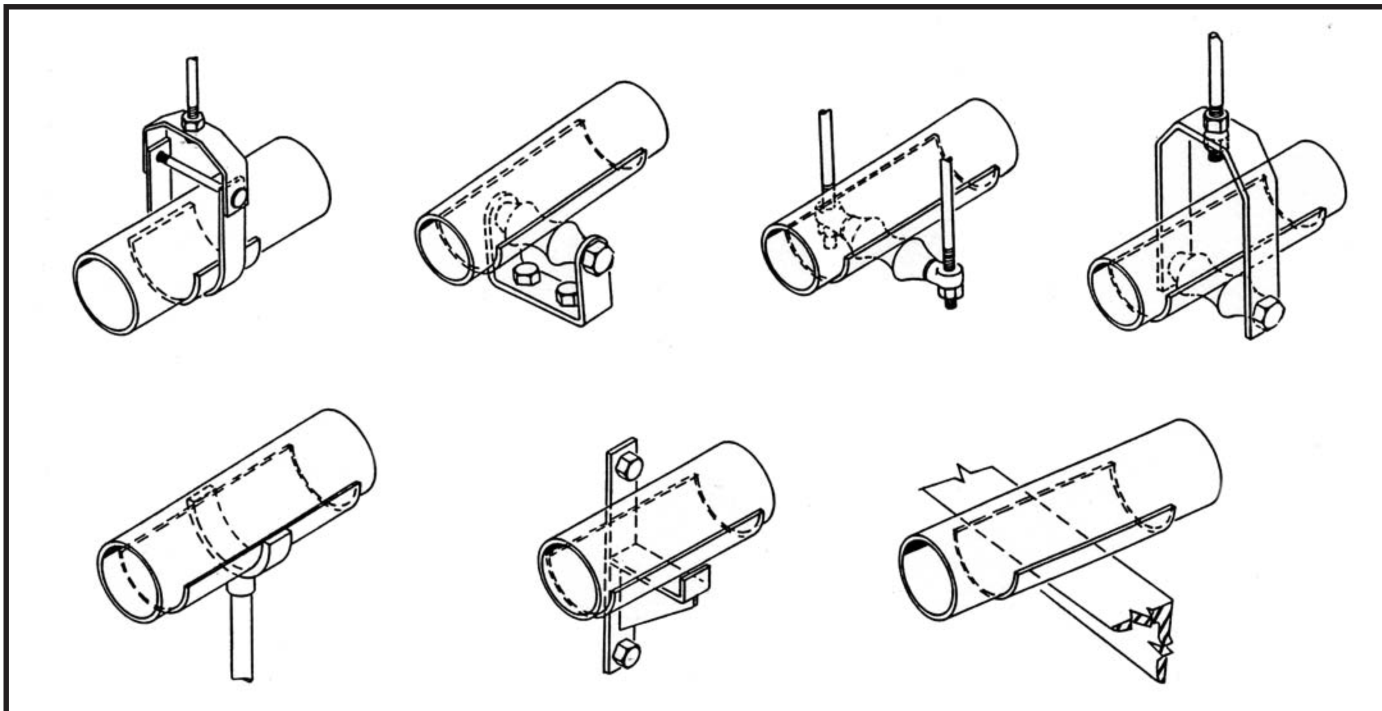
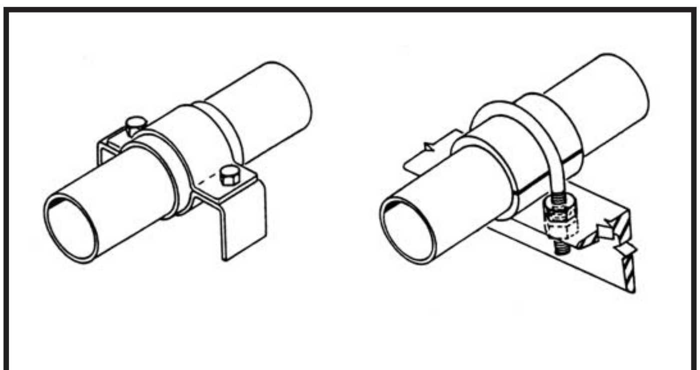
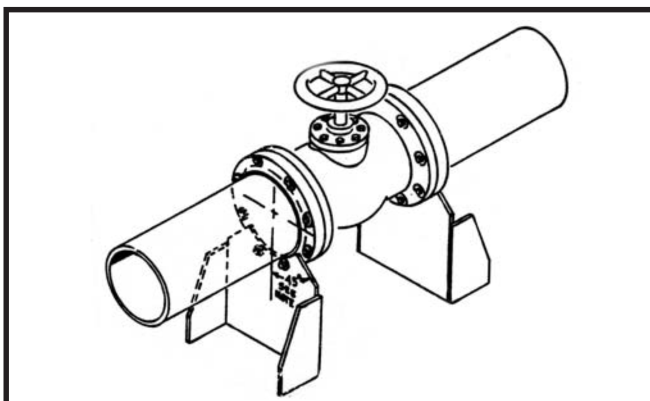


Figure C: Typical Guide Arrangement



(LOOSE ENOUGH TO ALLOW AXIAL MOVEMENT)

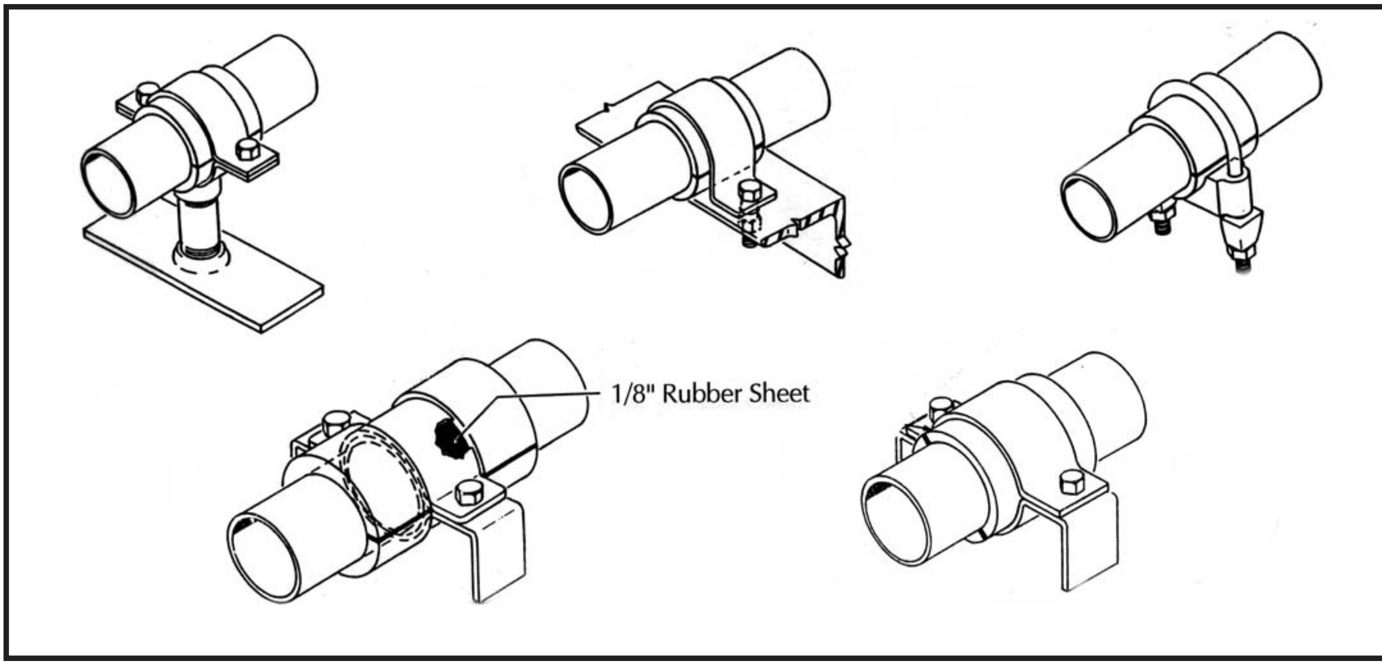
Figure D: Typical Valve Support & Anchor



ANCHORS AND GUIDES

Anchors must be designed to withstand the pressure and thermally induced endloads that will be produced by the pipe elements (see Table 10 & Table 11). Support saddles should be used at the top and bottom of the pipe within the anchor clamp or "U" bolt. 1/8" thick rubber sheeting should be used between the pipe OD and the support saddles to prevent damage to the pipe and to provide a positive grip on the pipe.

Figure E: Typical Anchors



THERMAL EXPANSION AND CONTRACTION

When subjected to temperature change Dual Tech will experience nearly twice the dimensional change of steel. Dimensional change will be the same for both Dual Tech PP and Dual Tech PVDF. This is because the thermoplastic liner pipe, which has an expansion coefficient 10 times that of FRP, is in fact limited to the dimensional change of the FRP reinforcement. Table 9 indicates Thermal Expansion/Contraction per 100 ft of pipe which will occur at various temperature changes.

Table 9: Thermal Expansion/Contraction per 100 ft of Pipe (Inches)

ΔT	10	20	30	40	50	60	70	80	90	100	200
ΔL	.12	.25	.33	.50	.62	.75	.88	1.01	1.13	1.26	2.52

Note: Pressure induced dimensional change does occur however the change is not significant enough to effect design. Pressure induced axial end load is sufficient to effect design and is addressed later. (See Table 11 on the following page.)

Dimensional change can be handled in one or more of several methods:

- Flexible design & installation employing directional changes to accommodate expansion or contraction,
- Employ expansion loops to create directional changes,
- Use mechanical expansion joints,
- Design and install a restrained system using anchors and guides,
- Use combinations of the above, as dictated by system layout.

End load values for expansion or contraction are the same. When designing restraints and anchors for expansion endload add the values shown in Table 10 and Table 11 to determine total endload.

Table 10: Thermal Endloads Due to Temperature Change

Nominal Size	Δ T (^{0}F)								
	20	40	60	80	100	120	140	180	200
1"	108	217	327	436	544	653	762	980	1088
1 1/2"	166	331	497	662	828	993	1159	1490	1655
2"	175	350	525	700	875	1050	1225	1575	1750
3"	296	524	785	1045	1308	1570	1832	2355	2617
4"	388	775	1161	1548	1935	2322	2709	3483	3870
6"	869	1739	2607	3475	4345	5214	6082	7821	8690
8"	1331	2662	3991	5322	6653	7984	9314	11976	13307
10"	1800	3601	5402	7203	9003	10804	12604	16206	18007
12"	3143	6288	9432	12578	15721	18865	22010	28299	31443

When designing to accommodate contraction due to low operating temperature and where the ΔT exceeds 100^{0}F, do not install a restrained system. Use changes of direction, loops and/or expansion joints to compensate for dimensional change.

Table 11: Axial Endload Due to 100 psi Internal Pressure in a Restrained System

Nom Ø	1	1 1/2	2	3	4	6	8	10	12
lb_f	68	120	160	400	650	1500	2500	4000	5600

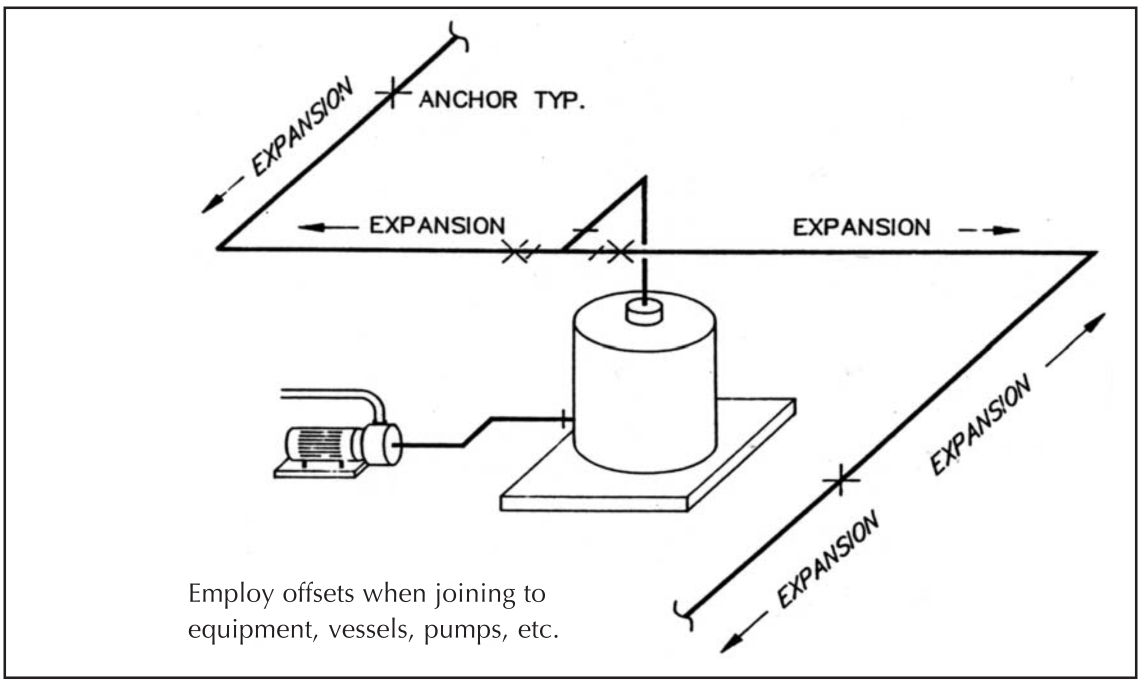
FLEXIBLE INSTALLATION

Often plant piping will consist of a complex arrangement where there are numerous changes of direction. These bends can be employed to compensate for small changes in length due to expansion and/or contraction of straight elements of the system. It may be necessary to add expansion loops within longer runs in order to absorb the greater dimensional change that occurrs in long straight runs.

Generally loops are going to be slightly more expensive than expanison joints and will require quite a bit of room. However, loops will allow you to minimize the number of flanges in the system as well as the maintainence those flanges will require.

Selection of anchor points in a flexible system is critical to ensure that expansion/contraction is accommodated by the correct piping elements. Normally anchors should be located at neutral points or at elements where movement must not be permitted (See Figure F).

Figure F: Anchor Location



Typical Flexible Arrangement

- Support spacing per Table 8
- Allow pipe to move axially in supports
- Clamp pipe at anchors to control direction of expansion

The amount of movement that can be accommodated by changes of direction is exhibited in Table 12 and is determined by pipe diameter and length of offset (A).

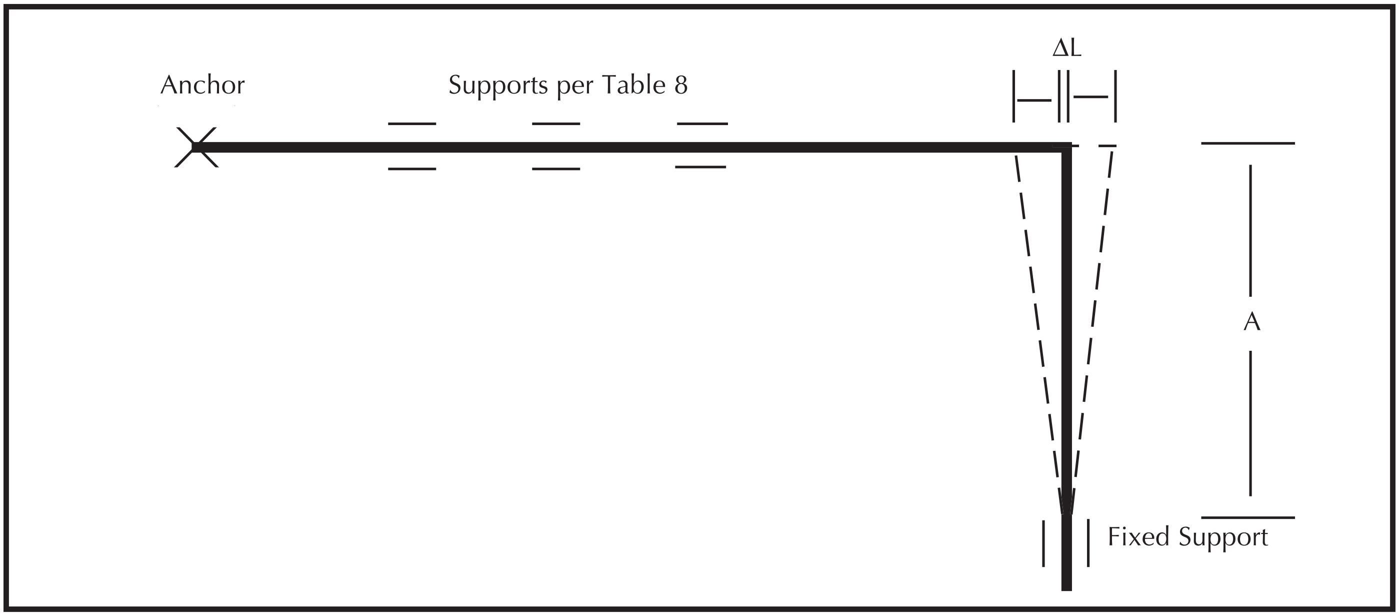


Table 12: Length "A" Required Offset in Feet

Pipe Ø	Change in Length (ΔL in inches)									
	0.25	.5	1	2	3	4	5	6	7	8
1	3.0	4.5	6.5	9.0	11	12	13	14	16	17
1 1/2	3.0	5	7	9.5	11.5	13	14.5	16.5	18	19
2	3.5	5	7	10	12	14	16	18	20	22
3	4.5	6	8	11	13	15.5	17	19	21	23
4	5	7	9	12	14.5	17.5	19	21	23	25.5
6	6	8	12	16	19	22	25	28	30	33
8	7	9.5	13	18	22	26	29	32	34	35.5
10	8	11	15	21	25	29	32	35	37	40
12	10	12	17	24	29	34	37	41	45	50

Note: One or more moveable supports may be required for offset A if the length of A exceeds the support spacing outlined in Table 8.

EXPANSION LOOPS

Often long straight runs will develop more dimensional change than can be accommodated by direction changes. When this occurs it will be necessary to design expanion loops or expansion joints into the system. The number of loops and dimensions of the offset legs will depend on pipe diameter, the amount of expansion to be absorbed and space available.

Figure G illustrates a typical loop arrangement. Dimensions for legs A are shown in Table 13. Loops can be installed either vertically or horizontally (leg B on the same elevation as the pipe). Horizontal installation is the most desirable if room permits.

Guide spacing required at the entrance and exit of the loop are shown in Table 14.

Figure G

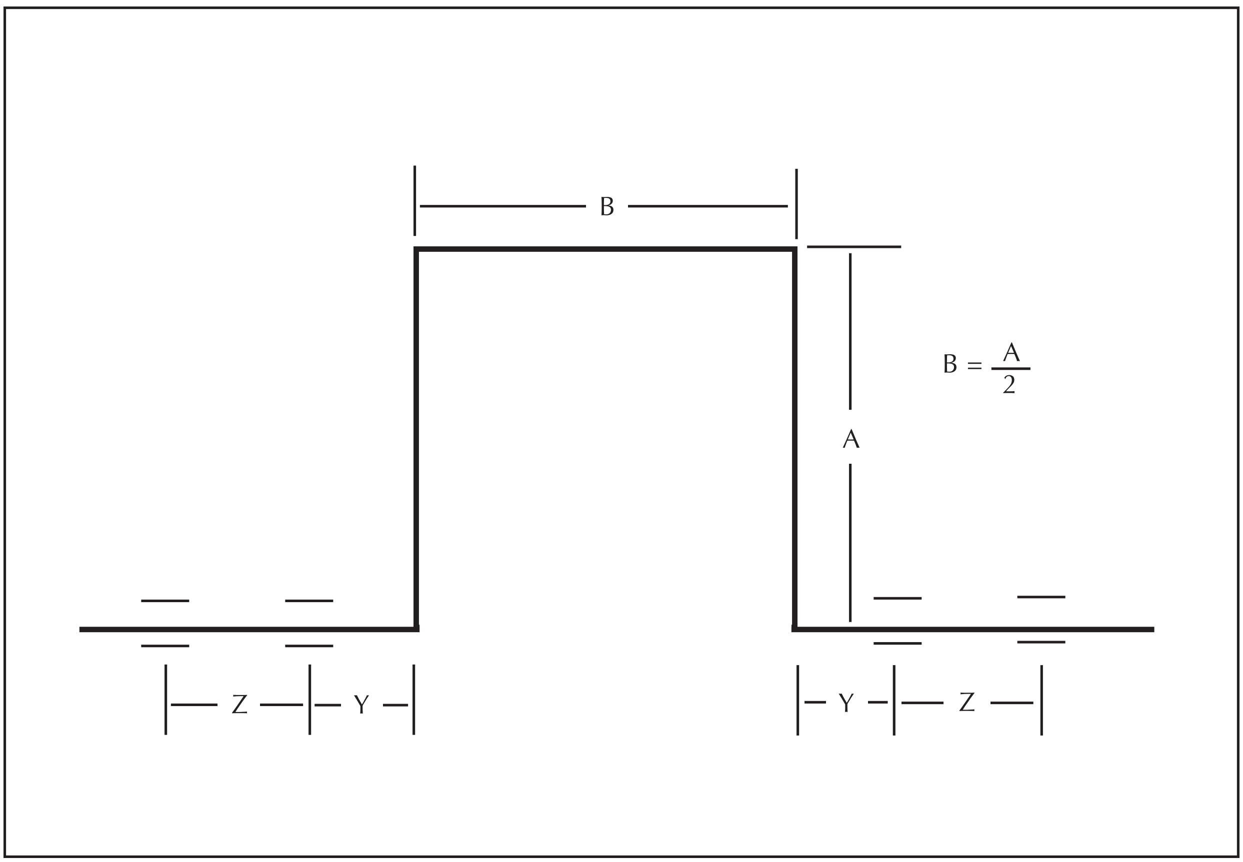


Table 13: Expansion Loop Design - Length of Leg "A" (Feet)

Pipe Ø	Change in Length ΔL (inches)											
	0.25	0.5	1	2	3	4	5	6	7	8	9	10
1	2.5	3.5	5	6	7	9	10	11	12	13	14	15
1 1/2	2.5	3.5	5	6.5	8	10	11	12	13	14	15	16.5
2	3.0	4.0	6	7.5	9	11	12.5	14	15	16	17	18
3	3.5	5.0	7.5	9.5	11.5	13	14.5	16	17.5	19	21	23
4	4	5.5	8	10.5	13	15	17	18	20	21	22.5	25
6	5	6.5	9	12	14.5	18	20	22	25	26	28	29
8	6	8	10	13	16	20	22	24	27	29.5	31.5	34
10	6.5	9	11	15	19.5	23	26	30	32	33.5	35	38
12	7	9.5	12.5	16.5	22	26	29	33	36	37.5	39	41

Table 14: Guide Spacing at Loop or Expansion Joint Entrance and Exit (Feet)

Dim. (Feet)	Pipe Ø								
	1	1 1/2	2	3	4	6	8	10	12
Y	.3	.5	.6	1	1.3	2	2.6	3.3	4
Z	1.1	1.7	2.3	3.5	4.6	7	9.3	11.6	14

Guide must be loose enough to allow axial movement but must not allow lateral movement.

EXPANSION JOINTS

The use of expansion joints to compensate for dimensional change is a relatively simple straight-forward solution to the problems resulting from expansion and/or contraction of the piping components. There are certain aspects of selection and installation which must be considered when employing expansion joints.

1. Bellows Type expansion joints are preferred because they require relatively low activation forces to initiate movement. The end load required to compress and/or extend the expansion joint must be lower than the end load values shown in Table 10.

2. Guides allowing axial movement must be utilized on the pipe at the entrance to the expansion joint in accordance with Table 14.

3. The remainder of the guides must allow axial movement and should be spaced in accordance with Table 15 (Guide Spacing for Restrained Piping) or Table 8 (Support Spacing) whichever is smaller.

4. Expansion joints must be installed at an appropriate mid-travel position taking into consideration the anticipated expansion or contraction that will be experienced.

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RESTRAINED INSTALLATION

Space constraints or other factors may require installation of systems or portions of a system where the system is restrained and movement is prevented by anchoring. When restraining elements of a system consideration must be given to the following:

1. Anchors must be designed to withstand the end load introduced by compressive stress resulting from increased temperature (See Table 10).

2. Systems operating or subjected to temperatures lower than the temperature at time of installation will experience tensile stress with resultant tensile end load. Tensile end load must not exceed the Maximum Allowable Tensile Load Rating (See Table 16).

3. Thermally induced compressive stress may cause buckling unless the pipe is guided at proper intervals. Consult Table 15 for guide spacing. Compare spacing shown in Table 15 with support spacing shown in Table 8 and use the smaller value to determine guide spacing.

Table 15: Guide Spacing in Feet

Nom. Size	Temp. ^{0}F Increase 40	60	80	100	120	140	160	180	200
1	6.9	6	5.2	4.8	4.4	4	3.6	3.3	3
1 1/2	7.8	6.6	5.8	5.2	4.7	4.2	3.7	3.5	3.3
2	8.5	7	6.2	5.5	4.9	4.2	3.9	3.7	3.5
3	12.2	10.2	8.4	7.8	7.1	6.5	6.2	5.9	5.5
4	15	13	11	10	9.2	8.6	8.1	7.8	7.5
6	*Spacing shown in Table 8 will indicate closer spacing in these sizes.*								
8									
10									
12									

Table 16: Allowable Tensile Load (lbs.)

Oper. Temp.	Nominal Size 1	1 1/2	2	2 1/2	3	4	6	8	10	12
75^{0}F	675	980	1150	1470	1725	2450	4800	8500	11200	18560
200^{0}F	340	485	550	695	830	1200	2380	4220	5470	9140

JOINING PROCEDURE

Both Dual Tech PP and Dual Tech VF are joined with the same basic procedure. There are slight differences in the welding temperature and weld forces employed. (Refer to welding technique for detailed explanation.) Dual Tech Piping is a dual laminate (composite) material, consequently it is necessary to employ technique that is specific to the material being joined.

The internal liner in Dual Tech is thermoplastic and is joined by butt fusion welding which is the easiest and most reliable method existing. In this procedure the ends of the pipes to be joined are melted and then fused together producing a weld through the entire cross sectional area of the liner. This weld can be visually inspected to determine weld quality to a very high degree of certainty.

The structural reinforcement applied as the external laminate of Dual Tech is a fiberglass reinforced thermosetting resin system (FRP). After welding of the liner is complete then the FRP is applied over the joint area using standard hand lay-up procedures. Upon completion and proper curing the resultant joint will provide the full specified pressure rating with a 10 / 1 safety factor.

DUAL TECH TOOLS, EQUIPMENT AND SUPPLIES

While the joining of Dual Tech may be different than joining other material, the procedure is not difficult but it must be followed precisely. There are tools designed specifically for working with Dual Tech. The following is a complete list of Dual Tech specific tools. This list does not include all equipment and supplies that might be necessary for the installation. Cranes, cherry pickers, scaffolding, pipe stands and rollers, cut off saws, etc. are selected and supplied by the installer, as they would be for any piping project.

DUAL TECH TOOLS

CONSULT FACTORY

Other Tools Required

- Chop Saw or Cutoff Saw -
  Must be capable of square cuts for full size range of pipe being installed.
- Pipe Stands with Pipe Vise -
  Padding must be used with the pipe vise to prevent damaging the pipe.
- Disc or Vibratory Sander (small) -
  Required to prepare the surface of the FRP for hand lay-up. #16 or #24 sanding disc recommended.
- Hot Air Gun -
  Required when doing field joints (hand lay-up) at temperatures below 60^0F.
- Heavy duty shop type vacuum cleaner.

SAFETY EQUIPMENT INCLUDING BUT NOT NECESSARILY LIMITED TO:

- Goggles or protective eye wear and
- Rubber gloves for use when working with resin mixtures and hand lay-up procedures.
- Ventilation equipment may be required in confined or poorly vented spaces.

(See Industrial Health information on the following pages.)

CUTTING PIPE TO DIMENSION

Tools Required:

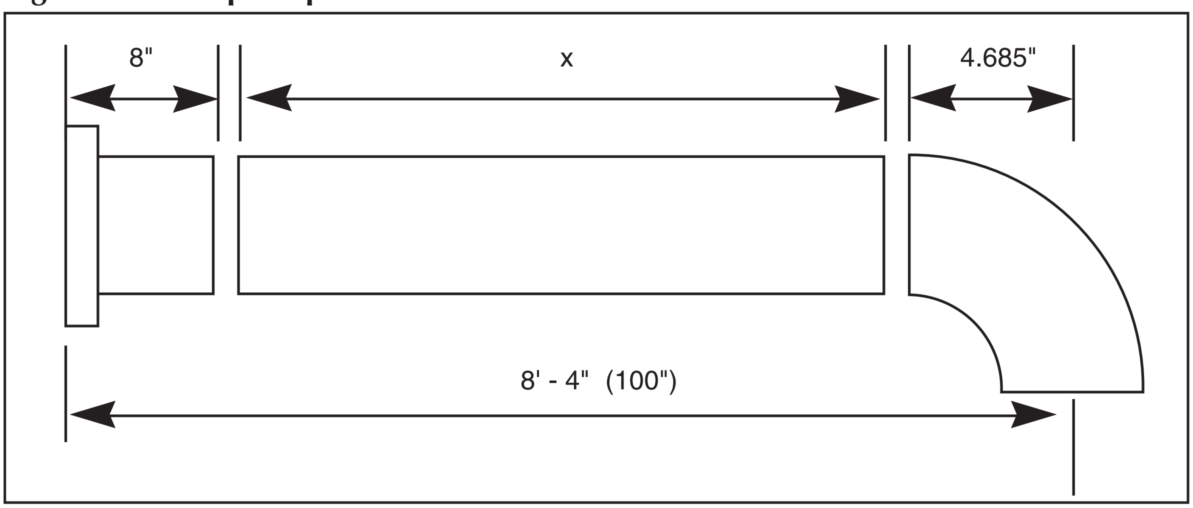
Tape Measure and Chop Saw or Cutoff Saw

An enormous amount of time will be saved if square cuts are made. This will avoid trimming and excessive planning of the pipe ends. Assuming you make square cuts you can cut pipe slightly longer than the desired finished dimension to allow for welds.

Allowance for dimensional loss due to welds:

1" - 3" Diameter	=	1/8" - 3/16" per weld
4" - 12" Diameter	=	3/16" - 1/4" per weld

Figure H: Example Pipe Section



Example:

A 4" diameter pipe with a 90^0 Elbow on one end, a flange on the other end and a required center to end dimension of 8'- 4".

4" 90^0 Elbow Center to End = 4.685" *
4" Stub End Over All Length = +8.000" *
12.685"

Required End to End Dimension = 100.000
-12.685
87.315 (or 87 5/16) = Finished pipe length

87 5/16" + 1/2" Weld Allowance = 87 13/16" Cut pipe to 87 13/16" to allow for both welds.

**See Appendix A for Dimensional Drawings.*

WELDING THE LINER

The Dual Tech liner pipe is welded using standard, well established, butt fusion welding technique as outlined in ASTM D2657-87. Dual Tech 1" - 6" diameters are welded using the PM160 welding tool and 8" - 12" are welded using the WR315 welding tool.

Pipe stands or supports will be required for this procedure. Stands or supports must be capable of supporting the sections to be welded while maintaining proper alignment so that angular deflection is avoided when making welds.

Both the PM160 and the WR315 are equipped with clamping rings which will hold the pipe in correct alignment during the welding procedure but the pipe must be properly aligned prior to clamping.

Clamping rings on one side of the tool are stationary (do not move) and these are used to clamp onto pipe in the run that has already been joined. Clamping rings on the other end of the tool are movable and clamp onto the section (length) being added. See Figure M below.

Procedures for Welding:

Note: When using the PM160 be sure clamping heads are aligned square to the long axis of the machine.

1. After properly adjusting stands or supports place pipe ends in clamping unit as shown with a minimum of 1/2" exposed on each side between the clamps.
2. Using the hand wheel or hydraulic unit, bring the pipe ends together until they touch. (If the pipe has been cut square the ends should butt together fairly flush.) Recheck pipe alignment to insure there is no angular deflection or axial misalignment. See Figure N.
3. After checking and correcting the alignment, separate the ends far enough to place & lock the planing unit into position in the clamping frame.
4. Turn on the planing unit and slowly bring the pipe ends into contact with the cutting blades. Continue shaving until a complete shaving of both ends has been achieved. (Usually 1 to 3 complete revolutions of the cutting blades.)

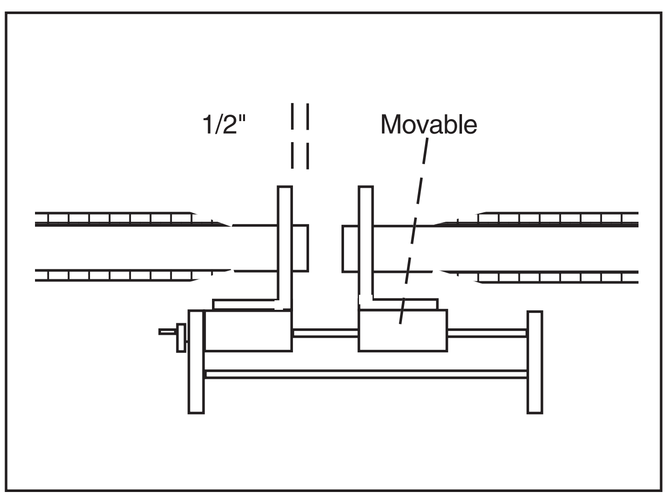


Figure M

5. Turn off and remove the planing unit.

6. Bring the ends together to insure that they butt together flush around the entire circumference of the pipe. If not flush repeat #4. (Maximum gap allowed approx. 1/64 of an inch.)

7. Separate pipe ends and insert the heated welding platten (mirror) in position.

8. Bring both pipe ends into contact with the platten increasing pressure to the values shown on the weld chart.

9. Watch for the evidence of melt which is indicated by the formation of a small bead of melted material at both pipe ends around the entire periphery of the pipe. When the bead reaches the height shown on the welding chart reduce pressure to near zero but maintain contact with the platten.

10. Begin timing the heat-soak cycle when the pressure has been reduced to near zero. (Times shown on weld chart.)

11. When time is reached separate pipe ends and remove the heated platten.

12. Quickly bring the melted ends together (do not slam) and increase the weld pressure until the weld pressure shown on the welding chart is reached.

13. Leave pipe clamped in the tool while cooling. (See cooling times on the weld chart.)

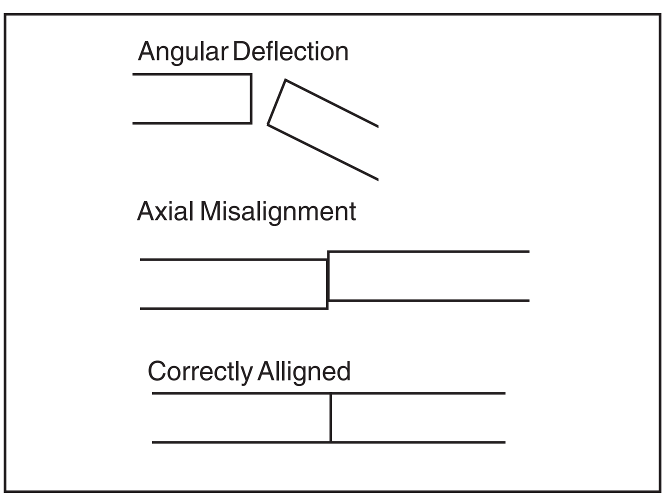


Figure N

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PP Dual Tech Weld Chart

Diameter	Weld Temp.	Beginning Melt Pressure & Bead Height		Heating Time at (near) 0 lbs.	Change Over Time In Seconds - Remove Heater & Increase to Weld Pressure		Weld Pressure	Approx. Cooling Time
(Inches)	Deg. C	Pressure lbs.	Height	in seconds	Change Over	Bring to Pressure	lbs.	Minutes
1	210	6	1/32	40	4	4	6	4
1 1/2	205	15	1/32	50	5	6	15	6
2	205	23	1/32	60	5	6	23	7
2 1/2	203	33	1/32	75	5	7	33	8
3	205	30	1/32	60	5	6	30	8
4	205	45	1/32	70	5	7	45	9
6	200	95	1/16	100	6	8	95	14
8	198	150	1/16	140	6	8	150	17
10	197	237	1/16	155	8	10	237	20
12	195	375	1/16	170	8	10	375	23

PVDF Dual Tech Weld Chart

Diameter	Weld Temp.	Beginning Melt Pressure & Bead Height		Heating Time at (near) 0 lbs.	Change Over Time In Seconds - Remove Heater & Increase to Weld Pressure		Weld Pressure	Approx. Cooling Time
(Inches)	Deg. C	Pressure lbs.	Height	in seconds	Change Over	Bring to Pressure	lbs.	Minutes
1	230	7	1/32	30	4	5	7	3
1 1/2	230	12	1/32	40	4	5	12	5
2	230	16	1/32	45	4	5	16	5
2 1/2	230	23	1/32	50	4	5	23	5
3	230	27	1/16	40	4	5	27	6
4	230	34	1/16	50	4	5	34	7
6	230	50	1/16	70	4	5	50	10
8	230	63	1/16	90	6	5	63	12
10	230	78	3/32	120	8	5	78	14
12	230	100	3/32	150	10	5	100	20

REINFORCEMENT OF FIELD JOINTS & FITTINGS

Generally it should be possible to butt fusion weld the entire pipe system before applying the FRP reinforcement at the field welds.

Note: The butt-fused system without field weld reinforcement will not span as great a distance as the reinforced pipe. The system may require additional temporary supports until all joints and fittings have been wrapped and cured.

Tools & Supplies Required

- *Premeasured Resin Kits (Includes resin, catalyst, brush, latex gloves and mixing paddle)*
- *Serrated Layup Rollers*
- *Chopped Strand Glass Mat*
- *Woven Roving / Bi/Ply*
- *Mylar Film 6 - 10 mil thick*
- *Wood Chisel - 1" Wide*
- *Small Mallet or Hammer*
- *Disc Sander - with #16 or #24 sanding disc*
- *Flat Work Surface - at least 24" x 30"*
- *Respirator, Goggles*
- *Shears (for use in cutting Mat and Roving)*
- *Hot Air Gun - required if working in temp. below 60^{0}F.*
- *Ventilation equipment (when in a poorly ventilated area)*

Surface Preparation

All surfaces to be wrapped must be clean & dry. Do not mix resin kits until surface is properly prepared.

A. Remove weld bead using the chisel and mallet. Holding the chisel at an angle as shown, cut through the bead and then work around the circumference of the pipe until the bead pops off. (See figure below.)

B. Using the disc sander, grind the surface of the liner lightly and then grind the surface of the FRP reinforcement as shown in the following table. *This must be done in order to achieve a satisfactory secondary bond of the hand layup to the wound FRP.*

NOTE: Grinding should be performed not more than 2 hours before hand lay-up joint is performed.

PIPE SIZE	X
1"	1 1/2"
1 1/2"	1 1/2"
2"	2"
2 1/2"	2"
3"	3"
4"	3"
6"	4"
8"	4"
10"	5"
12"	5"

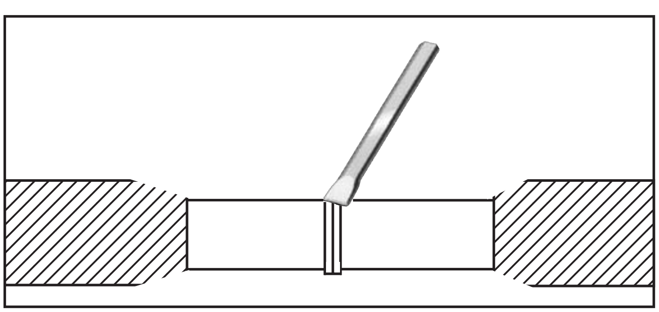

Figure O

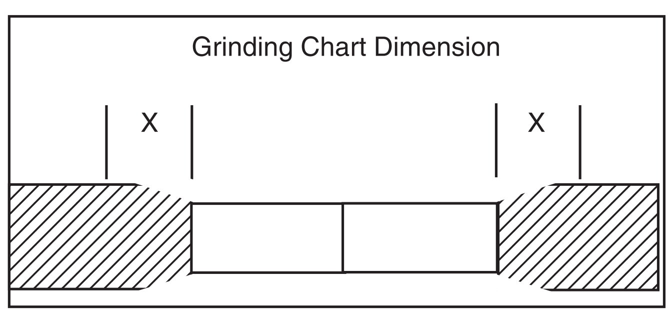

Figure P

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Performing Layup

A. Thoroughly dust surface with **clean dry cloth** to remove residue from grinding procedure. (Do not use solvent to clean surface.)

B. Read "Industrial Health Information" Section and comply before proceeding.

C. Mat and woven roving must be clean & dry.

D. Resin and Catalyst must be between 70^{0}F and 90^{0}F. If temperature is below 60^{0}F use the hot air gun to warm the surface of the pipe which is to be laminated.

E. Using shears cut strips of mat and woven roving according to the Sequence Chart and apply layers in the sequence shown. Each layer must overlap itself by at least 1" and should be staggered around the circumference. Each layer should be cut wider than the previous layer so it ties into the ground taper surface of the reinforcement on the pipe.

Lay-up Sequence Chart

Pipe Size	Overwrap Sequence
1"	MAT MAT WR MAT WR MAT
1 1/2"	MAT MAT WR MAT WR MAT
2"	MAT MAT WR MAT WR MAT
2 1/2"	MAT BI/PLY BI/PLY MAT
3"	MAT BI/PLY BI/PLY MAT
4"	MAT BI/PLY BI/PLY BI/PLY MAT
6"	MAT BI/PLY BI/PLY BI/PLY BI/PLY MAT
8"	MAT BI/PLY BI/PLY BI/PLY BI/PLY MAT
10"	MAT BI/PLY BI/PLY BI/PLY BI/PLY MAT
12"	MAT BI/PLY BI/PLY BI/PLY BI/PLY BI/PLY MAT

NOTE: Finished Lay-up will be thicker than filament winding, therefore here will be a slight bulge at each joint.

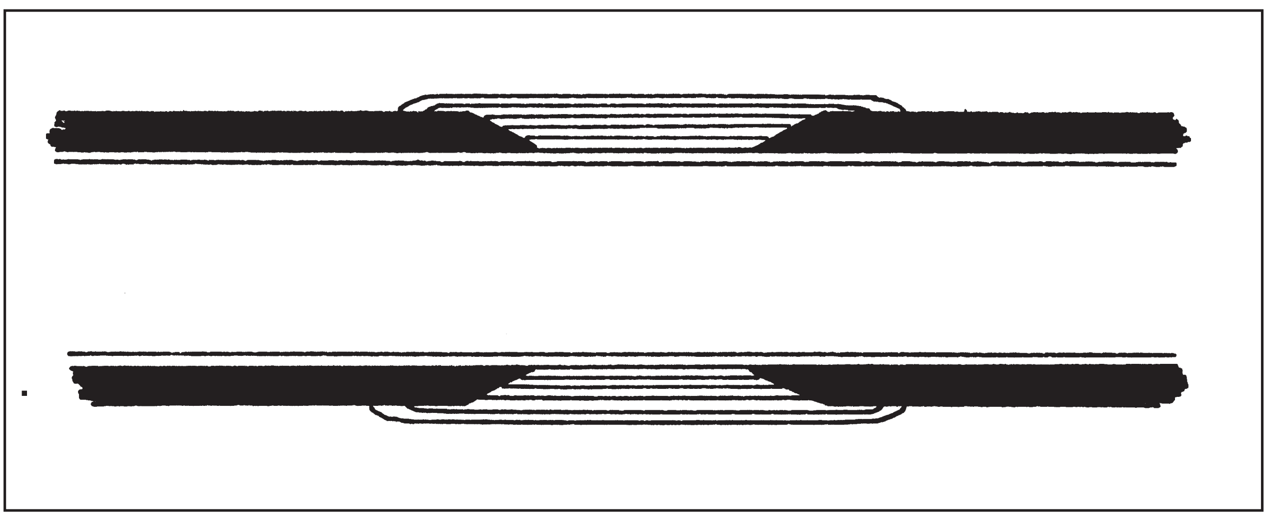

Figure Q

Procedures for Lay-up

1. Put on rubber gloves provided in the resin kit.

2. Mix contents of kit. Do not attempt to mix only part of the resin. Mix all the catalyst provided with all resin. Mix thoroughly and scrape the sides and bottom of the resin can. Stir for at least 60 seconds.

3. Allow mixture to sit for 2 - 3 minutes to allow air bubbles to dissipate.

4. Using brush provided paint the liner pipe surface with resin around the full circumference.

5. Apply the first layer of mat and using a serrated lay-up roller, roll out from center to edges to remove air pockets and to insure the mat is laying flat against the pipe. Make sure glass is wetted. Apply more resin if necessary.

6. Apply more resin lightly around circumference and apply 2nd layer of mat. Follow procedure in #5.

7. Continue adding layers as shown on the lay-up chart shown on page 32.

On 2 1/2" and larger pipe bi/ply is used for the intermediate layers. To prepare bi/ply for lay-up:

Spread a layer of resin on the mylar film on a flat surface. (Bi/ply is a 2 ply laminate of mat and woven roving.) Lay the bi/ply on top of the resin - mat side down - and roll out with a serrated roller until the bi/ply is saturated. The bi/ply can then be wrapped around the laminate surface - matt side down - and rolled out. Bi/ply should be wetted in this manner to insure the glass is thoroughly saturated.

NOTE: *In all layers, the glass should be rolled into the resin. Resin should not be rolled into the glass.*

8. When all layers have been applied and rolled, apply a topcoat of resin to cover the glass completely and seal the laminate. When laminating in temperatures below 60^0F it may be necessary to use a hot air gun to keep newly made laminates warm, avoid hot spots, until they cure.

Checking for Complete Cure**:**
Barcol Hardness values are used to determine completeness of cure. A Barcol Tester #934.1 made by Barber Coleman Company can be used for this test. The typical Barcol Hardness for Derakane 470 should be 30-40.

Lay-up Pattern For Fittings

Laminating elbows, tees, and reducers will be a little more difficult than straight joints. In all cases the laminate is to be built up to the same number of layers as shown in the Lay-up Sequence Chart. Surface Preparation must be followed in all cases as outlined earlier in the instructions.

Wrapping Elbows:
Cut mat and woven roving or biply in narrow strips. (Width of strips will depend on the pipe diameter to be wrapped.) Each turn around the fitting will slightly overlap the previous turn. Avoid puckers and crimps and roll the glass into the resin with the serrated roller. For 2" and smaller, elbows 1" wide or 1 1/2" fiberglass cloth can be more easily wound over the initial layer of mat. Top layer should still be made using mat.

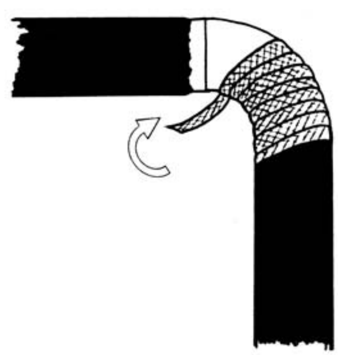

Figure R

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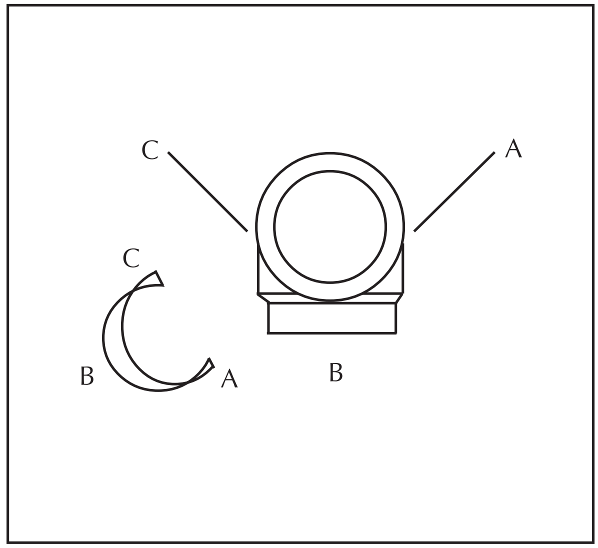


Wrapping Tees: Performing the laminate on a tee will require the most time because the laminate must be built-up piece by piece. Therefore it will be necessary to cut to fit.

1. Cut layers required to lay-up all three ends of the tee. Layers should be wide enough to cover the circumference from the shoulder of the tee to the correct X dimension shown on the "Grinding Chart" on page 9.

2. Cut X-Y pieces to fit the size tee being reinforced.

3. Cut narrow A-C strips from 10 oz. woven roving.

4. Apply X-Y piece rolling down over the shoulder of the tee onto the straight tangent.

- *Make short length wise cuts so glass will lay flat without puckering or crimping.*

5. Apply one layer to each end overlapping X-Y piece.

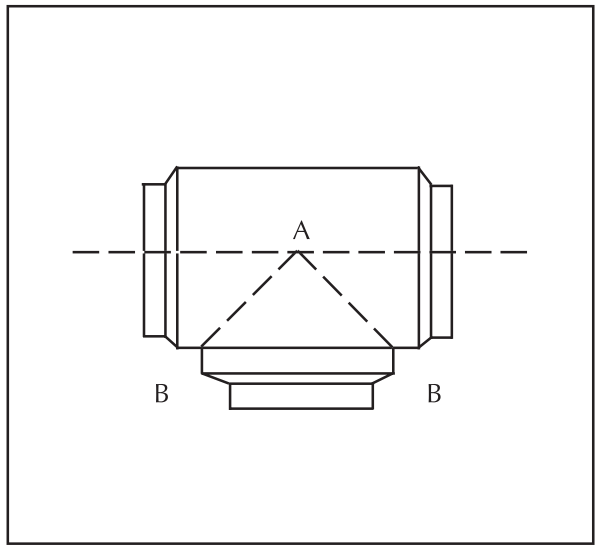
6. Apply A-C strips to both sides.

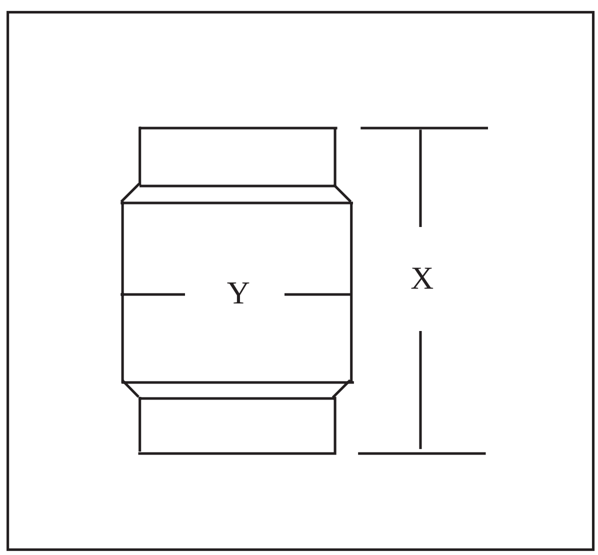
7. Apply each end layer.

8. Apply A-C strips.

9. Continue sequence until all layers have been applied.

NOTE:
Overlapping is critical. Be certain to insure that the alternating layers overlap each other.





Flanged Dual Tech

Dual Tech is available as a totally flanged pipe system. Although a flanged system is considerably more expensive, there are occasions where it can not be avoided. We are prepared to spool-up to customer supplied dimensions.

Dual Tech flanges consist of a stub end and loose backing ring combination. This arrangement will require flange bolts which are longer than those used with steel flanges. It is also necessary to use washers under the bolt heads and nuts. The following chart indicates the appropriate flange bolt requirements.

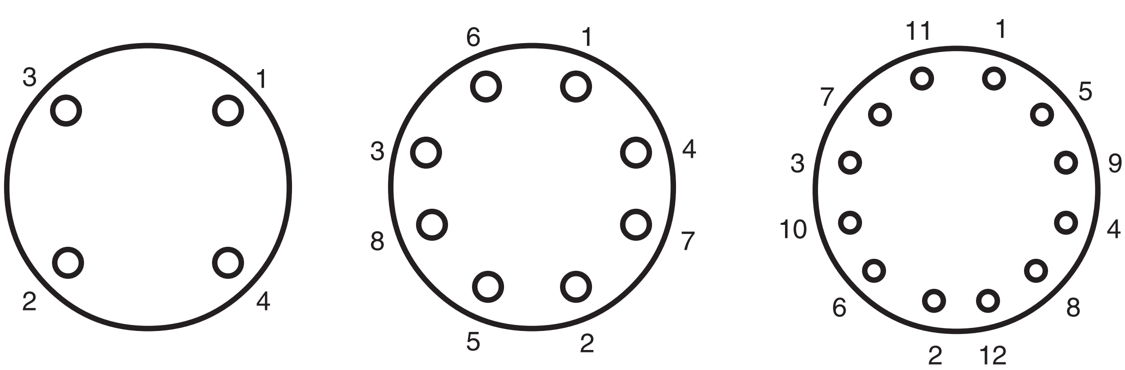
Flange	Bolt Ø	Length	#Req'd	Washer OD
1"	1/2"	4"	4	1"
1 1/2"	1/2"	4"	4	1 1/16"
2"	5/8"	5"	4	1 1/4"
2 1/2"	5/8"	5"	4	1 1/4"
3"	5/8"	5"	4	1 3/8"
4"	5/8"	5 "	8	1 3/8"
6"	3/4"	5 3/4"	8	1 1/2"
8"	3/4"	6 3/4"	8	1 1/2"
10"	7/8"	7 1/2"	12	1 3/4"
12"	7/8"	8"	12	1 3/4"

Flange bolts should be tightened in the sequence shown below. Tighten bolts in 2 passes. Bring bolts to 1/2 the torque values shown below on the first sequence then repeat the sequence tightening to the listed values.

NOTE: When using Dual Tech DTTS-Triple Seal Teflon Bonded Gaskets torque values can be reduced to 1/3 the values shown.

TORQUE VALUES

Size	FT/lbs	Size	FT/lbs
1"	11	1 1/2"	13
2"	14.5	2 1/2"	18
3"	19	4"	18
6"	25	8"	28.5
10"	36	12"	43



4 Hole Flange   8 Hole Flange   12 Hole Flange

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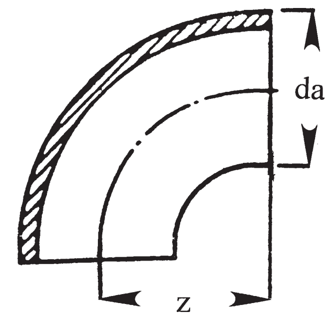
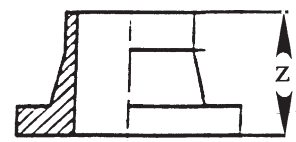
BUTT FUSION DUAL TECH FITTINGS FOR FIELD REINFORCEMENT

90 Degree Elbow



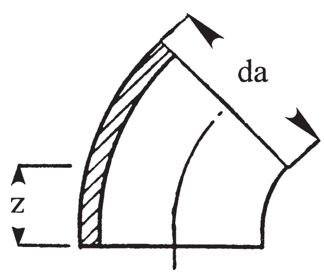
Size	da(in)	z (in)	Flg (in)
1	1.26	1.42	6.17
1 1/4	1.57	1.89	6.64
1 1/2	1.97	2.09	6.84
2	2.48	2.64	7.39
2 1/2	2.95	3.15	10.90
3	3.54	3.82	11.57
4	4.33	4.65	12.40
6	6.30	6.54	14.29
8	7.87	8.07	15.82
10	9.84	10.16	17.91
12	12.40	12.68	20.43

Stub End
(supplied with reinforcement)



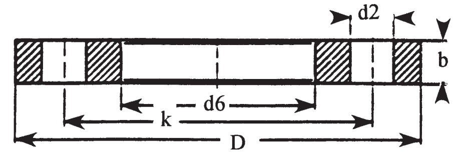
Size	z (in)
1	5.00
1 1/4	5.00
1 1/2	5.00
2	5.00
2 1/2	8.00
3	8.00
4	8.00
6	8.00
8	8.00
10	8.00
12	8.00

45 Degree Elbow



Size	da(in)	z (in)	Flg (in)
1	1.26	0.71	5.46
1 1/4	1.57	0.95	5.70
1 1/2	1.97	1.05	5.80
2	2.48	1.32	6.07
2 1/2	2.95	1.58	9.33
3	3.54	1.91	9.66
4	4.33	2.33	10.08
6	6.30	3.27	11.02
8	7.87	4.04	11.79
10	9.84	5.08	12.83
12	12.40	6.34	14.09

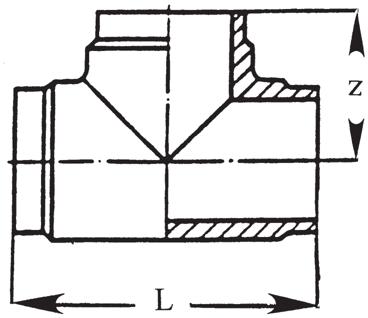
Backing Ring



Size	D (in)	k (in)	d6 (in)	d2 (in)	b (in)
1	4.438	3.125	1.688	0.625	0.500
1 1/4	5.125	3.500	2.000	0.625	0.500
1 1/2	5.250	3.875	2.438	0.625	0.688
2	6.313	4.750	3.063	0.750	0.688
2 1/2	7.063	5.500	3.500	0.750	0.688
3	7.500	6.000	4.313	0.750	0.688
4	9.063	7.500	5.063	0.750	0.688
6	11.00	9.500	7.000	0.875	0.938
8	13.500	11.750	9.313	0.875	0.938
10	16.063	14.250	11.575	1.000	1.188
12	19.000	17.000	13.313	1.000	1.188

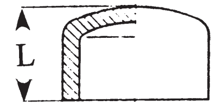
BUTT FUSION DUAL TECH FITTINGS FOR FIELD REINFORCEMENT

Tee



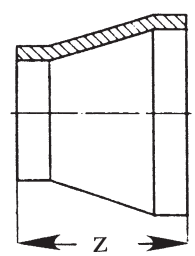
Size	L (in)	z (in)	Flg (z)	Flg (L)
1	3.43	1.65	6.40	12.93
1 1/4	3.66	1.77	6.52	13.16
1 1/2	3.94	1.93	6.68	13.44
2	5.04	2.44	7.19	14.54
2 1/2	6.10	3.19	10.94	21.60
3	7.20	3.62	11.37	22.70
4	10.04	5.12	12.87	25.54
6	13.19	6.50	14.75	28.69
8	17.13	8.58	16.33	32.63
10	17.32	3.44	11.19	32.82
12	21.85	11.02	18.77	37.35

Cap



Size	L (in)
1	1.063
1 1/4	1.299
1 1/2	1.575
2	1.811
2 1/2	2.165
3	2.520
4	3.031
6	4.291
8	5.315
10	2.165
12	2.362

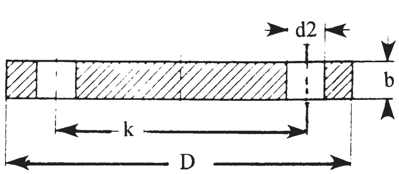
Concentric Reducer



Size	PP	Flg (in)	PVDF	Flg (in)
12 x 10	3.543	19.04	3.543	19.04
12 x 8	5.512	21.01	5.512	21.01
10 x 8	3.346	18.8	3.346	18.8
10 x 6	4.921	20.42	4.921	20.42
8 x 6	3.071	18.57	3.071	18.57
6 x 4	3.346	18.85	3.346	18.85
6 x 3	3.543	19.04	3.543	19.04
4 x 3	2.205	17.71	3.543	19.04
4 x 2 1/2	2.756	18.256	3.543	19.04
4 x 2	2.953	15.453	3.543	16.04
4 x 1 1/2	3.465	15.97	3.543	16.04

Size	PP	Flg (in)	PVDF	Flg (in)
3 x 2 1/2	2.087	17.59	2.95	18.45
3 x 2	2.874	15.37	2.953	15.45
3 x 1 1/2	2.480	14.98	2.953	15.45
2 1/2 x 2	1.890	14.39	1.890	14.39
2 1/2 x 1 1/2	2.323	14.82	2.323	14.82
2 1/2 x 1 1/4	2.520	15.02	2.520	15.02
2 1/2 x 1	2.323	14.82	2.323	14.82
2 x 1 1/2	1.772	11.27	1.772	11.27
2 x 1 1/4	1.969	11.47	1.969	11.47
2 x 1	2.362	11.62	2.362	11.62
-	-	-	-	-

Blind Flange



Size	D (in)	k (in)	d2 (in)	b (in)
1	4.438	3.125	0.625	0.660
1 1/4	5.125	3.500	0.625	0.660
1 1/2	5.250	3.875	0.625	0.850
2	6.313	4.750	0.750	0.910
2 1/2	7.063	5.500	0.750	0.850
3	7.500	6.000	0.750	1.114
4	9.063	7.500	0.750	1.114
6	11.00	9.500	0.875	1.300
8	13.500	11.750	0.875	1.300
10	16.063	14.250	1.000	1.420
12	19.000	17.000	1.000	1.420

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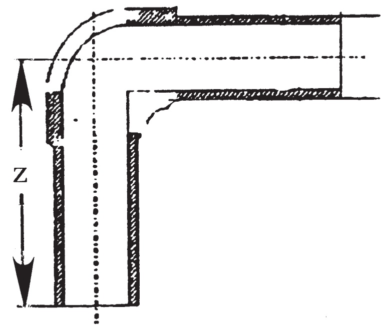
1.011605

Extended Leg 90 Degree Elbow

Supplied with Reinforcement

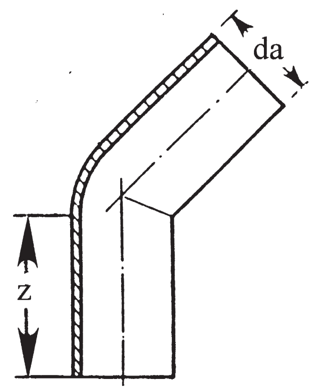
Size	da(in)	z (in)
1	1.26	3.858
1 1/4	1.57	4.252
1 1/2	1.97	4.409
2	2.48	4.567
2 1/2	2.95	5.157
3	3.54	5.630
4	4.33	6.496
6	6.30	9.252
8	7.87	10.433
10	9.84	16.160
12	12.40	18.680



Extended Leg 45⁰ Elbow

Supplied with Reinforcement

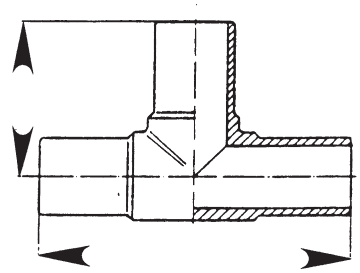
Size	da (in)	z (in)
1	1.26	1.929
1 1/4	1.57	2.126
1 1/2	1.97	2.204
2	2.48	2.284
2 1/2	2.95	2.578
3	3.54	2.815
4	4.33	3.248
6	6.30	4.626
8	7.87	5.217
10	9.84	8.080
12	12.40	9.340



Extended Leg Tee

Supplied with Reinforcement

Size	L (in)	z (in)
2	6.290	2.957
2 1/2	7.391	3.710
3	8.000	3.931
4	9.217	4.812
6	11.826	6.029
8	14.580	7.246
10	16.957	8.551
12	20.145	10.087



Note: Dimensional Tolerances are +/- 0.125"

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Material Safety Data sheets for DERAKANE vinyl ester resins are available from Dow to help users of DERAKANE resins meet their own handling needs and the requirements of OSHA and other governmental agencies. The following comments pertain to all DERAKANE resin products, and are general guidelines for handling these resins safely. The Material Safety Data sheet for the specific DERAKANE product should be consulted for more detailed health hazard and handling information before using this product.

Note: The information provided in Material Safety Data Sheets applies only to DERAKANE resins and not to other products used in formulating, including initiators, promoters, acceleratores, solvents, and other additives. Specific safety and handling procedures for these additives should be requested from the product manufacturer. When various material s are used in combination, formulators should follow the most stringent safety and handling procedures applicable to the products being used.
Caution: Do not blend promoters directly with peroxide since rapid decomposition or explosion could occur.

INDUSTRIAL HEALTH INFORMATION

BASE RESINS AND STYRENE DILUTION

DERAKANE vinyl ester resins are made from epoxy resin methacrylates. The base resins themselves do not pose any significant health or handling difficulties. These base resins, however, are diluted with styrene monomer. Because of their styrene monomer content and the recent focus on health issures concerning styrene monomer, it may be advisable to review exposure levels adn the recommended procedures for handling DERAKANE resins in your facility. (Recommended procedures for storing DERAKANE resins are provided in Section 8 of this bulletin.)

PHYSICAL PROPERTIES

The notaion, "based on styrene," appears beside several of the physical properties listed in Table 20. This means that the value reported applies to styrene itself, not to the resin, and therefore represents a "worst case" scenario.

Table 20

Liquid Property Data for Typical Vinyl Ester Resin

Boiling Point	294^{0}F, 146^{0}C(based on styrene)
Vapor Pressure	7mm Hg @ 20^{0}C(based on styrene)
Vapor Density	3.6 (based on styrene)
Solubility in water	Insoluble
Specific gravity	1.02 - 1.22
Appearance	Yellow to amber viscous liquid
Odor	Pungent styrene odor

FIRE AND EXPLOSION HAZARD DATA

Liquid resin material should be treated as a flammable material. Keep it away from heat, flames, and spark-producing equipment. The burning characteristics of the liquid resin are comparable to those of styrene. The red FLAMMABLE label is required on drums since the resins have a flash point under 100^{0}F. The resins are flamable and must be kept away from all sources of ignition. There should be absolutely no smoking in the work or storage areas. Caution should be exercised in respect to the location of flame-fired equipment such as hot water heaters, space heaters, etc.

TABLE 21

Flash Point and Flammable Limits in Air

Flash Point	70-80^{0}F, 21-27^{0}C
Flammable limits in air	
Lower limit	0.88% (based on styrene)
Upper limit	6.80% (based on styrene)

The flash point is the minimum temperature at which the material gives off a vapor in sufficient quantity to ignite in air, as tested by one of the approved methods. Since the flash pint is less thean 80^{0}F, flammable concentrations of vapors may be present when liquid DERAKANE resins are being used in the FRP shop.

The lower flammable limit is the minimum concentration of a vapor in air which will burn when exposed to an ignition source. Conversely, the upper flammable limit is the maximum concentration of a vapor that will burn when exposed to an ignition source. These limits are specific for a given temperature and are usually given for 25^{0}C (77^{0}F). It is important to prevent the formation of explosive or combustable mixtures and to take precautions to avoid ignition of any such mixtures formed. Resin handling areas should be well ventilated and motors must be explosion-proof or totally enclosed. All equipment, drums, tank trucks, and hose connections must b grounded for the safe discharge of static electricity.

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IN CASE OF FIRE

Fires involving DERAKANE resins can be extinguished safely with foam, dry powder, or carbon dioxide. Water is not normally an effective extinguishing agent for use with these water-insoluble resins. The use of foam requires caution if motors, hot plates, fans, or other kinds of electrical equipment are involved in the fire. When these resins burn, they may give off toxic by-products, such as carbon monoxide. For this reason, breathing of fumes, smoke, and vapors liberated by a resin fire should be carefully avoided. If there is a possibility of gross exposure to these toxic by-products, a positive-pressure, self-contained breathing apparatus, or equivalent, may be required.

Extra care should be taken in fire situations in which other resin drums are stored in the area. When the drums are exposed to heat or flame, an exothermic reaction can develop, possibly accompanied by hazardous decomposition of the product. The gases generated by decomposition may include carbon monoxide. Decomposition of brominated resins may release hydrogen bromide.

REACTIVITY DATA

DERAKANE resins are reactive and can polymerize even without the addition of peroxides. Polymerization initiated without peroxides is usually the result of inhibitor depletion, and the reaction proceeds slowly. However, exposure to high temperature, sunlight, or certain other chemicals can result in rapid polymerization with significant generation of heat. When this happens, decomposition gases, such as carbon monoxide, may be formed. It is best to store drums of DERAKANE resins indoors or away from direct sunlight. However, when the material is being used on a field job, this is not always possible. For that reason, the drums are painted white to limit the amount of heat they will absorb.

FIRST AID

Eye Contact - Styrene vapors, if present at a high enough concentration in the air may cause tears and eye irritation. If the eyes become irritated, ventilation needs to be improved. Workers should protect their eyes from splashes by using chemical goggles. If resin is accidentally sprayed into the eyes, it is important for the person to irrigate them continuously with low-pressure for at least 15 minutes. Medical personnel should be notified immediately. Include in the description of the accident other components of the mixture (peroxides, promoters, and fillers), because this information may affect the treatment the physician recommends.

Skin Contact - If resin comes in contact with the sin, it should be washed off with soap (if available) and water, not solvents. Prolonged or repeated contact with the skin may cause localized irritation, even a burn. Also, the sticky nature of the resins makes them very difficult to wash off exposed skin. Wearing protective body-covering clothing and impervious gloves can help minimize direct skin contact with the resin.

Inhalation - Inhalation of styrene vapors is the principal respiratory health concern associated with the use of DERAKANE resins. Exposure to high concentrations of vapors may lead to central nervous system effects (anesthesia or narcosis) and cause upper respiratory irritation.

Effective March 1989, the OSHA Permissible Exposure Limit (PEL) for styrene became 50 ppm as an 8 hour Time Weighted Average (TWA). In addition, there is a Short Term Exposure Limit (STEL) of 100 ppm as a 15 minute TWA.

A person adversely affected by styrene vapors should be removed to fresh air, made to rest, and kept warm. If the individual is not breathing, mouth-to-mouth resuscitation should be given. Medical attention should be obtained immediately.

Ingestion - If DERAKANE resins are accidentally swallowed, medical attention should be sought immediately. The physician should treat the condition symptomatically and should not induce vomiting.

PERSONNEL PROTECTION

Human contact with resins, initiators, and other modifiers should be minimized. Use of chemical goggles, clean, body-covering clothing and impervious gloves will reduce the potential for skin and eye contact. Proper ventilation and any appropriate engineering procedures should be used in the work area to maintain styrene monomer vapor concentrations below OSHA's Permissible Exposure Limit (PEL) of 5 ppm and OSHA's 15-minute Short-Term Exposure Limit (STEL) of 100 ppm. Good general ventilation should be required where emissions of vapor are high and where there is little air circulation, particularly in confined areas.

If respiratory protection is required, air-purifying respirators with organic vapor cartridges may be used for styrene concentrations up to 500 ppm. The service life of these cartridges depends on vapor concentration, the user's breathing rate, and relative humidity, among other factors, and should be determined for each work environment. The cartridges should be replaced if styrene odor becomes noticeable to the respirator wearer. If there is a possibility of gross styrene exposure, a positive-pressure, self-contained breathing apparatus, or equivalent, may be required.

Cured DERAKANE resins - those that are completely polymerized - are considered to be toxicologically inert and to present no handling hazards. The finished resins, however, may represent a health hazard from inhalation of dusts generated during grinding or machining, especially if they contain glass, silica powder, asbestos, or metal powders.

SPILLS

Small spills of DERAKANE resin can be handled by applying sand or other absorbent material to the spill and shoveling it into a container. The residue should be removed from the floor with hot, soapy water. Larger spills should be contained with a dike and the excess resin should be collected in containers. Again, the residue should be removed with hot, soapy water.

***CAUTION**: Solvent should not be used in the final cleanup, because their use could create unnecessary hazards of vapor inhalation & possible ignition.*

Only trained personnel should participate in the cleanup, and they must be properly protected from skin and eye contact and breathing vapors. See "Personnel Protection." Before any cleanup is begun, the spill area should be checked carefully & any possible sources of ignition should be removed.

ENVIRONMENTAL & DISPOSAL INFORMATION

Spills should be soaked up with a non-reactive absorbent such as sand. Residual resin should be cleaned up with hot soapy water or steam. Solvents are not recommended for clean-up unless the recommended exposure guidelines are followed.

DERAKANE resins can be disposed through burning in an adequate incinerator. Brominated resins (DERAKANE 510A, 510N, and 530) must be burned in an incinerator equipped with a halogen scrubber. Current regulations allow for cured resins to be disposed in an approved landfill in accordance with federal, state and local regulations which may have an impact on disposal of cured waste resin include RCRA, California Proposition 65 and Rule 1162. As these rules become defined further, Dow will be working with fabricators and distributors to keep them informed.

Note: In disposal of any wastes, all federal, state, and local regulations must be met.

HEALTH AND HAZARD DATA

In March of 1987 The International Agency for Research on Cancer (IARC), decided to reclassify styrene from its 1982 status, "not classifiable as to carcinogenicity to humans," to Group 2B as a "possible carcinogen to humans." This decision was based on new criteria for evaluation and did not reflect the generation of any new carcinogenicity data since the previous classification five years earlier. In fact, no animal exposure studies have been identified which demonstrate conclusively that styrene is carcinogenic.

As a result of the reclassification of styrene, all DERAKANE vinyl ester resins are now classified as a "potential carcinogen to humans" on their Material Safety Data sheets because the resins contain more than 0.1% styrene monomer.

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Web site: www.simtechUSA.com

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Simtech Industrial Products, Inc. products are warranted to be free from defects in materials and workmanship for one (1) year from date of shipment. No claim shall be permitted under this warranty unless Buyer gives Simtech Industrial Products, Inc. written notice of all respects in which Buyer claims the product to be defective. Notice must be received within ten (10) days from the date which the Buyer discovers, or should have discovered the defect. Buyer shall give Simtech Industrial Products, Inc. a reasonable opportunity to inspect the product after notice has been given. This warranty shall not apply to any products or components, which have been subjected to abnormal use, negligence or accident.

Seller's sole obligation under this warranty shall be limited solely on the repair or replacement, as elected by Simtech Industrial Products, Inc., of defective or non-conforming material. To the maximum extent permitted by law, Buyer irrevocably waives all claims for money damages relating to the condition, use and performance of the goods purchased. In no event shall Simtech Industrial Products, Inc. liability exceed the purchase price of the product sold by Simtech Industrial Products, Inc.

In no event, whether because of a breach of warranty or representation or any other cause, whether based upon contract, tort, warranty or otherwise, arising out of the performance or nonperformance by seller of its obligations under this agreement or with respect to the products sold pursuant here to; shall seller be liable for lost earnings, income or profits or indirect, incidental, liquidated or consequential damages.

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