Eng-2100

DURCOR®

Design & Specification Guide

PTFE Lined Structural Composite Piping System

PureFlex®

an ANDRONACO INDUSTRIES company

DURCOR®
Like no other

Revolutionary

Durcor® is the world's first advanced structural composite piping system designed exclusively to be lined with seamless PTFE. Durcor's architecture was optimized from the start, not compromised by conversion. It is the strongest, lightest, most chemically resistant piping system available.

Durcor's thick wall PTFE liner provides unmatched internal chemical resistance while its revolutionary vinyl ester / fiberglass housing provides outstanding exterior corrosion protection, high impact resistance, excellent span and burst capabilities. The construction of Durcor offers the ultimate in physical properties and corrosion resistance and carries the industry's first (5) year bumper to bumper warranty.

5 YEAR WARRANTY
Bumper-to-Bumper

Applications

- ✓ Acids
- ✓ Solvents
- ✓ Caustic
- ✓ Chlor-Alkali
- ✓ Pharmaceutical
- ✓ Bleaches
- ✓ Mining

Materials & Construction

All Durcor pipe is manufactured with glass fibers and a premium grade vinyl ester resin in an automated manufacturing process developed by PureFlex® for composite pressure piping. Interior heavy wall virgin PTFE pipe liner provides maximum chemical resistance.

Fittings

All fittings are manufactured in hardened, dedicated tooling and are consistently produced using similar glass / resin ratios and systems as the pipe.

Joining Systems

All molded flanges, fixed and rotating, are positively located over pipe ends and attached with PureFlex adhesive for maximum integrity.

Pipe Construction

A. Minimum of (3) resin-rich surface veils of a minimum 20 mils to form the inner surface of the Durcor pipe.

B. Dense bundles of glass rovings are applied in both the axial and radial directions to provide the mechanical properties of Durcor pipe.

C. A protective heavy layer of chopped strand mat is applied over the glass rovings.

D. Two final layers of resin-rich surfacing veil for UV protection.

E. Fittings shall be molded in dedicated resin transfer tooling.

Applicable Documents

ASTM F1545 "Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges"

ASTM D4894 "Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials"

ASTM D4895 "Polytetrafluoroethylene (PTFE) Resin Produced From Dispersion"

ASTM D1599 "Resistance To Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings"
This standard defines the procedure to determine burst pressures of pipe, tubing, and fittings. The resultant burst pressure then provides an ultimate hoop stress value based on product dimensions. Durcor pipe and fittings have been tested for short term burst pressure and the ultimate hoop stress determined. Recommended working pressures for Durcor piping are one-fourth of the ultimate stress values obtained.

ASTM D5685 "Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe Fittings"

ASTM D4024 "Machine Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Flanges"

Drop Impact Testing

Following the test procedures of the falling weight impact testing per ASTM D2444 "Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)", results showed that Durcor pipe can withstand a room temperature drop impact energy of up to 72 ft-lbs without failure. Additionally, the impact resistance increased with decreasing temperatures when Durcor pipe was saturated to (-40 °F), the drop impact resistance improved to over 80 ft-lbs.

Physical Properties

Average Physical Properties

Property	75 °F	250 °F	Typical FRP @ 75 °F	Method
Axial Tensile Strength	43,500 psi	28,275 psi	11,600 psi	ASTM D2105
Axial Tensile Design Strength	10,875 psi	7,070 psi	3,870 psi	ASTM D2105
Axial Modulus of Elasticity	2.76 X 10^6 psi	1.70 X 10^6 psi	1.60 X 10^6 psi	ASTM D2105
Axial Compression Strength	50,750 psi	34,075 psi	14,500 psi	ASTM D695
Axial Compression Design Strength	12,690 psi	8,520 psi		ASTM D695
Compression Modulus	2.39 X 10^6 psi	1.47 X 10^6 psi		ASTM D695
Beam Bending Ultimate Stress	47,100 psi	35,300 psi	12,380 psi	ASTM D2925
Beam Bending Design Stress	5,900 psi	4,410 psi		ASTM D2925
Poisson's Ratio	0.32		0.65	
Flexural Modulus of Elasticity	3.26 X 10^6 psi	1.89 X 10^6 psi	1.81 X 10^6 psi	ASTM D790

Coefficient of Linear Thermal Expansion	6.7 X 10^{-6} in/in/°F	10 X 10^{-6} in/in/°F
Specific Gravity	1.92 (housing) and 2.15 (PTFE)	1.80
Heat Deflection Temperature	266 °F	
Hazen-Williams Flow Coefficient	155	150
Thermal Conductivity	2.6 Btu/ft-hr-°F	

PTFE Physical Properties

Property	ASTM Method	Unit	Value
Tensile Strength	D638	psi	3,500
Ultimate Elongation	D638	%	250
Flexural Modulus	D790	psi	70,000
Hardness	D2240	Shore D	55
Thermal Conductivity	E1530	Btu-in/hr-ft^2-°F	1.7
Dielectric Strength	D149	V/mil	600
Water Absorption	D570	%	<0.01
Static Coefficient of Friction			0.05
Specific Gravity			2.14-2.19

Strong, Light Weight, Zero Corrosion

DURCOR® Engineering Data

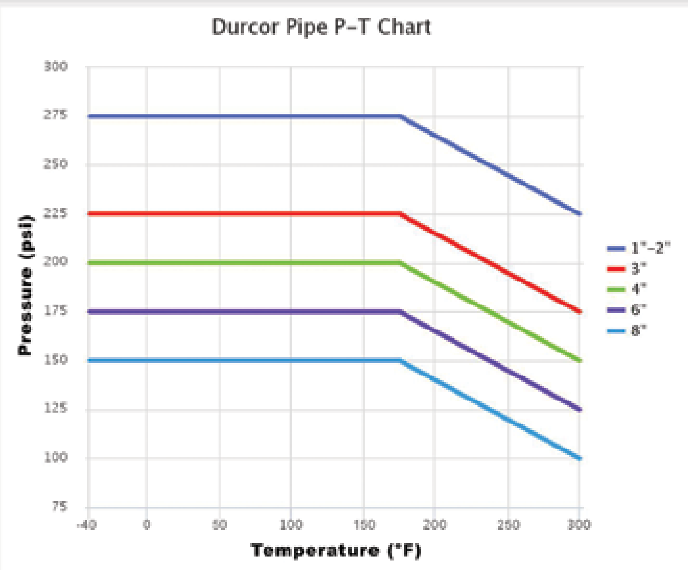
Nominal Dimensional Data

Size	PTFE Lined ID		Liner Thickness		Pipe OD		Dry wt/ft		Capacity	
(in)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(lbs/ft)	(kg/m)	(gal/ft)	(ft^3/ft)
1	0.79	20.1	0.13	3.3	1.36	34.5	0.83	1.25	0.03	0.003
1-1/2	1.34	33.3	0.15	3.8	1.92	48.8	1.29	1.94	0.07	0.010
2	1.74	44.2	0.16	4.1	2.38	60.5	1.75	2.63	0.12	0.017
3	2.75	69.8	0.16	4.1	3.50	88.9	3.14	4.71	0.31	0.041
4	3.71	93.7	0.18	4.5	4.50	114.3	4.37	6.56	0.56	0.075
6	5.50	139.7	0.28	7.1	6.63	168.4	9.14	13.72	1.23	0.165
8	7.36	186.9	0.31	7.9	8.63	219.2	13.56	20.34	2.21	0.296

Pressure Ratings

Nom. Pipe Size (in)	Max. Pressure @ 75 °F (psi)	Max. Pressure @ 300 °F (psi)
1	275	230
1-1/2	275	230
2	275	230
3	225	175
4	200	150
6	175	125
8	150	100

Working pressures represent a minimum of 4:1 safety factor.



Pressure-Temperature data applicable only to uninsulated piping.
If piping insulated, maximum operating temperature 250 °F.

ASTM D5685 Fitting Designation Codes

Size (in)	Code
1 thru 2	RTRF-34H5F
3 - 4	RTRF-34H5E
6 - 8	RTRF-34H5D

ASTM D4024 Flange Designation Code

Size (in)	Code
1	RTR-244E-75X
1-1/2	RTR-244E-65X
2	RTR-244E-65X
3	RTR-244D-44X
4	RTR-244D-44X
6	RTR-244C-43X
8	RTR-244C-33X

Flange Thickness

Size (in)	Thickness (in)
1	0.78
1-1/2	0.78
2	0.9
3	1.16
4	1.16
6	1.25
8	1.38

Flange Drilling

ANSI B16.5 CL 150
DIN PN10/PN16
JIS B2211 5KG/10KG

Pipe Sectional Properties

Size (in)	Reinforcement Area (in^2)	Moment of Inertia (in^4)	Weight of Water Filled Pipe (lb/in)
1	0.59	0.111	0.090
1-1/2	0.86	0.337	0.156
2	1.08	0.648	0.229
3	2.22	3.007	0.477
4	3.14	7.311	0.754
6	5.66	28.654	1.618
8	8.50	73.238	2.668

PTFE Flare Diameters

Size (in)	Nom. Flare Dia. (in)
1	2.00
1-1/2	2.88
2	3.63
3	5.00
4	6.19
6	8.50
8	10.63

Fluid Flow

Equivalent Feet of Head Loss Through Fittings

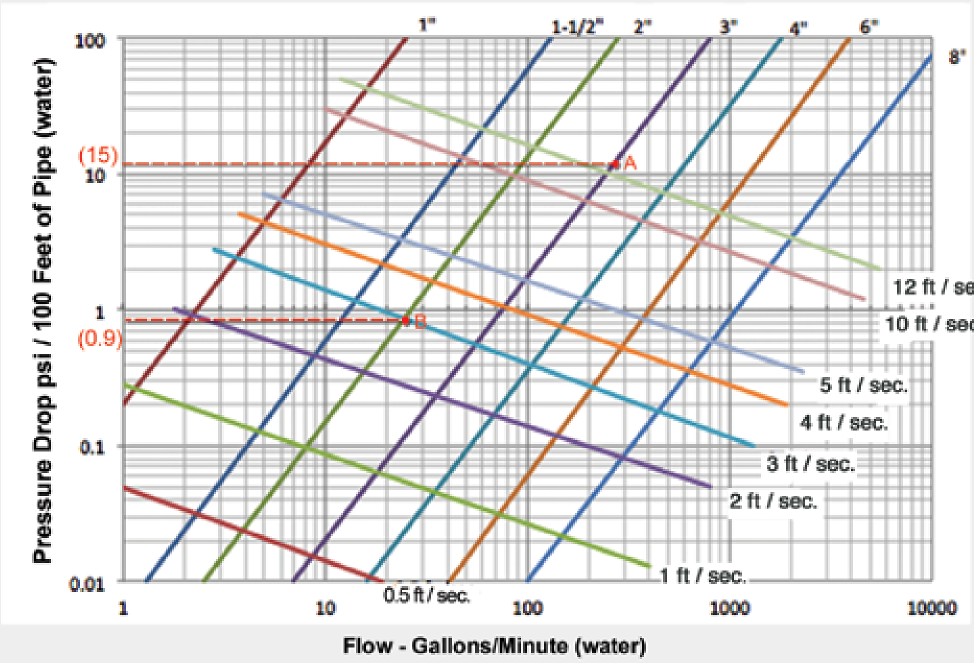
Size (in)	Elbows 90°	Elbows 45°	Standard Tees Thru Run	Standard Tees Thru Branch
1	1.8	0.9	1.2	4.5
1-1/2	3.5	1.8	2.3	7.5
2	4.5	2.3	3	10
3	7	4	4.1	15
4	10	6	6	20
6	15	9.5	10	32
8	19	12	14	42

Values are in feet of pipe.

Fluid Flow

Durcor PTFE lined pipe provides a low friction smooth bore that will maintain its characteristics for many years. Although smooth when purchased new, in time, metallic piping will scale, pit, and be a growth surface for fungi, adhesives, reaction crystals, calcium, etc. The PTFE surface of Durcor piping is not prone to any of these and thus will maintain a predictable low level of pressure drop and prevent the pump from working harder.

Using the following chart, the expected pressure drop per 100 feet of Durcor pipe as well as expected loss in feet of head for common fittings can be determined.



Pressure drop can be determined from head loss by applying the following formula:

P = (FT * SG)/2.31

P = Pressure drop (psi)
FT = Feet of head
SG = Fluid specific gravity

Example:

3" Durcor pipe carrying a fluid flow rate of 300 GPM. To determine the predicted loss in pressure over 100 feet of pipe, follow the 3" line (purple) in the chart to the 300 GPM horizontal axis location, which is (2) vertical lines to the right of the 100 GPM line. Where the 3" line intersects the 300 GPM line, (A), draw a straight horizontal line to the left vertical axis. It will land at 15 psi.

Example:

2" Durcor pipe carrying a fluid travelling at 3 ft/sec. Follow where the 2" line (green) and the 3 ft/sec. line (turquoise) intersect one another (B). Draw a straight horizontal line to the left vertical axis to 0.9 psi.

Durcor® Wall Thickness Calculations Based on ASME B31.3 Chapter VII

Ref. Section A304.1.2 "Straight Pipe Under Internal Pressure"

For RTR (Filament Wound) and RTM (Centrifugally Cast) Pipe

t = PD/(2SF + P)

t = Pressure design thickness
P = Internal design gage pressure
D = Outside diameter of pipe
S = Design stress
F = Service (design) factor

Based on Section A302.3.2, the design stress (S) is determined by one-tenth of the minimum tensile strength of Durcor. The tensile strength of Durcor is 43,500 psi, therefore, the (S) is determined to be 4,350 psi. The conservative service (design) factor is 0.5.

Wall Thickness

Size (in)	Gage Pressure	Calculated Wall (in)	Actual Wall (in)	Actual/ Calculated
1	275	.080	.160	2.00X
1-1/2	275	.115	.155	1.35X
2	275	.140	.150	1.07X
3	225	.172	.215	1.25X
4	200	.198	.240	1.21X
6	175	.256	.285	1.11X
8	150	.288	.325	1.13X

In all cases, wall thickness exceeds minimum pressure design thickness using the 0.5 service (design) factor.

Design for Expansion and Contraction

Simple supported Durcor piping can be easily designed by considering the degree of thermal expansion along straight runs of pipe and any possible pressure thrusts created by closed end systems.

Length Changes Due to Thermal Expansion in an Unrestrained Condition

All piping materials will expand linearly with increasing temperature when in an unrestrained condition. Durcor piping exhibits extremely low expansion rates with increasing temperatures, however, these changes do need to be considered in piping design. The amount of linear thermal expansion of Durcor pipe is consistent over the operating range and is determined to be 6.7 X 10^{-6} in/in/°F (1.2 X 10^{-5} in/in/°C).

The formula for determining expansion:

$\Delta L = \alpha * L * \Delta T$

ΔL = Change in length (in)
α = Coefficient of thermal expansion (in/in/°F)
L = Length of pipe (in)
ΔT = Change in temperature (°F)

Example: Determine how much thermal expansion to expect when installing 300 feet of Durcor piping at 70 °F intended to operate at 200 °F.

α = 6.7 X 10^{-6} in/in/°F
L = 300 feet X 12 inches/foot = 3600 inches
ΔT = (200 – 70) = 130 °F
ΔL = 3.13 inches

Flexijoint® PTFE Expansion Joint Allowable Axial Movements (inch)

Size (in)	2 conv.	3 conv.	4 conv.	5 conv.	6 conv.	7 conv.	8 conv.	9 conv.	10 conv.	11 conv.	12 conv.
1	11/32	1/2	21/32	27/32	1	1-5/32	1-5/16	1-1/2	1-21/32	1-13/16	2
1-1/2	11/32	17/32	11/16	7/8	1-1/32	1-7/32	1-3/8	1-9/16	1-23/32	1-29/32	2-3/32
2	11/32	17/32	23/32	7/8	1-1/16	1-1/4	1-7/16	1-19/32	1-25/32	2	2-3/16
3	13/32	5/8	27/32	1-1/32	1-1/4	1-15/32	1-21/32	1-7/8	2-3/32	2-5/32	2-9/16
4	7/16	21/32	7/8	1-3/32	1-5/16	1-17/32	1-3/4	1-31/32	2-3/16	2-7/16	2-11/16
6	15/32	23/32	31/32	1-3/16	1-7/16	1-11/16	1-29/32	2-5/32	2-13/32	2-21/32	2-29/32
8	17/32	25/32	1-1/16	1-5/16	1-9/16	1-27/32	2-3/32	2-11/32	2-5/8	2-29/32	3-3/16

Ethylene™ Flexijoint® with Durcor® Flanges
(shown)
The industry standard for severe service

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Expansion Data

Thermal Expansion

The effect of thermal gradients on piping systems may be significant and should be considered in every piping system stress analysis. Pipeline movements due to thermal expansion or contraction may cause high stresses or even buckle a pipeline if improperly installed. Several piping system designs are used to manage thermal expansion and contraction in above ground piping systems. They are listed below, according to economic preference:

1. Use of inherent flexibility in directional changes
2. Restraining axial movements and guiding to prevent buckling
3. Use expansion loops to absorb thermal movement
4. Use mechanical expansion joints to absorb thermal movement

To perform a thermal analysis, the following information is required:

1. Isometric layout of piping system
2. Physical and material properties of pipe
3. Design temperatures
4. Installation temperature (final tie-in temperature)
5. Terminal equipment load limits
6. Support movements

Unrestrained Piping

Unrestrained Durcor piping will not exhibit a measureable change in length due to the thrust effects of internal pressure. This is unique for fiberglass reinforced piping. Typically, accommodations for growth must be factored for FRP piping as the axial elastic modulus of typical FRP piping is significantly less than the radial elastic modulus. Due to this anisotropic property and combined with Poisson's ratio, growth for typical FRP piping from internal pressure thrusts from 150 psi can be from ¼" to ½" per 100 feet of piping.

The axial elastic modulus of Durcor piping (2.76×10^6 psi) is over 50% greater than that of typical FRP pipe. With a radial elastic modulus of 2.10×10^6 psi, the axial component accounts for the majority of the stiffness of the pipe. This relativity results in un-measureable growth from internal pressures. Length growth from pressure thrust in unrestrained Durcor piping is only .03-.06 in/100 ft.

Unrestrained Thermal Expansion Uninsulated Pipe

Change in Temperature (°F)	Pipe Change in Length (in/100 ft)
25	0.20
50	0.40
75	0.60
100	0.81
125	1.00
150	1.21
175	1.41
200	1.61

Durcor® vs. Competition

Temperature Change (°F)	Durcor	Fiberglass	PVC	CPVC	Carbon Steel	Stainless Steel
25	0.20	0.31	0.90	1.14	0.22	0.27
50	0.40	0.61	1.80	2.28	0.44	0.54
75	0.60	0.92	2.70	3.42	0.65	0.82
100	0.81	1.23	3.60	4.56	0.88	1.09
125	1.00	1.54	4.50	5.70	1.10	1.36
150	1.21	1.84	5.40	6.84	1.32	1.63
175	1.41	2.15	6.30	7.98	1.54	1.90
200	1.61	2.45	7.20	9.12	1.76	2.17

Restrained Systems

When it is necessary to restrain the piping system with anchors, the ability of the Durcor piping to absorb the resultant compressive loads needs to be determined. These compressive loads are caused by restricting the thermal expansion of the piping and pressure thrust acting on the pipe from fluid pressure. Guides are recommended whenever Durcor is fully restrained by anchors to provide lateral support. Guide spacing will be provided in this section.

Thrust Attributable to Temperature Changes in Anchored Piping

The force created by fully anchoring Durcor pipe and introducing a temperature gradient is calculated by:

$$F = \alpha * (\Delta T) * A * E$$

- F = Thrust (lbf)
- α = Coefficient of thermal expansion (in/in/°F)
- ΔT = Change in temperature from installation to operating (°F)
- E = Ambient temperature axial modulus of elasticity (psi)

If the change in temperature is increasing, use the compression modulus. If temperature is decreasing, use the axial modulus of elasticity.

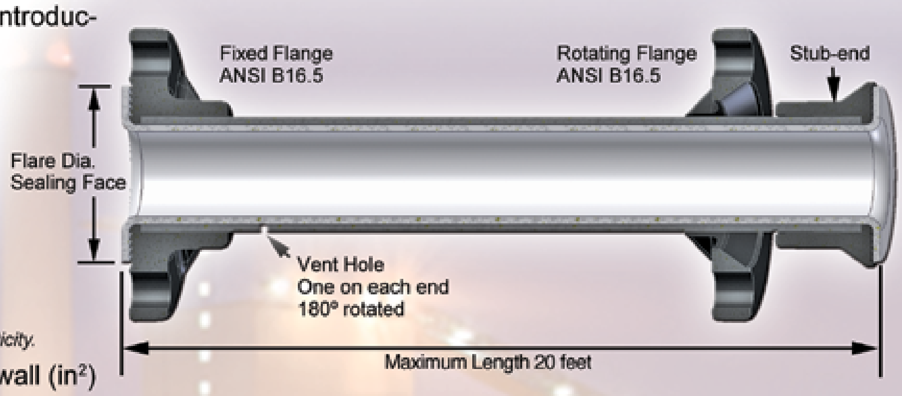
- A = Cross sectional area of the reinforced pipe wall (in^2)

Example: Anchored 2" Durcor will operate at 150 °F, how much thrust will be exerted on the pipe?

- $\alpha = 6.7 \times 10^{-6}$ in/in/°F
- $\Delta T = (150 - 70) = 80$ °F
- $A = 1.08\ in^2$ for 2" Durcor
- $E = 1.94 \times 10^6$ psi (compression modulus @150 °F)
- $F = 1{,}123$ lbf

Restrained Pipe End Loads from Pressure Thrust

Size (in)	50 psi (lbf)	150 psi (lbf)	275 psi (lbf)
1	42	126	231
1-1/2	98	294	540
2	155	465	852
3	340	1,020	
4	585	1,755	
6	1,305	3,915	
8	2,245	6,735	



Restrained Thermal End Loads

Size (in)	100 °F Thermal End Load (lbs)	125 °F Thermal End Load (lbs)	150 °F Thermal End Load (lbs)	175 °F Thermal End Load (lbs)	300 °F Thermal End Load (lbs)
1	221	413	575	707	925
1-1/2	323	602	838	1,031	1,348
2	405	756	1,052	1,295	1,693
3	833	1,554	2,163	2,661	2,394
4	1,178	2,198	3,060	3,764	4,316
6	2,124	3,962	5,515	6,785	7,780
8	3,189	5,950	8,283	10,190	11,683

Above data is based on reduction of compression modulus of elasticity by 6,000 psi/°F.

Supports

Supports

Proper pipe support spacing depends on the temperature and weight of the fluid in the pipe. The support spacing table is based on unrestrained continuous beam theory using the pipe bending modulus. The maximum span lengths were developed to ensure a design that limits mid-span deflection to 1/2 inch and dead weight bending to 1/8 of the ultimate bending stress. Any additional loads on the piping system such as insulation, wind, seismic, etc., require further consideration. Restrained (anchored) piping systems operating at elevated temperatures may result in guide spacing that is shorter than unrestrained piping systems. In this case, the maximum guide spacing governs the support span requirements for the system. Pipe spans near elbows require special attention. Both supported and unsupported elbows are considered in the following tables and must be followed to properly design the piping system.

There are basic rules to follow when designing piping system supports:

1. Do not exceed the recommended support span.
2. Support valves and heavy in-line equipment independently. This applies to both vertical and horizontal piping.
3. Protect pipe from external abrasion at supports.
4. Avoid point contact loads.
5. Avoid excessive bending. This applies to handling, transporting, initial layout, and final installed position.
6. Avoid excessive vertical run loading. Vertical loads should be supported sufficiently to minimize bending stresses at outlets or fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow.

Maximum Support Spacing for Uninsulated Pipe

Pipe Size (in)	*Continuous Spans of Pipe (ft)		
	75 °F	150 °F	300 °F
1	11.1	10.5	9.3
1-1/2	12.7	12.1	10.7
2	13.6	13.0	11.4
3	16.6	15.9	14.0
4	18.3	17.5	15.4
6	21.5	20.6	18.1
8	24.1	22.9	20.2

*Maximum mid-span deflection 1/2" with a specific gravity of 1.0 axial modulus of elasticity is reduced to 6,000 psi/°F.

Adjustment Factors for Various Spans With Unsupported Fittings at Change in Direction

	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from supported end or unsupported fitting	0.80
c+d	Sum of unsupported spans at fitting	≤0.75*
e	Simple supported end span	0.67

*For example: If continuous support is 10 ft, c+d must not exceed 7.5 ft (c = 3 ft and d = 4.5 ft) would satisfy this condition.

Support Spacing vs. Specific Gravity

Specific Gravity	3	2	1.5	1.25	1	0.75	Gas/Air
Multiplier	0.76	0.84	0.9	0.95	1	1.07	1.4

Example: 3" pipe @ 150 °F with a 1.5 specific gravity fluid, maximum support span spacing = 15.9 X 0.90 = 14.3 feet.

Piping Supports, Guides, and Anchors

Support Span

The combination of the lightweight of Durcor pipe along with an extremely high axial tensile modulus relative to other fiberglass piping, results in greater span distances between supports, thus reducing the cost for supports.

Support Spans for uniformly distributed loads:

$$L = 0.258(EI/w)^{1/4}$$

L = Support spacing (ft)
E = Axial modulus of elasticity (psi)
I = Moment of inertia (in^4)
W = Weight of water-filled pipe/inch (lb)

Guide Spacing

If Durcor pipe is anchored and restrained, the compressive thrust from pressure/temperature requires the use of guides to provide lateral stability to the pipe. This is determined by using the Euler equation for critical elastic buckling for a slender column:

$$L = \pi * (I/(\alpha * \Delta T * A))^{1/2}$$

L = Recommended guide spacing (in)
I = Moment of inertia (in^4)
A = Cross sectional area of reinforcement (in^2)
α = Coefficient of thermal expansion (in/in/°F)
ΔT = Change in temperature

Since a low coefficient of thermal expansion increases spacing, the resulting guide spacing for Durcor pipe is quite large.

Guide Spacing Between Anchors

Size (in)	Spacing @ 100 °F (ft)	Spacing @ 150 °F (ft)	Spacing @ 300 °F (ft)
1	7.9	4.9	2.8
1-1/2	11.5	7.1	4.2
2	14.5	8.9	5.2
3	21.5	13.1	7.8
4	28.0	17.1	10.0
6	41.5	25.5	15.0
8	54.2	33.2	19.5

Assumes installation temperature of 75 °F.

Testing

Durcor piping systems should be hydrostatically tested prior to beginning service. Care should be taken to avoid water hammer. All anchors, guides, and supports must be in place prior to testing the line.

Test pressure should not be more than 1-1/2 times the working pressure of the piping system and never exceed 1-1/2 times the rated operating pressure of the lowest rated component in the system. **Warning**: Do not hydro-test until all supports, anchors, and guides are properly installed.

Water Hammer

Care should be taken when designing a PTFE-lined composite piping system to eliminate sudden surges. Soft start pumps and slow actuating valves should be considered.

Flange Torque

Durcor pipe may be bolted to mating raised face pipe flanges per the following recommended torques. Bolts should be tightened in a criss-cross fashion using lubricated fasteners. Applied torque should be in 30% increments until attaining full torque.

A final clockwise torquing of all bolts will ensure even stress. Actual sealing torque required will need to be determined based on any gasketing and condition of mating flanges.

A re-torquing of connections is recommended after 24 hours or one thermal cycle to accommodate the seating of the PTFE seal and bolt relaxation.

When bolting Durcor pipe or fittings to themselves or when bolted to PTFE-lined steel pipe or fittings, gaskets are not required and the following torque guildelines are applicable.

Size (in)	Lightly oiled ASTM A193 Gr. B7	PTFE coated ASTM A193 Gr. B7
1	10 – 15	5 – 10
1-1/2	20 – 25	10 – 15
2	35 - 45	20 - 25
3	40 - 50	25 - 30
4	30 – 40	20 – 25
6	50 – 60	30 – 35
8	80 – 90	50 – 55

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How to Specify

Standard Specification for Durcor® PTFE-Lined Composite Piping

Scope

This specification applies to all Durcor lined pipe and fittings manufactured by PureFlex Inc. ASTM standards are referenced where applicable. Portions of such standards may be cited as there exists no one standard today that encompasses all aspects of this piping system.

Applicable Documents

ASTM F1545 "Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges"

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Section 1 - Quality Control

1.1 All pipe and fittings to be manufactured in dedicated tooling with written work instructions to ensure consistent and repeatable product.

1.2 Manufacturing operation to be certified to ISO 9001:.

1.3 PTFE pipe liners to be roll tested for sub-surface cracks.

1.4 PTFE liners to be candlelight inspected for defects. Neither physically damaged material nor cosmetic discolorations are allowed.

1.5 PTFE shall be physically tested for tensile and elongation conformance to applicable ASTM standard.

1.6 Pipe and fittings to be hydrostatically shell tested at 1.5X maximum allowable working pressure as per AQL Level 2.

Section 2 - Design

2.1 Pipe shall be tested and qualified to assure a minimum of 4X safety factor between short term burst and maximum allowable working pressure at the maximum allowable fluid temperature.

2.2 Flanges to conform dimensionally to ANSI B16.5, except in thickness. Flange composite shall have a nominal tensile strength of 50,000 psi as per ASTM D-638 and a notched Izod impact strength of 35 ft-lb/in per ASTM D-256.

2.3 Man-made (hand lay-up or contact molded) fabrications shall not be allowed.

2.4 Fittings to be resin transfer molded in dedicated tooling. Premium vinyl ester resin to fully infuse ECR glass reinforcements which have been proven in design analysis and testing to produce repeatable safety factors of at least 4:1.

2.5 PTFE liner thicknesses to exceed the requirements of ASTM F1545.

2.6 PTFE liners to be uniform with no welds or seams. Chemical or mechanical bonding of PTFE to composite shall not be allowed.

2.7 Product to be full vacuum rated to the maximum allowable operating temperature.

2.8 Pipe shall be constructed of premium vinyl ester resin reinforced with 75% continuous glass bundles oriented in the axial and radial directions. Pipe thermal expansion shall not exceed 6.7 $X10^{-6}$ in/in/°F.

2.9 Composite to be UV inhibited.

2.10 Flange sealing diameters to comply with ASTM F1545. Flange connection shall not require additional spacer gaskets or backup flanges when bolted in a raised face condition.

2.11 Pipe to be vented to allow release of any potentially trapped permeated gases. The Durcor housing is impervious to corrosion attack from chlorinated permeants.

2.12 No metallic materials are to be used in the piping system with the exception of fasteners.

2.13 No painting or special corrosion-resistant protection is required.

Section 3 - Materials and Construction

3.1 PTFE Physical Properties

Property	ASTM Method	Unit	Value
Tensile Strength	D638	psi	3,500
Ultimate Elongation	D638	%	250
Flexural Modulus	D790	psi	70,000
Hardness	D2240	Shore D	55
Thermal Conductivity	E1530	Btu-in/hr-ft^2-°F	1.7
Dielectric Strength	D149	V/mil	600
Water Absorption	D570	%	<0.01
Static Coefficient of Friction			0.05
Specific Gravity			2.14-2.19

3.2 Pipe Construction

a. Epoxy vinyl ester resin
b. Resin-rich surface veils of a minimum 20 mils to form the inner surface of the Durcor pipe.
c. Dense bundles of glass rovings are applied in both the axial and radial directions to provide the mechanical properties of Durcor pipe.
d. Pipe is to have a final layer of veil for added UV protection.
e. Fittings shall be molded in dedicated resin transfer tooling.

3.3 Flange Torque

Durcor pipe may be bolted to mating raised face pipe flanges per the following recommended torques. Bolts should be tightened in a criss-cross fashion using lubricated fasteners. Applied torque should be in 30% increments until attaining full torque.

A final clockwise torquing of all bolts will ensure even stress. Actual sealing torque required will need to be determined based on any gasketing and condition of mating flanges.

A re-torquing of connections is recommended after 24 hours or one thermal cycle to accommodate the seating of the PTFE seal and bolt relaxation.

When bolting Durcor pipe or fittings to themselves or when bolted to PTFE-lined steel pipe or fittings, gaskets are not required and the following torque guildelines are applicable.

Size (in)	Lightly oiled ASTM A193 Gr. B7	PTFE coated ASTM A193 Gr. B7
1	10 – 15	5 – 10
1-1/2	20 – 25	10 – 15
2	35 - 45	20 - 25
3	40 - 50	25 - 30
4	30 – 40	20 – 25
6	50 – 60	30 – 35
8	80 – 90	50 – 55

3.4 Handling and Storage

Care is to be taken to not damage PTFE liner. Do not insert forklift forks into ID of pipe. Leave protective end caps on until installation. Durcor pipe is impervious to weathering. No special considerations are required for storage beyond avoiding high energy impact onto the pipe.

3.5 Painting Requirements

Durcor pipe is UV-inhibited and does not corrode from environmental exposure. Painting is not required. Coatings for corrosion protection are not required.

3.6 Approved Supplier(s)

PureFlex Inc. (616) 554-1100 or approved equal.

PF-0413-0216REV

PureFlex® Inc.
an ANDRONACO INDUSTRIES company
4855 Broadmoor Ave.
Kentwood, MI. 49512
Ph 616.554-1100 Fax 616.554-3633
www.pureflex.com