The Performance Pipe
Field Handbook

NOTICE

This Field Handbook contains selected information that is excerpted and summarized from the PPI Handbook for Polyethylene Pipe and Performance Pipe literatures. This handbook is a quick reference aid. The user should review the original source of publication which are all available at www.performancepipe.com for the most current version and for additional information.

This Field Handbook is not a design or installation manual, and it may not provide all necessary information, particularly with respect to special or unusual applications. This Field Handbook should not substitute for the design materials, standards and specifications available, and should not replace the advice of a qualified licensed engineer. Performance Pipe recommends engaging the services of a qualified licensed engineer for the evaluation of site-specific conditions, the determination of requirements, technical procedures and specific instructions for a project.

The information in this handbook is accurate to the best of Performance Pipe's knowledge, but the information in this handbook cannot be guaranteed because the conditions of use are beyond Performance Pipe's control.

INTRODUCTION

The Performance Pipe Field Handbook is generally directed toward municipal and industrial applications for Performance Pipe DriscoPlex® OD controlled piping products. The Handbook includes cautions and general information, piping products and features, and general design information about fluid flows, thermal and burial effects, and general installation information about handling and storage, joining, installation, inspection and testing, and operational guidelines. Information about fittings and Performance Pipe oilfield and gas distribution products is not included in the handbook. Please refer to specific Performance Pipe publications for information about these products.

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PRODUCTS AND FEATURES

Performance Pipe DriscoPlex® OD controlled polyethylene pipe and fittings are made from high-density polyethylene materials in accordance with applicable standards, for example ASTM, AWWA or API. OD controlled DriscoPlex® piping products typically are rated for pressure service, but may also be used for non-pressure and gravity flow applications. Product lines for particular applications are identified by a DriscoPlex® pipe number series.

Table 1 DriscoPlex® Piping Products for Municipal and Industrial Applications

Typical Markets	DriscoPlex® Series Piping Systems	Typical Features (Note 1)
Mining	DriscoPlex® 1700	IPS with Colored stripes to identify DR (see Table 2)
Water Distribution& Transmission	DriscoPlex® 4000	DIPS size AWWA C906 and NSF/ANSI 61 or NSF/ANSI 14
	DriscoPlex® 4100	IPS sized in Black AWWA C906 and NSF/ANSI 61 and/or 14 Available to Factory Mutual (Note 2) Colored Stripes optional
Water Service Tubing	DriscoPlex® 5100	IPS, CTS, and IDR sized in Solid Black or Blue meeting AWWA C901 and NSF/ANSI 61 and NSF/ANSI 14
Sewer Lines	DriscoPlex® 4600	IPS solid light colored Pipe to facilitate internal inspection
	DriscoPlex® 4700	DIPS gray Pipe to facilitate internal inspection
Industrial	DriscoPlex® 1000	IPS sized pipe in solid black

Notes for Table 1 Typical Features:
1. All Pipes are manufactured from Polyethylene PE4710 Pipe Resins
2. FM Approved for Class 150, Class 200 and Class 267 in sizes through 24"

IDENTIFICATION STRIPES AND COLORS

Where used for identification, the industry recognizes the following colored stripes

- Yellow for natural gas
- Blue for potable water
- Red for fire main
- Green for wastewater
- Purple for reclaimed

Table 2 Color Stripes to Identify DR
(DriscoPlex® 1700 Pipe for Mining applications)

Color	Pink	White	Red	Gold	Gray	Orange	Blue	Purple	Green	Brown
DR	6	7	9	11	13.5	15.5	17	21	26	32.5

Typical Physical Properties

Table 3 provides typical material physical property information for the DriscoPlex® HDPE material used for many Performance Pipe products.

SUNLIGHT (ULTRAVIOLET) EFFECTS

Performance Pipe black pipes include a minimum 2% carbon black in the material to provide long term UV protection. Black products and black products with color stripes are suitable for applications where there is long-term, direct exposure to ultraviolet light. This includes all surface, suspended, and above grade applications.

Sacrificial UV absorbers temporarily protect colored products by absorbing UV energy, but are used up over time. Color products, such as DriscoPlex® 4600 and 4700 light colored pipe are intended for underground long term service. Unprotected outdoor storage should not exceed 2 years for these products.

Table 3 Typical Material Physical

Property	Standard	Typical Value†	
Material Designation	ASTM F 412	PE4710	PE2708
Cell Classification	ASTM D 3350	445574C (black)	234373E (Yellow)
Density [4]	ASTM D 1505	0.960 g/cc (black) >0.947 (colored)	0.939 g/cc (Yellow)
Melt Index [4]	ASTM D 1238	0.08 g/10 min	0.18 g/10 min
Flexural Modulus [5]	ASTM D 790	>120,000 psi	>90,000 psi
Tensile Yield Strength [5]	ASTM D 638 Type IV	>3500 psi	2800 psi
SCG (PENT) [7]	ASTM F 1473	>500 hours	>2000 hours
HDB at 73°F (23°C) [4]	ASTM D 2837	1600 psi	1250 psi
Color; UV stabilizer [C] [E]	ASTM D 3350	Black Color	Yellow
HDS at 73°F	ASTM D2837	1000 psi	800 psi
Linear thermal expansion	ASTM D 696	8×10^{-5} in/in/°F	10×10^{-5} in/in/°F
Elastic Modulus	ASTM D 638	>175,000	100,000
Brittleness Temperature	ASTM D 746	<-103°F	<-103°F
Hardness	ASTM D 2240	Shore D 62	Shore D 63

†NOTICE. This typical physical property information is for polyethylene resins used to manufacture some Performance Pipe DriscoPlex® polyethylene piping products. It is not a product specification, and does not establish minimum or maximum values or manufacturing tolerances for resins or for piping products. These typical physical property values were determined using compression-molded plaques prepared from resin. Values obtained from tests of specimens taken from piping products can vary from these typical values. Performance Pipe has made every reasonable effort to ensure the accuracy of this information, but it may not provide all necessary information, particularly with respect to special or unusual applications. Some Performance Pipe products are made from materials having typical physical properties different from the values presented in this table.

Pressure Rating Design

DriscoPlex® PE 4710 polyethylene pipe can be applied over a wide temperature range, and perform well from –40°F to 140°F for pressure service, or to up to 180°F for gravity flow (non-pressure) or short term service. Gravity flow or non-pressure service above 180°F is not recommended. Pressure service above 140°F is not recommended. Pressure ratings are reduced at elevated temperatures (73.4°F and above). See Table 5.

PIPE PRESSURE RATING (PR)

DriscoPlex® OD controlled pressure pipes are pressure rated per ASTM F714 using the formula below.

$$PR = \frac{2\,HDS\,f_T\,A_f}{(DR-1)}$$

Where:

PR	=	Pressure Rating, psi
HDS	=	Hydrostatic Design Stress at 73°F, Table 3, psi
A_f	=	Environmental Application Factor, Table 4
f_T	=	Temperature Compensating Multiplier, Table 5
DR	=	OD Controlled Pipe Dimension Ratio

$$DR = \frac{OD}{t}$$

OD	=	OD-Controlled Pipe Outside Diameter, in.
t	=	Pipe Minimum Wall Thickness, in.

The dimension ratio, DR, is the ratio of the wall thickness to the pipe outside diameter. The lower the DR, the thicker the pipe wall, which correlates to a higher pressure rating.

Two design factors, A_f and f_T, are used to incorporate the environmental and service temperature conditions of the application into the product pressure rating. See Table 4 and Table 5.

Table 4 Environmental Design Factors for PE4710, A_f

Application	A_f
Water: Aqueous solutions of salts, acids and bases, Sewage, Wastewater, Alcohols, Glycols (anti-freeze solutions)	1.0
Nitrogen; Carbon dioxide; Methane; Hydrogen Sulfide; Non-Federally regulated applications involving dry natural gas or other non-reactive gases	1.0
Fluids such as solvating/permeating chemicals in pipe or soil (typically hydrocarbons) in >2% concentrations, natural or other fuel-gas liquid condensates, crude oil, fuel oil, gasoline, diesel, kerosene, hydrocarbon fuels, wet gas gathering, LVP Liquid Hydrocarbons, produced water with >2% hydrocarbons. Clean, dry, oil free gases having mild oxidizing effects (air oxygen, etc.)	0.5
Gases having mild oxidizing effects (air, oxygen, etc.) that contain solvating or permeating chemical vapors (lubricants, solvents, etc.)	0.4

Different Design Factors may be required by local or other regulations.

Table 5 PE4710 Temperature Compensating Multipliers, f_T

Average Annual Operating Temperature	f_T for PE 4710
$\leq 80°F$ (27°C)	1.0
$\leq 90°F$ (32°C)	0.9
$\leq 100°F$ (38°C)	0.8
$\leq 110°F$ (43°C)	0.8
$\leq 120°F$ (49°C)	0.7
$\leq 130°F$ (54°C)	0.7
$\leq 140°F$ (60°C)	0.6

[1]The average annual temperature is a weighted average of the daily operating temperature, and is not the highest temperature observed in the system.

[2] The f_T values are based on PE 4710 compounds with HDB = 1600 psi at 73°F and HDB = 1000 psi at 140°F and are calculated using the temperature equation that is shown in the PPI Handbook, Chapter 3, Appendix A and in PPI TR-3.

The f_T values shown in here are conservative since they are based on the highest temperature within each temperature range and are rounded.

Pressure Surge

When there is a sudden change in liquid flow velocity, a pressure surge will occur. With its unique ductile elastic properties, DriscoPlex® pipes have high tolerance for surge cycles. The low elastic modulus also provides a dampening mechanism for shock loads. For the same water velocity change, surge

pressures in DriscoPlex® polyethylene pipe are about 86% less than in steel pipe and about 50% less than in PVC pipe. Unlike other plastic and metal pipes, surge pressures in DriscoPlex® HDPE pipe are _above_ the working pressure capacity of the pipe.

Table 6 Surge Allowance at 80°F or less per ASTM F714

| DR | PR, psi | Recurring Surge Events | |
		Allowable Total Pressure During Surge, psi	Corresponding Sudden Velocity Change, fps
21	100	150.0	5.0
17	125	185.0	5.3
13.5	160	240.0	6.3
11	200	300.0	7.0
DR	PR, psi	Occasional Surge Events	
		Allowable Total Pressure During Surge, psi	Corresponding Sudden Velocity Change, fps
21	100	200	10.0
17	125	250	11.1
13.5	160	320	12.6
11	200	400	14.0

- _Surge allowance is available only for surge events. Surge allowance is applied above the working pressure; therefore, it cannot be used to increase continuous internal pressure capacity above that permitted by the working pressure._
- _PR, pressure rating, and surge allowance are per ASTM F714 and for PE4710 pipes. See Appendix A of PP501 for PC, pressure class, per AWWA C906._

Fitting Pressure Ratings

Like pipe, fittings for pressure service are pressure-rated using long-term internal pressure tests. Molded fittings are pressure rated the same as the DR of the fitting outlet.

Vacuum Ratings

Vacuum Ratings for Performance Pipe HDPE pipes are in Table 14. The vacuum capabilities of the pipeline vary with the pipe DR, temperature and the time of exposure to the vacuum conditions.

Chemical Resistance

Information about short-term chemical immersion tests of unstressed specimens is in the *PPI Handbook of Polyethylene Pipe*. (See link on the Performance Pipe website "Technical Library" page.) Additional information on chemical compatibility may be found in *PPI TR-19, Thermoplastic Piping for the Transport of Chemicals.* Because the particular conditions of an application may vary, short-term, unstressed chemical immersion test information is useful only as a preliminary guide. The apparent absence of effect in a short-term immersion test does not imply that there will be no effect where there is long-term exposure or applied stress or combinations chemicals or elevated temperature either individually or in any combination.

Potable water disinfection by chloramines and chlorine has been extensively tested and shown to have no affect on the long-term performance of Performance Pipe HDPE pipes for typical water distribution pipelines. Performance Pipe has not conducted tests on exposure to chlorine dioxide used as a secondary disinfectant. AWWA reports that this occurs in a very small percentage of US utilities. Performance Pipe is not intended for hot water service, and areas of significant elevated temperatures may require a pressure reduction or service life reduction where there is a continued replenishment of water disinfectant chemicals.

FLUID FLOW

DriscoPlex® polyethylene pipe is used to transport fluids that may be liquid or slurry, where solid particles are entrained in a liquid, or gas. This section provides general information for Hazen-Williams and Manning water flow and for Mueller high-pressure and low-pressure gas flow[1]. The flow information in this section may apply to certain conditions and applications, but it is not suitable for all applications. The user should determine applicability before use.

AIR BINDING AND VACUUM RELEASE

In rolling or mountainous country, additional drag due to air binding must be avoided. Air binding occurs when air in the system accumulates at local high spots. This reduces the effective pipe bore, and restricts flow. Vents such as standpipes or air release valves may be installed at high points to avoid air binding. If the pipeline has a high point above that of either end, vacuum venting may be required to prevent vacuum collapse, siphoning, or to allow drainage.

INSIDE DIAMETER

OD controlled DriscoPlex® polyethylene pipe is made using an extrusion

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[1]For flow formulas that require a surface roughness value, $\varepsilon = 7 \times 10^{-5}$ ft. is typically used for HDPE pipe.

process that controls the outside diameter and wall thickness. As a result, the inside diameter will vary according to the combined OD and wall thickness tolerances and other variables including toe-in, out of roundness, ovality, installation quality, temperature and the like. An inside diameter for flow calculations is typically determined by deducting two times the average wall thickness from the average OD. Average wall thickness is minimum wall thickness plus 6%.

When an actual ID is required for devices such as inserts or stiffeners that must fit precisely in the pipe ID, please refer to the manufacturing standard (ASTM, AWWA, etc.) or take actual measurements from the pipe.

Hazen-Williams

For some applications, empirical formulas are available, and when used within their limitations, reliable results can be obtained with greater convenience. Hazen and Williams developed an empirical formula for water at 60° F. Water's viscosity varies with temperature, so some error can occur at other temperatures.

Hazen-Williams formula for friction (head) loss in feet:

$$h_f = \frac{0.002083\,L}{d^{4.8655}}\left(\frac{100\,Q}{C}\right)^{1.85}$$

Hazen-Williams formula for friction (head) loss in psi:

$$p_f = \frac{0.0009015\,L}{d^{4.8655}}\left(\frac{100\,Q}{C}\right)^{1.85}$$

Where
- h_f = friction (head) loss, feet of water
- L = pipe length, ft
- d = pipe inside diameter, in.
- Q = flow, gal./min.
- C = Hazen-Williams Friction Factor, dimensionless
- p_f = friction (head) loss for water, psi

Water flows through pipes of different materials and diameters may be compared using the following formula. The subscripts 1 and 2 refer to the known pipe and the unknown pipe.

$$\% \ flow = 100 \frac{d_2}{d_1} \left(\frac{C_2}{C_1} \right)^{0.3806}$$

Table 7 Hazen-Williams Friction Factor, C

Pipe Material	Values for C		
	Range High / Low	Average Value	Typical Design Value
Polyethylene pipe or tubing	160 / 150	150-155[A]	150
Cement or mastic lined iron or steel pipe	160 / 130	148	140
Copper, brass, lead, tin or glass pipe or tubing	150 / 120	140	130
Wood stave	145 / 110	120	110
Welded and seamless steel	150 / 80	130	100
Cast and ductile iron	150 / 80	130	100
Concrete	152 / 85	120	100
Corrugated steel	–	60	60
[A] Determined on butt fused pipe with internal beads in place.			

Manning

For open channel water flow under conditions of constant grade, and uniform channel cross section, the Manning equation may be used. Open channel flow exists in a pipe when it runs partially full. Like the Hazen-Williams formula, the Manning equation is limited to water or liquids with a kinematic viscosity equal to water.

Manning Equation

$$V = \frac{1.486}{n} r^{2/3} S^{1/2}$$

where

V = flow velocity, ft/sec
n = roughness coefficient, dimensionless (Table 8)
r = hydraulic radius, ft

$$r = \frac{A}{P}$$

A = channel cross section area, ft^2
P = perimeter wetted by flow, ft
S = hydraulic slope, ft/ft

$$S = \frac{h_1 - h_2}{L} = \frac{h_f}{L}$$

h_1 = upstream pipe elevation, ft
h_2 = downstream pipe elevation, ft
h_f = friction (head) loss, ft of liquid

It is convenient to combine the Manning equation with:

$$Q = AV$$

To obtain:

$$Q = \frac{1.486\, A}{n} r^{2/3}\, S^{1/2}$$

Where terms are as defined above, and

Q = flow, cu-ft/sec

When a circular pipe is running full or half-full,

$$r = \frac{D}{4} = \frac{d}{48}$$

Where
D = pipe bore, ft
d = pipe bore, in

Full pipe flow in cu-ft per second may be estimated using:

$$Q = \left(6.136 \times 10^{-4}\right)\frac{d^{8/3}\, S^{1/2}}{n}$$

Full pipe flow in gallons per minute may be estimated using:

$$Q' = 0.275 \frac{d^{8/3} S^{1/2}}{n}$$

Nearly full circular pipes will carry more liquid than a completely full pipe. When slightly less than full, the hydraulic radius is significantly reduced, but the actual flow area is only slightly lessened. Maximum flow is achieved at about 93% of full pipe flow, and maximum velocity at about 78% of full pipe flow.

Table 8 Values of n for use with Manning Equation

Surface	n, range	n, typical design
Polyethylene pipe	0.008 – 0.011	0.009
Uncoated cast or ductile iron pipe	0.012 – 0.015	0.013
Corrugated steel pipe	0.021 – 0.030	0.024
Concrete pipe	0.012 – 0.016	0.015
Vitrified clay pipe	0.011 – 0.017	0.013
Brick and cement mortar sewers	0.012 – 0.017	0.015
Wood stave	0.010 – 0.013	0.011
Rubble masonry	0.017 – 0.030	0.021

Compressible Gas Flow

Flow formulas for smooth pipe may be used to estimate gas flow rates through DriscoPlex® polyethylene pipe. For high pressures, the High Pressure Mueller Equation can be used.

High-Pressure Mueller Equation:

$$Q_h = \frac{2826\, d^{2.725}}{S_g^{\,0.425}} \left(\frac{p_1^{\,2} - p_2^{\,2}}{L} \right)^{0.575}$$

Where

Q_h = flow, standard ft³/hour
S_g = gas specific gravity
p_1 = inlet pressure, lb/in² absolute
p_2 = outlet pressure, lb/in² absolute
L = length, ft
d = pipe bore, in

LOW PRESSURE GAS FLOW

For applications where less than 1 psig is encountered, such as landfill gas gathering or wastewater odor control, the low-pressure Mueller equation may be used.

Low-Pressure Mueller Equation

$$Q_h = \frac{2971 d^{2.725}}{S_g^{0.425}} \left(\frac{h_1 - h_2}{L} \right)^{0.575}$$

Where terms are as defined previously, and

    h_1 = inlet pressure, in H_2O

    h_2 = outlet pressure, in H_2O

Comparative Flows for Slipliners

Sliplining rehabilitation of deteriorated gravity flow sewers involves installing a polyethylene liner inside of the original pipe. For conventional sliplining, clearance between the liner outside diameter, and the existing pipe bore is required to install the liner. So after rehabilitation, the flow channel is smaller than the original pipe. However, DriscoPlex® polyethylene pipe has a smooth surface that resists aging and deposition. It may be possible to slipline, and maintain all or most of the original flow capacity. See Table 9

Comparative flow capacities of circular pipes may be determined by the following:

$$\% \, flow = 100 \frac{Q_1}{Q_2} = 100 \frac{\left(\dfrac{d_1^{8/3}}{n_1} \right)}{\left(\dfrac{d_2^{8/3}}{n_2} \right)}$$

Table 9 was developed using the above formula where

    d1 = the liner ID,

    d_2 = the existing sewer ID.

Table 9 Comparative Flows for Slipliners

Existing Sewer ID, in	Liner OD, in.	Liner DR 26			Liner DR 21			Liner DR 17		
		Liner ID, in.	flow vs. concrete %	flow vs. clay %	Liner ID, in.	flow vs. concrete %	flow vs. clay %	Liner ID, in.	flow vs. concrete %	flow vs. clay %
4	3.500	3.215	93.0	80.6	3.147	87.9	76.2	3.064	81.8	70.9
6	4.500	4.133	61.7	53.5	4.046	58.3	50.5	3.939	54.3	47.0
6	5.375	4.937	99.1	85.9	4.832	93.6	81.1	4.705	87.1	75.5
8	6.625	6.085	80.3	69.6	5.956	75.9	65.8	5.799	70.7	61.2
10	8.625	7.922	89.5	77.6	7.754	84.6	73.3	7.549	78.8	68.3
12	10.750	9.873	99.1	85.9	9.665	93.6	81.1	9.409	87.1	75.5
15	12.750	11.710	86.1	74.6	11.463	81.4	70.5	11.160	75.7	65.6
16	14.000	12.858	93.0	80.6	12.587	87.9	76.2	12.254	81.8	70.9
18	16.000	14.695	97.0	84.1	14.385	91.7	79.4	14.005	85.3	74.0
21	18.000	16.532	88.1	76.3	16.183	83.2	72.1	15.755	77.5	67.1
24	22.000	20.206	105.3	91.3	19.779	99.5	86.2	19.256	92.6	80.3
27	24.000	22.043	97.0	84.1	21.577	91.7	79.4	21.007	85.3	74.0
30	28.000	25.717	110.5	95.8	25.173	104.4	90.5	24.508	97.2	84.2
36	32.000	29.391	97.0	84.1	28.770	91.7	79.4	28.009	85.3	74.0
36	34.000	31.228	114.1	98.9	30.568	107.7	93.4	29.760	100.3	86.9
42	36.000	33.065	88.1	76.3	32.366	83.2	72.1	31.511	77.5	67.1
48	42.000	38.575	93.0	80.6	37.760	87.9	76.2	36.762	81.8	70.9

Fitting and Valve Friction Losses

Fluids flowing through a fitting or valve will experience a friction loss, which is frequently expressed as an equivalent length of pipe. Equivalent length is found by multiplying the applicable resistance coefficient, K, for the fitting by the pipe diameter, D, in feet.

$$L = K' D$$

Table 10 Fitting Equivalent Lengths, K'D

Fitting	K'D
90° molded elbow	30 D
45° molded elbow	16 D
45° fabricated elbow	12 D
90° fabricated elbow	24 D
Equal outlet tee, run/branch	60 D
Equal outlet tee, run/run	20 D
Conventional globe valve, full open	350 D
Conventional angle valve, full open	180 D
Conventional Wedge Gate Valve, full open	15 D
Butterfly valve, full open	40 D
Conventional swing check valve	100 D

THERMAL EFFECTS

In response to changing temperature, unrestrained polyethylene pipe will undergo a length change. Anchored or end restrained pipe will develop longitudinal stresses instead of undergoing a change in length. This stress will be tensile during temperature decrease, or compressive during temperature increase. If the compressive stress level exceeds the column buckling resistance of the restrained length, then lateral buckling (or snaking) will occur. While thermal effect stresses are well tolerated by polyethylene pipe, anchored or restrained pipe may apply stress to restraining structures. Restraining structures must be designed to resist thermal effect loads that can be significant, particularly during thermal contraction. See PP814 "Engineering Considerations for Temperature Change" on the Performance Pipe website.

Unrestrained Thermal Effects

The theoretical length change for an unrestrained pipe on a frictionless surface is:

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

Where:

- ΔL = length change, in
- L = pipe length, in
- α = thermal expansion coefficient, in/in/°F
- = about 8×10^{-5} in/in/°F for DriscoPlex® PE 4710
- ΔT = temperature change, °F

An approximate "rule of thumb" is 1/10/100, that is, 1 in for each 10° F change for each 100 ft of pipe. This is a significant length change compared to other piping materials and should be taken into account when designing unrestrained piping such as surface and above grade piping. A temperature rise results in a length increase while a temperature drop results in a length decrease.

End Restrained Thermal Effects

A length of pipe that is restrained or anchored on both ends and subjected to a temperature decrease will apply significant tensile loads on the end restraints. Thermal contraction tensile stress can be determined using:

$$\sigma = E \alpha \Delta T$$

Where terms are as defined above, and

- σ = longitudinal stress in pipe, psi
- E = elastic modulus, psi (Table 11)

The selection of the modulus can have a large impact on the calculated stress. When determining the appropriate time interval, consider that heat transfer occurs at relatively slow rates through the wall of polyethylene pipe, so temperature changes do not occur rapidly. Therefore, the average temperature is often chosen when selecting an elastic modulus.

As longitudinal tensile stress builds in the pipe wall, a thrust load is created on the end structures. This load can be significant and may be determined using:

$$F = \sigma A$$

Where terms are as defined above, and

    F =   end thrust, lb

    A =   cross section area of pipe, in^2

Table 11 Typical Elastic Modulus for DriscoPlex® PE 4710 Pipe

Load Duration	Elastic Modulus†, 1000 psi , at Temperature, °F (°C)							
	-20 (-29)	0 (-18)	40 (4)	60 (16)	73 (23)	100 (38)	120 (49)	140 (60)
Short-Term	330.2	283.4	193.7	153.4	130.0	94.9	75.4	55.9
10 h	165.1	141.7	96.9	76.7	65.0	47.5	37.7	28.0
100 h	139.7	119.9	82.0	64.9	55.0	40.2	31.9	23.7
1000 h	116.8	100.3	68.5	54.3	46.0	33.6	26.7	19.8
1 y	101.6	87.2	59.6	47.2	40.0	29.2	23.2	17.2
10 y	86.4	74.1	50.7	40.1	34.0	24.8	19.7	14.6
50 y	73.7	63.2	43.2	34.2	29.0	21.2	16.8	12.5
† Typical values taken from PPI Handbook of Polyethylene Pipe, 2nd. Ed. (2008)								

Flexible polyethylene pipe does not transmit compressive force very well. During temperature increase, the pipe usually will deflect laterally (snake sideways) before developing significant compressive force on structural restraints. Lateral deflection may be approximated by

$$y = L\sqrt{\frac{\alpha\,\Delta T}{2}}$$

Where

    y =   lateral deflection, in

    L =   distance between endpoints, in

    α =   thermal expansion coefficient, in/in/°F

  ΔT =   temperature change, °F

A long, semi-restrained pipe run can snake to either side of the run centerline. Total deflection is

$$Y_T = 2(\Delta y) + D$$

Where terms are as defined above and

   Y_T =   total deflection, in

    D =   pipe diameter, in

To minimize thrust loads on restraints or to control which side of the centerline the pipe snakes, an initial deflection can be provided so the pipe does not contract to a straight line at minimum expected temperature. Likewise, during thermal expansion, pipe that is pre-snaked requires less force than predicted to continue snaking. At the time of installation, the anticipated temperature change from installation temperature to minimum temperature should be determined. Using this temperature change and the distance between points, determine lateral deflection, and install the pipe with this lateral deflection plus the minimum lateral deflection specified by the designer.

Care should be taken to ensure that thermal expansion deflection does not result in kinking. Thermal expansion deflection bending should not result in a bend that is tighter than the minimum long-term cold field-bending radius in Table 26.

EXPANSION JOINTS

In general, expansion joints are not recommended for use with HDPE pipe, especially in pressure service. If used, expansion joints must be specifically intended for use with HDPE pipe to activate at very low longitudinal forces and permit large movements. Expansion joints intended for use with other piping materials are not recommended for several reasons. (1) Expansion allowance is frequently insufficient for polyethylene. (2) The force required to activate the joint may exceed the column buckling strength of the polyethylene pipe. (3) Expansion joints for pressure service may include internal components that when pressurized, will place an end load on the pipe. HDPE pipe has low resistance to end loads, and likely will deflect sideways rather than compress the expansion joint. Contact the expansion joint manufacturer prior to use.

Heat Transfer

Polyethylene pipe may be heat traced, insulated, or both. Temperature limited (120°F maximum) heat tracing tape should be used, and the tape should be installed over a pressure-sensitive metallic tape installed on the pipe. The metallic tape helps distribute heat over the pipe surface.

Thermal conductivity terms:

C = thermal conductance, BTU/(hr-ft^2-°F)
t = thickness, in

$$C = \frac{k}{t} = \frac{1}{R}$$

Table 12 Typical Thermal Properties for DriscoPlex® HDPE

Property	ASTM Reference	Nominal Value
Thermal Conductivity, k	C 177	3.5 Btu/in)
Thermal Resistance, R (1" thickness)	–	0.3 (hr-ft^2-°F)/Btu

ABOVE GRADE SUPPORTS

Above grade applications frequently require non-continuous support for DriscoPlex® OD controlled polyethylene pipe. Such applications usually involve piping in a rack or trestle, on sleepers, or suspended from an overhead structure. In such cases, the pipeline must be properly supported, thermal expansion and contraction movement must be accommodated and supports must be spaced to limit vertical deflection between supports. See PP815 "Above Grade Pipe Support" on the website.

Supports for DriscoPlex® OD controlled pipe must cradle at least the bottom 120° of the pipe, and be at least 1/2 pipe diameter wide. Edges should be rounded or rolled to prevent cutting into the pipe. Commercial pipe supports such as u-bolts, narrow strap-type hangers, and roller type supports are unsuitable unless modified for width and cradling. The weight of the pipe and its contents must be distributed over a broad surface. Narrow support surfaces can produce high concentrated stress, and possibly lead to pipeline failure. Figure 1 and Figure 2 illustrate supports and hangers.
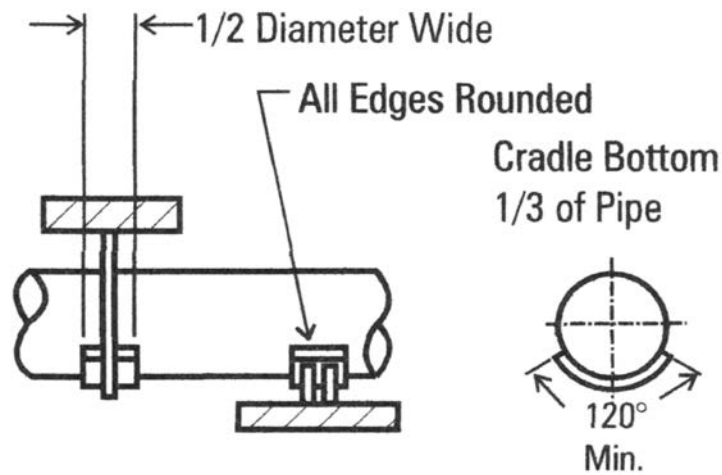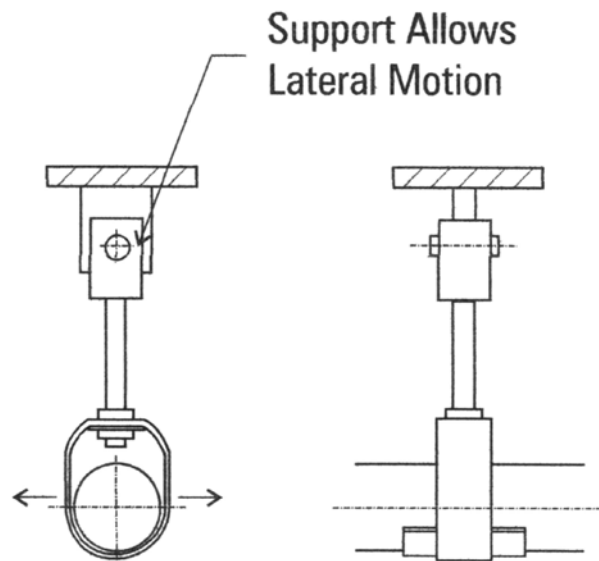
Figure 1 Pipeline Supports

Figure 2 Pipeline Hanger

Support Spacing

Support spacing depends upon the allowable deflection between supports, which in turn depends upon the pipeline, the fluid within it, and the service temperature. Performance Pipe recommends that the allowable long-term deflection between supports should not exceed 1". Recommended support spacing may be determined from the following:

$$L_S = \sqrt[4]{\frac{384\,E\,I\,y_S}{5\left(W_P + W_F\right)}}$$

where:

  L_S = distance between supports, in
  E = long-term modulus for the service temperature, lb/in^2
      (SeeTable 11)
  I = moment of inertia, in^4
  y_S = deflection between supports, in
  W_P = weight of pipe, lb/in
  W_F = weight of fluid in pipe, lb/in

Each support along a piping run is loaded from both sides. When run supports are equally spaced, the load on supports along the run is:

$$W_{RUN} = L \left(W_P + W_F \right)$$

where:

  W_{RUN} = load on supports along the run, lb

When supports are at the beginning or end of the run, the supports are loaded from only one side, thus the load on end supports is:

$$W_{END} = \frac{L \left(W_P + W_F \right)}{2}$$

Where:

  W_{END} = load on end supports, lb

The support spacing values in Table 13 were determined using a 1 in. deflection for DriscoPlex® PE 4710 pipes filled with water at 73°F (23°C). Support spacing will be greater at lower temperatures and when the pipe is not completely filled or fluid in the pipe is lighter than water (gases, etc.). Support spacing will be reduced for higher temperatures and for fluids in the pipe that are heavier than water (brine, slurries, etc.). The support spacing formulas in this section or in the *PPI Handbook of Polyethylene Pipe* should be used to determine support spacing when conditions vary from those in Table 13.
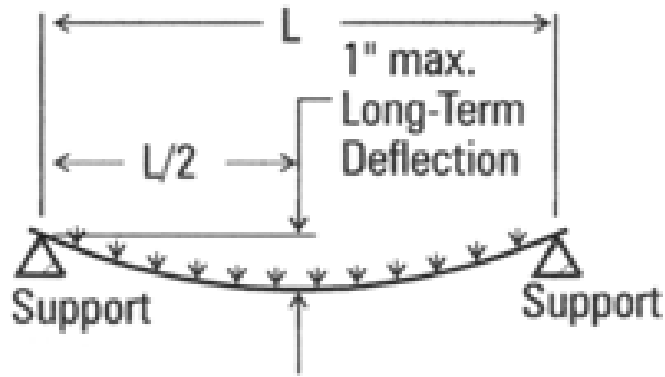
Figure 3 Support Spacing

Table 13 Support Spacing for DriscoPlex® PE 4710 Pipes

IPS size	OD, IN	DR 7.3	DR 11	DR 13.5	DR 17	DR 21	DR 26	DR 32.5	DR 41
2	2.375	5.3	4.9						
3	3.500	6.4	6.0	5.8	5.5	5.3			
4	4.500	7.3	6.8	6.5	6.3	6.0	5.7	5.4	
5	5.563	8.1	7.6	7.3	7.0	6.7	6.4	6.0	
6	6.625	8.8	8.3	7.9	7.6	7.3	6.9	6.6	
8	8.625	10.1	9.4	9.1	8.7	8.3	7.9	7.5	
10	10.750	11.2	10.5	10.1	9.7	9.2	8.8	8.4	
12	12.750	12.2	11.5	11.0	10.5	10.1	9.6	9.1	
14	14.000	12.8	12.0	11.5	11.0	10.6	10.1	9.6	
16	16.000	13.7	12.8	12.3	11.8	11.3	10.8	10.2	
18	18.000	14.5	13.6	13.1	12.5	12.0	11.4	10.9	
20	20.000	15.3	14.3	13.8	13.2	12.6	12.0	11.5	
22	22.000	16.1	15.0	14.5	13.8	13.2	12.8	12.0	
24	24.000	16.8	15.7	15.1	14.4	13.8	13.2	12.5	
26	26.000	17.5	16.3	15.7	15.0	14.4	13.7	13.1	
28	28.000		17.0	16.3	15.6	14.9	14.2	13.5	
30	30.000		17.6	16.9	16.1	15.4	14.7	14.0	13.3
32	32.000		18.1	17.5	16.7	15.9	15.2	14.5	13.7
34	34.000		18.7	18.0	17.2	16.4	15.7	14.9	14.2
36	36.000		19.2	18.5	17.7	16.9	16.2	15.4	14.6
42	42.000			20.0	19.1	18.3	17.4	16.6	15.7
48	48.000			21.4	20.4	19.5	18.6	17.7	16.8
54	54.000				21.7	20.7	19.8	18.8	17.8

BURIED PIPE DESIGN

The design of a subsurface pipe installation is based on the interaction between, the pipe and the surrounding soil . The stiffness of pipe and soil relative to each other determine pipe and embedment design and control overall performance for an application.

Embedment and static and dynamic loads from the surface cause vertical and horizontal pipe deflection. Pipe deflection mobilizes passive resistance forces from the embedment soil, which in turn limits horizontal deflection and balances the vertical load. Greater passive resistance is mobilized with stiffer surrounding soil, so less deflection occurs. Most polyethylene pipe should be considered flexible because the pipe's contribution to resisting deflection is usually less than that of the surrounding soil.

With polyethylene pipe it is important to check each application to ensure the adequacy of the installed design, including both pipe and embedment soils. PPI *Handbook of Polyethylene Pipe (available at Performance Pipe's website)* contains additional information.

The design guidelines in the *PPI Handbook of PE Pipe* are contingent upon the pipe being installed according to recognized industry standards for flexible pipe installation including as ASTM D-2321 *Standard Practice for underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow applications*, and ASTM D-2774 *Standard Practice for Underground Installation of Thermoplastic Pressure Pipe*.

WATER ENVIRONMENT CONSIDERATIONS

Water environment applications include any installation in a predominantly water environment, such as outfalls, crossings, floating and submerged pipelines, and wetland and marsh area installations. Sliplining may require design consideration for external hydrostatic loads if the water table rises above the liner. Water environment design considerations include external pressure, weighting, and flotation at or above the surface.

External Hydraulic Pressure

For the purposes of this discussion, unrestrained DriscoPlex® OD controlled polyethylene pipes are freestanding pipes that are not encapsulated in backfill or encased in grout. When installed where continuous or occasional submergence may occur, such pipes may be caused to collapse if the net external hydraulic pressure exceeds the flattening resistance of the pipe.

Flattening resistance should be considered for applications such as pipes carrying gases, pipes partially full of liquids, and any application where the internal pressure is less than the static external hydraulic load.

Open ended lines will be pressure balanced, and the static head in a full pipe crossing a water body will usually be the same or higher than the water height above the pipeline.

Table 14 External Pressure Resistances, psi

Service Temp., °F	Pipe DR	External Pressure Resistance, psi					
Values are for 3% oval pipe and include a 2.0 safety factor. Multiply psi by 2.307 to obtain feet of water.							
		50 y	10 y	1 y	1000 h	100 h	10 h
40	9	80.4	94.3	110.9	127.6	152.5	180.3
	11	41.2	48.3	56.8	65.3	78.1	92.3
	13.5	21.1	24.7	29.1	33.4	40.0	47.3
	17	10.1	11.8	13.9	15.9	19.1	22.5
	21	5.1	6.0	7.1	8.2	9.8	11.5
	26	2.6	3.1	3.6	4.2	5.0	5.9
	32.5	1.3	1.5	1.8	2.1	2.5	3.0
73	9	54.0	63.3	74.5	85.6	102.4	121.0
	11	27.6	32.4	38.1	43.8	52.4	61.9
	13.5	14.1	16.6	19.5	22.4	26.8	31.7
	17	6.7	7.9	9.3	10.7	12.8	15.1
	21	3.5	4.1	4.8	5.5	6.6	7.7
	26	1.8	2.1	2.4	2.8	3.4	4.0
	32.5	0.9	1.0	1.2	1.4	1.7	2.0
100	9	39.4	46.2	54.3	62.5	74.7	88.3
	11	20.2	23.7	27.8	32.0	38.3	45.2
	13.5	10.3	12.1	14.2	16.4	19.6	23.2
	17	4.9	5.8	6.8	7.8	9.3	11.0
	21	2.5	3.0	3.5	4.0	4.8	5.7
	26	1.3	1.5	1.8	2.0	2.4	2.9
	32.5	0.6	0.8	0.9	1.0	1.2	1.4
120	9	31.3	36.7	43.2	49.7	59.4	70.2
	11	16.0	18.8	22.1	25.4	30.4	35.9
	13.5	8.2	9.6	11.3	13.0	15.6	18.4
	17	3.9	4.6	5.4	6.2	7.4	8.8
	21	2.0	2.3	2.8	3.2	3.8	4.5
	26	1.0	1.2	1.4	1.6	1.9	2.3
	32.5	0.5	0.6	0.7	0.8	1.0	1.1

Submergence Weighting

DriscoPlex® polyethylene materials are lighter than water and pipe will float slightly above the surface when filled with water. Submerged pipe must be ballasted to keep it submerged.

DETERMINATION OF THE REQUIRED WEIGHTING

The net upward buoyant force exerted by a submerged pipeline equals the sum of the weight of the water the pipe displaces (W_{DW}) minus the weight of the pipe and its contents. For fully submerged pipe, the upward buoyant force from the weight of water the pipe displaces is approximated by:

$$W_{DW} = 0.00545 D_O^2 \rho_W$$

Where: W_{DW} = weight of displaced water (lbs/ft)

D_O = pipe's outside diameter (in)

ρ_W = Density of fluid (lbs/ft³) (~62.4 lbs/ft³ for fresh water)

The ballast weight must counter the net upward buoyant force and be sufficient to counter external forces due to currents, wave/tidal action, etc. For many submerged installations, a weighting of 25% to 50% of the pipe displacement (W_{DW}) has been demonstrated as sufficient to counter upward forces and maintain a properly anchored submerged PE pipe that is <u>full of water</u>. However, the project's professional engineer should make the final determination of the required weighting based on the project's specific parameters. Once the required weighting is determined, weight spacing and buoyancy of the weights themselves are used to determine the required ballast weight on land. Details on calculating required ballast weights are given in Chapter 10 of the PPI *Handbook of Polyethylene Pipe* available at www.plasticpipe.org.

Table 15 presents calculated weights using the concepts in Chapter 10 of the PPI Handbook. Key assumptions in the values to note include:

- HDPE pipe sizes are IPS (iron pipe size OD)
- Pipe installed in fresh water (density of 62.4 lbs/ft^3)
- Installed pipe remains full of fresh water (density of 62.4 lbs/ft^3)
- Ballast Spacing = 10 feet
- Ballast weights have a specific gravity of 2.4 (concrete with density of ~150 lbs/ft^3)

Table 15 Minimum Design Ballast Weight

Pipe Size IPS	Minimum Design Ballast Weight in Air, B_A (lbs)			
	Deep Water		Near Shore	
	25% W_{DW}	50% W_{DW}	60% W_{DW}	70% W_{DW}
12	237	474	569	663
18	472	944	1,133	1,322
24	840	1,679	2,015	2,351
36	1,889	3,778	4,533	5,289

For other sizes or project parameters that differ from the assumptions, the required weighting can be calculated using the concepts in Chapter 10 of the PPI Handbook of PE Pipe.

MAXIMUM BALLAST WEIGHT FOR FLOAT AND SINK INSTALLATION

Many marine installations involve placing the ballast weights on air filled pipe, towing the pipeline into position, and then filling the line with water to sink the pipe. There is a limit on the ballast weights that will facilitate this installation method. The maximum upward buoyant force for 100% air filled pipe would roughly equate to W_{DW} minus the weight of the pipe. For the float and sink method, typically the ballast weight in water (Bw) is limited to roughly 65 to 85% of this maximum. Table 16 presents calculated weights based on these concepts. Key assumptions to note in values include:

- HDPE Pipe sizes are IPS (iron pipe size OD)
- Pipe installed in fresh water (density of 62.4 lbs/ft^3)
- Pipe is full of air and based on 85% of weight for neutral buoyancy
- Ballast Spacing = 10 feet
- Ballast weights have a specific gravity of 2.4 (concrete with density of ~150 lbs/ft^3)

Table 16 Maximum Ballast Weight for Float and Sink

| Pipe Size IPS	Maximum Ballast Weight in Air for Float & Sink Installation (lbs)		
	DR 11	DR 17	DR 21
12	537	625	658
18	1,070	1,246	1,311
24	1,902	2,215	2,330
36	4,280	4,984	5,243

For other sizes or project parameters that differ from the assumptions (such as weight spacing, etc.), the required weighting can be calculated using the concepts in Chapter 10 of the PPI Handbook of PE Pipe.

If the required weights exceed the values that will allow the float and sink method, some options include adding additional weight after installation, temporarily increasing buoyancy by the use of empty tanks or drums, or attaching the weights from a barge from which the pipe is slid to the bottom by means of a sled designed to prevent over bending the pipe during the installation.

WEIGHT SHAPES

Submergence weights are frequently made of reinforced concrete, which allows considerable flexibility of shape design. Weights are typically formed in two or more sections that clamp around the pipe over an elastomeric padding material. There should be clearance between the sections, so when clamped onto the pipe, the sections do not slide along the pipe. In general, weights are flat bottom, and bottom heavy. This prevents rolling from crosscurrent conditions. Fasteners securing the weight sections together must be resistant to the marine environment.

Figure 4 Concrete Ballast Weight
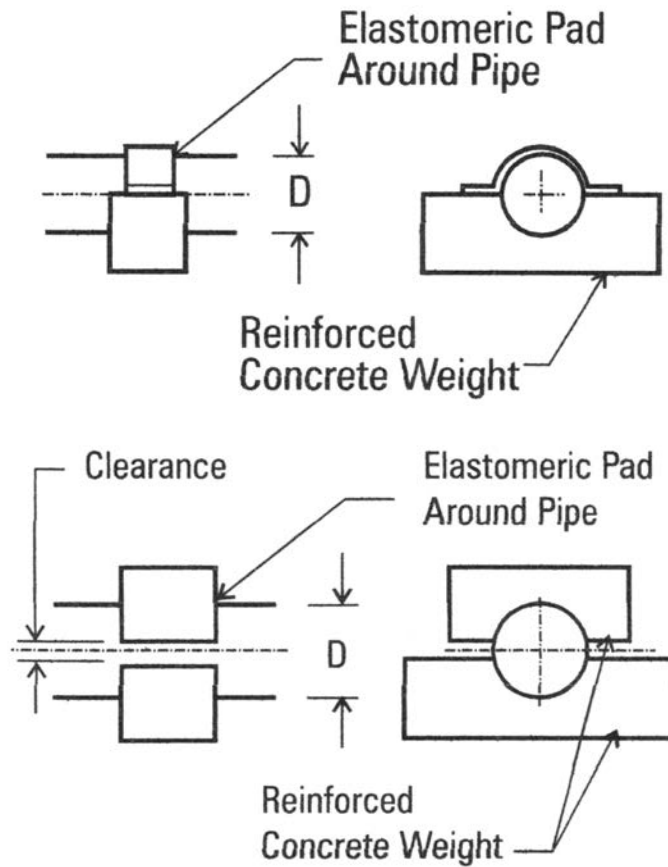
Floating Pipelines

Pipelines for dredging or for discharging slurries into impoundments may be required to float on or above the surface. Polyethylene is about 4.5% lighter than water, so the pipe will float when filled with water. However, liquid slurries may be heavy enough to sink the line.

When the pipeline is supported above the surface, the floats must support their own weight and the weight of the pipeline and its contents. When floated at the surface, the displacement of the pipeline in the water reduces floatation requirements. Figure 5 and Figure 6 illustrate float attachment methods.

Figure 5 Flotation Above the Surface
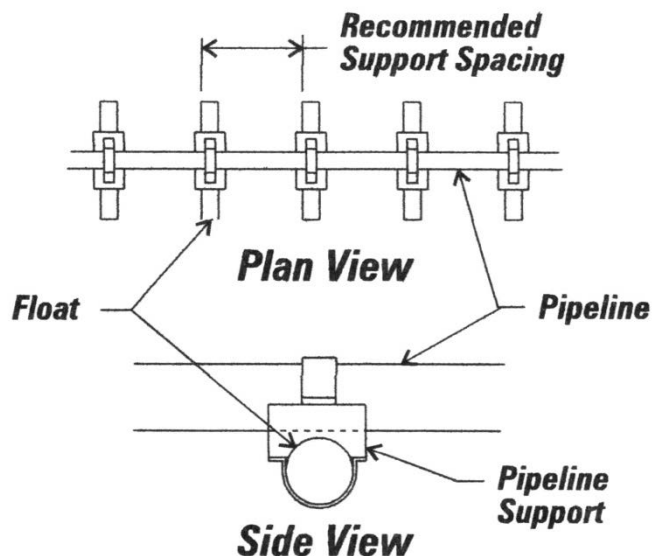
Figure 6 Flotation On the Surface
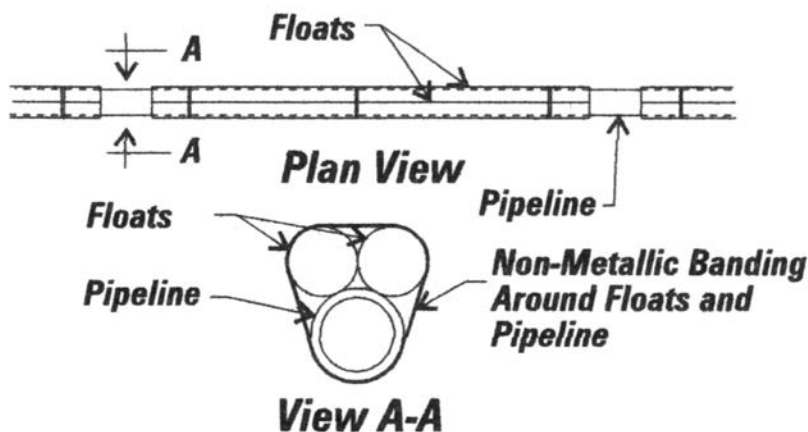
POLYETHYLENE PIPE FOR FLOTATION

DriscoPlex® OD controlled pipe may be used for flotation to support pipelines above the water or at the surface. Typically, floats are pipe lengths that are capped on the ends. Floats can be filled with lightweight foam so that physical damage will not allow the float to fill with water and impair its ability to support a load.

Float sizing is an iterative process because the float must support itself as well as the load. The first step is to determine the load, and choose an initial size for the float.

Step 1. Load Determination

The supported load is the weight of the pipeline and its contents plus the weight of the float and the structure for attaching the float to the pipeline. If the float is foam-filled, the weight of the foam must also be included.

$$P = W_P + W_C + W_S + W_F + W_M$$

Where

P	=	supported load, lb/ft
W_P	=	weight of pipeline, lb/ft
W_C	=	weight of pipeline contents, lb/ft
W_S	=	weight of float attachment structure, lb
W_F	=	weight of float, lb/ft (Table 17)
W_M	=	weight of foam fill, lb/ft

$$W_M = V_F\, M_M$$

V_F	=	float internal volume, ft³/ft (Table 17)
M_M	=	density of foam fill, lb/ft³

Thermoplastic foams typically weigh 2 to 3 lb/ft³. **Float spacing should not exceed maximum support spacing intervals. See Table 13**.

Table 17 Polyethylene Float Properties†

Nominal Size	Float Diameter, d, in	Float Weight, W_F, lb/ft	Float Buoyancy, B, lb/ft	Internal Volume, V_F, ft³/ft
4	4.500	0.83	6.9	0.097
6	6.625	1.80	14.9	0.211
8	8.625	3.05	25.3	0.357
10	10.750	4.75	39.3	0.555
12	12.750	6.67	55.3	0.781
14	14.000	8.05	66.7	0.941
16	16.000	10.50	87.1	1.230
18	18.000	13.30	110	1.556
20	20.000	16.41	136	1.921
22	22.000	19.86	165	2.325
24	24.000	23.62	196	2.767
26	26.000	27.74	230	3.247
28	28.000	32.19	267	3.766
30	30.000	36.93	306	4.323
32	32.000	42.04	349	4.919
34	34.000	47.43	393	5.553

| 36 | 36.000 | 53.20 | 441 | 6.225 |

† Properties based on black HDPE material (0.960g/cm³ density) and DR 32.5 pipe.

Step 2. Float Submergence Percentage
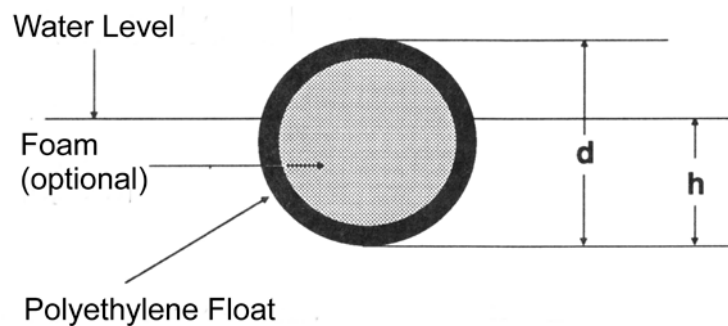
The percent submergence is the percent of the float that is below the water level as illustrated in Figure 7.

$$\% \, Submergence = 100 \, \frac{h}{d}$$

Where

h = pipe submergence below water level, in
d = pipe diameter, in

Figure 7 Float Submergence

The designer should choose an appropriate percent submergence and submergence margin. For the floats in Table 17, submergence margins are shown in Table 18. If the percent submergence is too high, point-loaded floats may deflect at the load center and be more deeply submerged at the load center compared to unloaded areas.

Table 18 Submergence Margin

% Submergence	*Submergence Margin*
55%	2
43%	3
37%	4

Step 3. Float Support Capacity

Determine the float buoyancy, B, from Table 17 for the initial float size. Then determine the submergence factor, f_S, from Table 19.

Table 19 Submergence Factor, f_S

Submergence		Submergence		Submergence		Submergence	
%	Factor, f_S	%	Factor, f_S	%	Factor, f_S	%	Factor, f_S
5	0.019	30	0.252	55	0.564	80	0.858
10	0.052	35	0.312	60	0.623	85	0.906
15	0.094	40	0.377	65	.0688	90	0.948
20	0.142	45	0.436	70	0.748	95	0.981
25	0.196	50	0.500	75	0.804	100	1.000

Determine the load supporting capacity of the float, P_F.

$$P_F = f_S\, B$$

Where

P_F = float load supporting capacity, lb/ft

f_S = submergence factor from Table 19

B = buoyancy from Table 17

Step 4. Compare Float Support Capacity to Load

The support capacity of the float must equal or exceed the load it is to support.

$$P_F \geq P$$

If the load, P, is greater than the float support capacity, P_F, choose a larger float and repeat Steps 1, 2 and 3. If the float support capacity, P_F, is significantly greater than the load, P, a smaller float may be adequate.

Step 5. Check Actual Float Submergence

Once the proper float size has been determined, check the actual float submergence.

$$f_{SA} = \frac{P}{B}$$

Where

f_{SA} = actual float submergence factor

The actual float submergence factor, f_{SA}, may be compared to the values in Table 19 to determine the approximate percent submergence.

RECEIVING AND HANDLING

RECEIVING INSPECTION

There is no substitute for visually inspecting an incoming shipment to verify that the paperwork accurately describes the load. Performance Pipe products are identified by markings on each individual product. These markings should be checked against the Packing List. The number of packages and their descriptions should be checked against the Bill of Lading.

The delivering truck driver will ask the person receiving the shipment to sign the Bill of Lading, and acknowledge that the load was received in good condition. Any damage, missing packages, etc., should be noted on the bill of lading at that time and reported to Performance Pipe immediately.

Unloading

Unsafe unloading or handling can result in death, injury or damage. Keep unnecessary persons away from the area while unloading.

Observe the unloading and handling instructions that are supplied with the load and available from the driver. UNLOADING AND HANDLING INSTRUCTIONS ARE AVAILABLE AT WWW.PERFORMANCEPIPE.COM *AND INCLUDE A VIDEO IN SPANISH AND ENGLISH.*

UNLOADING SITE REQUIREMENTS

Before unloading the shipment, there must be adequate, level space to unload the shipment. The truck should be on level ground with the parking brake set and the wheels chocked. Unloading equipment must be capable of safely lifting and moving pipe, fittings, fabrications or other components.

Silo packs and other palletized packages should be unloaded from the side with a forklift. Non-palletized pipe, fittings, or other components should be unloaded from above with lifting equipment and wide web slings, or from the side with a forklift.

Pipe must not be rolled or pushed off the truck. Pipe, fittings, and other components must not be pushed or dumped off the truck, or dropped.

HANDLING EQUIPMENT

Equipment must be appropriate for lifting and handling and have adequate rated capacity to lift and move components from the truck to temporary storage. Safe handling and operating procedures must be followed.

Equipment such as a forklift, a crane, a side boom tractor, or an extension boom crane is used for unloading.

When using a forklift, or forklift attachments on equipment such as articulated loaders or bucket loaders, lifting capacity must be adequate at the load center on the forks. Forklift equipment is rated for a maximum lifting capacity at a distance from the back of the forks, see Figure 8. If the weight-center of the load is farther out on the forks, lifting capacity is reduced.

Before lifting or transporting the load, forks should be spread as wide apart as practical, forks should extend completely under the load, and the load should be as far back on the forks as possible.

During transport, a load on forks that are too short or too close together, or a load too far out on the forks, may become unstable and pitch forward or to the side, and result in injury or damage.

Lifting equipment such as cranes, extension boom cranes, and side boom tractors, should be hooked to wide web choker slings that are secured around the load or to lifting lugs on the component. Only wide web slings should be used. Wire rope slings and chains can damage components, and should not be used. Spreader bars should be used when lifting pipe or components longer than 20'.

Before use, inspect slings and lifting equipment. Equipment with wear or damage that impairs function or load capacity should not be used.

Figure 8 Forklift Load Capacity
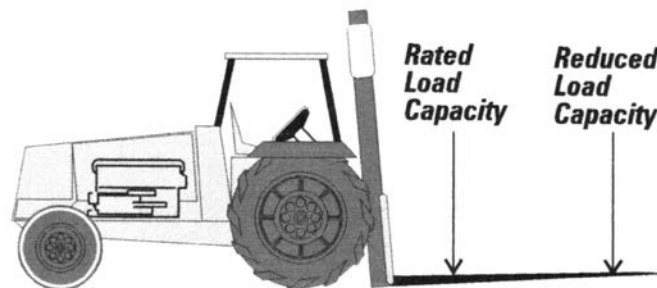
PRE-INSTALLATION STORAGE

The storage area should provide protection against physical damage to components, be of sufficient size to accommodate piping components, to allow room for handling equipment to get around, and have a relatively smooth, level surface free of stones, debris, or other material that could damage pipe or components, or interfere with handling.

PIPE STACKING HEIGHTS

Coiled pipe is best stored as received in silo packs. Individual coils may be removed from the silo pack without disturbing the stability of the package.

Pipe received in bulk packs or strip load packs should be stored in the same package. If the storage site is flat and level, bulk packs or strip load packs may be stacked evenly upon each other to an overall height of about 6'. For less flat or less level terrain, limit stacking height to about 4'.

Before removing individual pipe lengths from bulk packs or strip load packs, the pack must be removed from the storage stack and placed on the ground.

Figure 9 Loose Pipe Storage
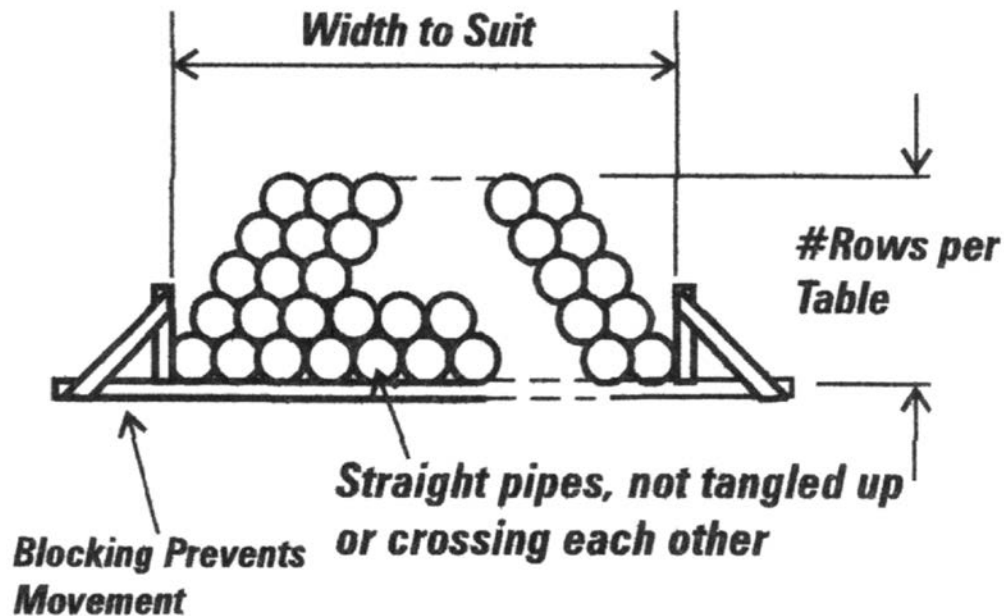
Individual pipes may be stacked in rows. Pipes should be laid straight, not crossing over or entangled with each other. **The base row must be blocked to prevent sideways movement or shifting.** See Figure 9 and Table 20. Loose pipe should be placed on wooden dunnage at least 4 inches wide, and evenly spaced at intervals of about 6 feet beginning about 2 feet from the end of the pipe. The interior of stored pipe should be kept free of debris and other foreign matter.

Table 20 Suggested Jobsite Loose Storage Stacking Heights

Nominal Size	Stacking Height, rows	
	DR Above 17	DR 17 & Below
4	15	12
6	10	8
8	8	6
10	6	5
12	5	4
14	5	4
16	4	3
18	4	3
20	3	3
22	3	2
24	3	2
26	3	2
28	2	2
32	2	2
36	2	1
42	1	1
54	1	1
Suggested stacking heights based on 6' for level terrain and 4' for less level terrain.		

Cold Weather Handling

Temperatures near or below freezing will affect polyethylene pipe by increasing stiffness, vulnerability to impact damage and sensitivity to suddenly applied stress especially when cutting. Polyethylene pipe will be more difficult to uncoil or field bend in cold weather.

Significant impact or shock loads against a polyethylene pipe that is at freezing or lower temperatures can fracture the pipe.

- *Do not drop pipe. Do not allow pipe to fall off the truck or into the trench.*
- *Do not strike the pipe with handling equipment, tools or other objects.*
- *Do not drag pipe lengths at speeds where bouncing against the surface may cause impact damage.*

Pipe should be firmly supported on both sides when cutting with a handsaw. Low temperature can cause the pipe to fracture at the cut if bending stress is applied.

Ice, snow, and rain are not harmful to the material, but may make storage areas

more troublesome for handling equipment and personnel. Unsure footing and traction require greater care and caution to prevent damage or injury.

JOINING & CONNECTIONS

For satisfactory material and product performance, system designs and installation methods rely on appropriate, properly made connections. An inadequate or improperly made field joint may cause installation delays, may disable or impair system operations, or may create hazardous conditions.

DriscoPlex® OD controlled piping products are connected using heat fusion, electrofusion, and mechanical methods such as MJ Adapters, flanges, and compression couplings. Joining and connection methods will vary depending upon requirements for internal or external pressure, leak tightness, restraint against longitudinal movement (thrust load capacity), gasketing requirements, construction and installation requirements, and the product.

Warning – Connection design limitations and manufacturers joining procedures must be observed. Otherwise, the connection or products adjacent to the connection may leak or fail which may result in property damage, or hazards to persons.

Correctly made fusion joints do not leak. Leakage at a joint or connection may immediately precede catastrophic failure. Never approach or attempt to repair or stop leaks while piping is pressurized. Always depressurize piping before making repairs.

Always use the tools and components required to construct and install joints in accordance with manufacturer's recommendations and instructions. However, field connections are controlled by, and are the responsibility of the field installer.

GENERAL PROCEDURES

All field connection methods and procedures require that the component ends to be connected must be clean, dry, and free of detrimental surface defects before the connection is made. Contamination and unsuitable surface conditions usually produce an unsatisfactory connection. Gasketed joints require appropriate lubrication.

CLEANING

Before joining, and before any special surface preparation, surfaces must be clean and dry. General dust and light soil may be removed by wiping the surfaces with clean, dry, lint free cloths. Heavier soil may be washed or scrubbed off with soap and water solutions, followed by thorough rinsing with clear water, and drying with dry, clean, lint-free cloths.

Note: The use of chemical cleaning solvents is not recommended.

CUTTING DRISCOPLEX® OD CONTROLLED PIPE

Joining methods for plain end pipe require square-cut ends. Pipe cutting is accomplished with guillotine shears, run-around cutters and saws. Before cutting, provide firm support on both sides.

Guillotine shears are commonly available for 2" and smaller pipe and tubing, and may incorporate a ratcheting mechanism to drive the blade through the pipe. Run-around pipe cutters are equipped with deep, narrow cutter wheels, and because of wall thickness, are usually limited to about 4" pipe. Care should be taken to avoid cutting a spiral groove around the pipe. Guillotine and run-around cutters provide a clean cut without chips.

For larger diameters, handsaws and chain saws are used. Coarse tooth handsaws provide greater chip clearance between the teeth, and maintain a clean blade when cutting. Chain saws are usually operated without chain lubrication because chain oil contamination will need to be removed from the pipe. Bucking spikes should be removed.

Saws will produce chips that must be removed from the pipe bore and cleared from the jobsite. Pipe ends may require deburring.

CUTTING BRANCH OUTLET HOLES

With the exception of self-tapping saddle tees, hole cutting will be required for field installed side outlet fittings. Commercial hole saws for metals are generally unsatisfactory for polyethylene because they do not provide adequate chip clearance, and may not be deep enough for the wall thickness. Polyethylene pipe hole saws are deep shell cutters with very few teeth, large chip clearance, and inside relief to retain the coupon. Polyethylene pipe joining equipment manufacturers should be contacted for additional information on hole saws.

When cutting, hole saws should be withdrawn frequently to clear the chips. Powered hole saws should be operated at relatively low speeds to avoid overheating and melting the material.

Heat Fusion Joining

Refer to Performance Pipe *Heat Fusion Joining Procedures and Qualification Guide,* Bulletin PP-750 and ASTM F2620 for recommended heat fusion joining procedures. This handbook does not provide heat fusion joining procedures.

Performance Pipe Fusion Joining Procedures should be reviewed before making heat fusion joints, and should be observed when making heat fusion joints with DriscoPlex® OD controlled polyethylene-piping products.

Heat fusion joining is a process where mating surfaces are prepared for joining, heated until molten, joined together and cooled under pressure. All fusion procedures require appropriate surface preparation tools, alignment tools, and temperature controlled heating irons with properly shaped, non-stick heater faces. *An open flame cannot be used for heating because it oxidizes the surface and prevents bonding.* During joining, all heat fusion procedures require the mating components to be moved several inches apart to accommodate surface preparation and surface heating tools.

Butt fusion joins plain end pipe or fittings end to end. Saddle fusion joins a curved base, branch outlet to the side of a pipe. Socket fusion joins a male pipe or fitting end into a female socket fitting. Heat fusion joining procedures do not add material to the joint; that is, no welding rods, adhesives, or cements are used.

Heat fusion joints made between appropriate products using appropriate equipment and recommended procedures are fully restrained, permanent joints. That is, correctly made heat fusion joints may be expected to last the life of the system and withstand thrust loads equal to the strength of the pipe without adding external restraint or thrust blocking.

Table 21 Approximate Butt Fusion Joining Rates

Pipe Size, IPS	Approximate Number of Fusions per Day
≤ 10"	15 – 40
10" – 18"	10 – 24
18" – 24"	6 – 16
24" – 36"	5 – 15
36" – 48"	4 – 10
54"	3 – 6

BEAD REMOVAL

Butt fusion produces a double-roll melt bead on the inside and the outside of the pipe. External beads typically do not to interfere with clearance during sliplining or insertion renewal, and internal beads have little or no effect on flow. Bead removal is time consuming, and if done improperly, may compromise long-term performance.

External beads are removed with run-around cutting tools, which are forced into the bead; then drawn around the pipe. Internal beads may be removed with remote controlled cutters, or length-by-length with a cutter fitted to a long pole. Manual or power tools such as chisels or planers may also be used, but care must be taken not to cut into the pipe surface.

BUTT FUSION IN THE FIELD

Set-up time is minimized when pipe lengths are fed through the machine and joined into long strings.

***Caution** – Dragging pipe strings along the ground at speeds above a walking pace can damage the pipe, especially in cold weather.*

Many Performance Pipe Distributors provide fusion joining services, and rent heat fusion equipment and may be consulted about equipment rental and fusion joining services. Performance Pipe does not rent fusion equipment or provide contract field fusion joining services.

Fusion procedure and equipment settings should be verified for the conditions at the jobsite. Verification can include ensuring operator training and qualification, testing for fusion quality, and recording fusion procedure and equipment operation.

The fusion technician should be able to document training and demonstrate proficiency with the fusion procedure, equipment and products being fused. Some fusion equipment may be connected to devices (such as a data logger) that can record equipment settings and operation during fusion. When used in combination with appropriate field fusion verification tests, data logger

information can provide a record of field fusion quality.

SADDLE (SIDEWALL) AND SOCKET FUSION

Saddle (sidewall) fusion is used to connect PE service and branch lines to PE mains. Socket fusion is used to connect smaller sizes typically for geothermal or force main applications. Refer to Performance Pipe Bulletin PP-750 for saddle and socket fusion procedures.

Saddle and socket fusion joints must be protected from bending during installation or as a result of soil settlement. More information can be found in the Controlling Shear and Bending section on page 73.

Electrofusion

Electrofusion is a heat fusion process where a coupling or saddle fitting contains an integral heating source. After surface preparation, the fitting is installed on the pipe and the heating source is energized. During heating, the fitting and pipe materials melt, expand and fuse together. Heating and cooling cycles are automatically controlled.

Electrofusion is the only heat fusion procedure that does not require longitudinal movement of one of the joint surfaces. It is frequently used where both pipes are constrained, such as for repairs or tie-in joints in the trench. Joints made between dissimilar polyethylene brands or grades are also made using electrofusion, as the procedure accommodates polyethylene materials with different melt flow rates. Electrofusion equipment and component manufacturers should be contacted for specific information.

EXTRUSION WELDING

Extrusion welding employs a small handheld extruder that feeds molten PE onto pre-heated, specially prepared PE surfaces. Preparation requires removing a thin layer of material from the surfaces of the parts being welded and cleaning, scraping, planing or beveling. The extrusion gun preheats the surfaces; then feeds a molten polyethylene bead into the prepared joint area.

The ideal environment for extrusion welding is in a plant or shop area where the requisite conditions for good welding are present, that is, cleanliness, properly trained operators and the special jigs and tools that are required for the extrusion welding process. Using prescribed procedures, welded joints produced under ideal conditions can develop up to 70% the tensile strength of the base material. Field joints usually require special care and highly trained operators to produce similar quality joints.

Typically, extrusion welding is used for shop fabrication of low pressure or non-pressure structures, such as manholes, tanks, very large fittings, dual containment systems and odor control structures.

Extrusion welding is not a substitute for butt, saddle or socket fusion and is not to be used to join or repair pressure pipe or fittings. Extrusion welding is not the same as Hot Gas (Hot Air) Welding.

HOT GAS WELDING

Hot gas (hot air) welding is not to be used with Performance Pipe polyethylene piping products.

Hot air (hot gas) welding uses hot air to melt a polyethylene "welding rod" and join the surfaces. It is usually limited to use with low molecular weight, high melt flow rate polyethylene materials. However, Performance Pipe polyethylene pipe products are made from stress-rated, high molecular weight, low melt flow rate polyethylene materials. These high quality polyethylene materials do not melt or flow easily. Under good conditions, hot gas weld strength is typically less than 15% of the parent material's strength, thus, hot gas welding is unsuitable for use with all Performance Pipe polyethylene piping products.

Mechanical Connections

Mechanical connections are used to connect polyethylene components to themselves or to other pipe materials or components. For MJ (mechanical joint) and flange connections, an adapter is butt fused to PE pipe; then the adapter is connected to the mating component. Other mechanical connectors connect directly to plain-end PE pipe. Compression couplings require a stiffener in the pipe ID for pullout resistance. Insert fittings for small pipe and tubing fit into the pipe ID, and use a compression sleeve on the OD.

DRISCOPLEX® MJ ADAPTER

DriscoPlex® MJ Adapters are manufactured in standard IPS and DIPS sizes for connecting IPS-sized or DIPS-sized polyethylene pipe to mechanical joint pipe, fittings and appurtenances that meet AWWA C111/ANSI A21.11. DriscoPlex® MJ Adapters seal against leakage and restrain against pullout. No additional external clamps or tie rod devices are required.

Figure 10 DriscoPlex® MJ Adapter with Optional Stiffener
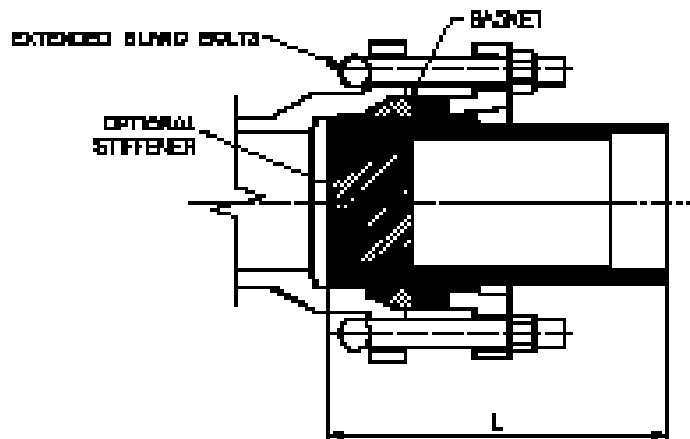
DriscoPlex® MJ Adapters can be provided as a complete kit including the MJ adapter with a stainless steel stiffener, extended gland bolts and nuts, gland and gasket. The internal stiffener is optional for some sizes.

MJ ADAPTER ASSEMBLY

Alignment

When fitting up, DriscoPlex® MJ Adapters must be aligned straight into the mating hub <u>before</u> tightening the gland bolts. Do not draw the MJ Adapter into alignment by tightening the gland bolts. When fitted-up with hand-tight gland bolt nuts, the gap between the socket hub flange and gland bolt flange should be the same all around the joint. The difference between the widest gap and the narrowest gap should not be more than 3/16" (5 mm). (The actual gap measurement can be 1" (25 mm) or more.)

Because polyethylene pipe is flexible, it is not necessary to allow for angular misalignment at MJ Adapter connections.

Assembly

1. Inspect the MJ Adapter kit to be sure all components are present in the correct quantities. The DriscoPlex® MJ Adapter kit includes the MJ Adapter with the stiffener, gasket, gland, extended-length gland bolts and nuts.
2. Fit the gland over the fusion end of the MJ adapter (the long end from the rib) and slide it against the rib. The gland projection fits against the rib. See

the illustration above.

3. Join the MJ Adapter to polyethylene pipe. Butt fusion using *Performance Pipe Recommended Fusion Procedures*, Bulletin PP-750, is the preferred joining method. When the gland is against the MJ Adapter rib, the butt fusion end of the MJ Adapter is long enough to be clamped in a butt fusion machine and make the butt fusion. Allow the fusion to cool properly before handling.

4. The mating mechanical joint socket hub and the end of the MJ Adapter must be clean. Thoroughly remove all rust and foreign material from the inside of the socket hub. Wipe the mating end of the MJ Adapter with a clean, dry cloth to remove all dirt and foreign material.

5. Install the gasket on MJ Adapter. Seat the thick section of the gasket against the MJ Adapter rib.

6. Lubricate the gasket, the end of the MJ adapter, and the inside of the socket hub with an approved pipe lubricant meeting AWWA C111. *Do not use soapy water.*

7. Insert the MJ Adapter into the socket hub. Make sure it is evenly and completely seated in the socket hub. *The MJ Adapter and the socket hub must be aligned straight into each other.* See "Alignment" above.

8. Insert the gland bolts, and run the nuts up finger-tight.

9. Tighten the gland bolts evenly to 75 – 90 ft-lb (102 – 122 n-m). Tighten in torque increments of about 15 – 20 ft-lb (20 – 27 n-m) each and follow a tightening pattern – tighten the bottom bolt; then the top bolt; then the bolts to either side, and finally the remaining bolts in a crossing pattern from one side to the other. At one torque increment, tighten all bolts completely through the pattern before going up to the next higher torque increment and tightening through the pattern. *Tightening with torque-measuring wrenches is strongly recommended.* During tightening, maintain approximately the same gap between the gland and the face of the socket hub flange at all points around the joint.

Flange Connections

Flanged joints are made using a DriscoPlex® Flange Adapter that is butt fused to pipe. A back-up ring is fitted behind the flange adapter sealing surface flange and bolted to the mating flange. DriscoPlex® Flange Adapters have a serrated sealing surface. At lower pressure, typically 100 psi or less, a gasket is usually not required. At greater pressure, the serrations help hold the gasket. See Figure 11.

Standard back-up rings are Standard back-up rings are convoluted ductile iron with AWWA C207 150 lb drilling. One edge of the back-up ring bore must be radiused or chamfered. This edge fits against the back of the sealing surface flange.

Figure 11 Flange Adapter and Back-Up Ring
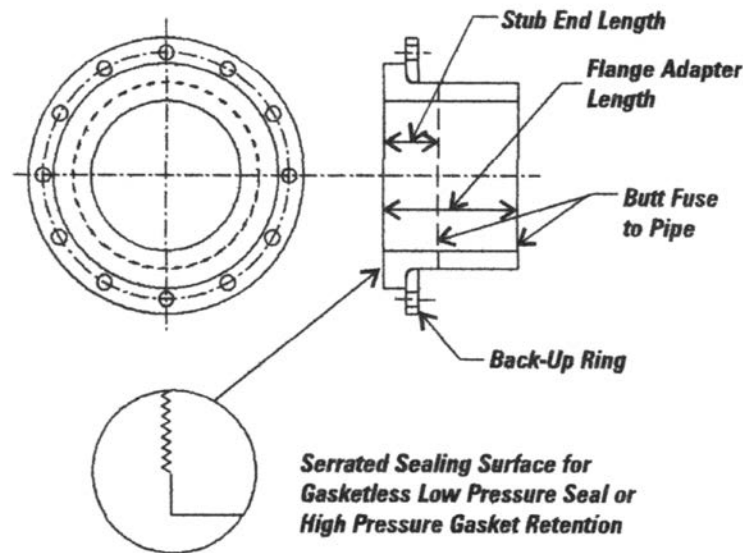
FLANGE GASKETS

A flange gasket may not be necessary between polyethylene flanges. At lower pressures (typically 100 psi or less) the serrated flange-sealing surface may be adequate. Gaskets may be needed for higher pressures or for connections between polyethylene and non-polyethylene flanges. If used, gasket materials should be chemically and thermally compatible with the internal fluid and the external environment, and should be of appropriate hardness, thickness, and style. Elevated temperature applications may require higher temperature capability. Gasket materials are not limited to those shown in Table 22. Other materials may also be suitable. Gasket thickness should be about 1/8"-3/16" (3-5 mm), and about 55-75 durometer Type A hardness per ASTM D2240. Too soft or too thick gaskets may blow out under pressure. Overly hard gaskets may not seal.

Figure 12 Flange Adapter and Back-Up Ring
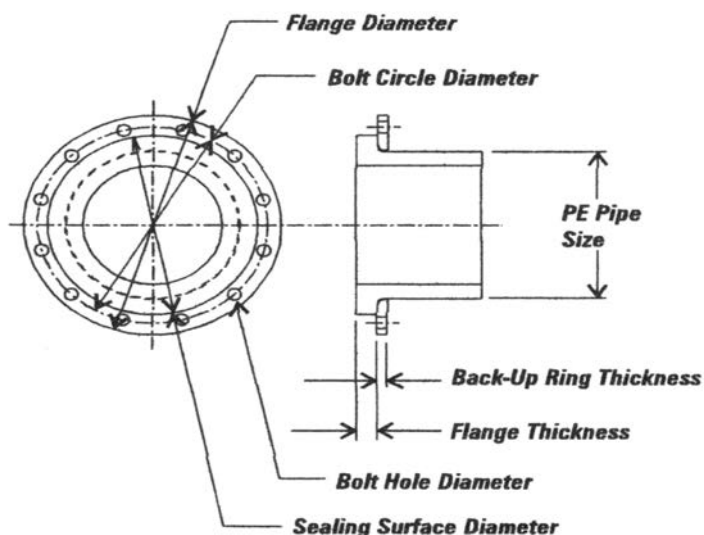
Table 22 Materials Used for Gaskets

Gasket MaterialA	Suitable Chemicals
Brown Rubber (cloth reinforced)	Water (hot or cold)
Neoprene	Water, weak acids
Nitrile	Water, oils
SBR Red Rubber (cloth or wire reinforced)	Air, gas water, ammonia (weak solutions)
PTFE gaskets with micro-cellular layers outside & hard center	Strong caustics, strong acids, and hydrocarbons
Hard, compressed Nitrile bound Aramid fiber	Water, oils, aliphatic hydrocarbons
A Consult gasket supplier for specific recommendations. Other materials may also be suitable for various applications.	

Common gasket styles are full-face or drop-in. Full-face style gaskets are usually applied to larger sizes (12" (300 mm) and larger) because flange bolts will hold a flexible gasket in place while fitting the components together. Drop-in style gaskets are usually applied to smaller pipe sizes.

Figure 13 Flange Gasket Styles

Full Face Style   Drop-In Style
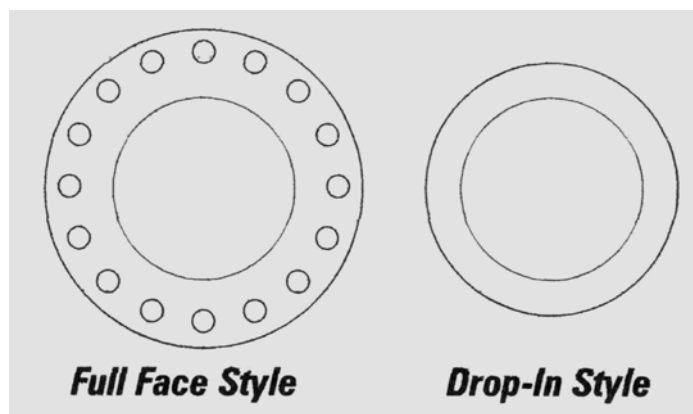
Flange Bolting

Mating flanges are usually joined together with hex head bolts and hex nuts, or threaded studs and hex nuts. Bolting materials should have tensile strength equivalent to at least SAE Grade 2 or ASTM 307 Grade B for joining flanges with rubber gaskets. When using non-rubber gaskets or when using Class 300 back-up rings, higher strength bolts may be required. Check with gasket supplier. Corrosion resistant materials should be considered for underground, underwater or other corrosive environments. Flange bolts are sized 1/8" smaller than the bolthole diameter. Flat washers should be used between the nut and the back-up ring.

Flange bolts must span the entire width of the flange joint, and provide sufficient thread length to fully engage the nut.

$$L_B = 2(T_b + T_f) + T_g + d_B$$

Where

   L_B = minimum bolt length, in
   T_b = back-up ring thickness, in
   T_f = flange adapter flange thickness, in
   T_g = gasket thickness, in
   d_b = bolt diameter, in

Figure 14 Flange Bolt Length
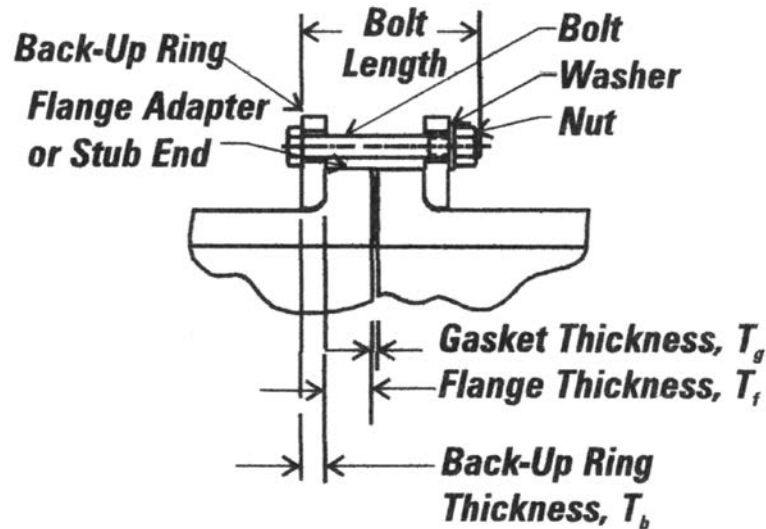
The L_B term provides for a standard flat washer under the nut and full thread engagement into a standard nut. Bolt length should be rounded up to the nearest standard bolt length. Rounding down may result in bolts shorter than the required minimum length. A gasket may or may not be present so gasket thickness should be included only when a gasket is used.

If threaded studs are used, then nuts and washers are installed on both sides. For two DriscoPlex® Flange Adapters (Stub-Ends), stud length is determined by:

$$L_S = 2\,(T_b + T_f + d_B) + T_g$$

Where terms are as above and
L_S =   minimum stud length, in

As with bolts, stud length should be rounded up to the nearest standard length.

Figure 15 Buried Flange Connection Foundation
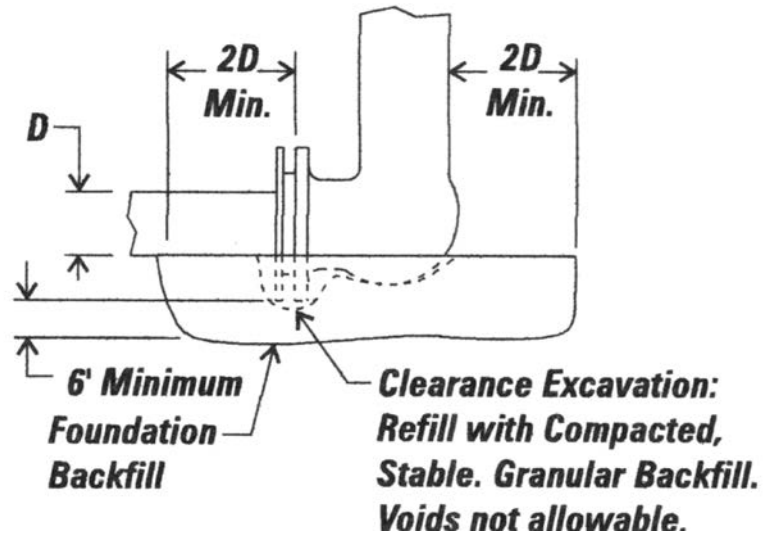
Surface and above grade flanges must be properly supported to avoid bending stresses. See Figure 29, Figure 30 and Figure 31. Below grade flange connections to heavy appurtenances such as valves or hydrants or to metal pipes require a support foundation of compacted, stable granular soil (crushed stone) or compacted cement stabilized granular backfill or reinforced concrete as illustrated in Figure 29.

Table 23 Flange Dimensions

IPS Pipe Size	Flange OD	Bolt Circle Diameter	Bolt Hole Diameter	No. of Bolts
2	6.00	4.75	0.75	4
3	7.50	6.00	0.75	4
4	9.00	7.50	0.75	8
6	11.00	9.50	0.88	8
8	13.50	11.75	0.88	8
10	16.00	14.25	1.00	12
12	19.00	17.00	1.00	12
14	21.00	18.75	1.12	12
16	23.50	21.25	1.12	16
18	25.00	22.75	1.25	16

Flange Assembly

Caution – Alignment – <u>Before tightening</u>, **mating flanges must be centered to each other and sealing surfaces must be vertically and horizontally parallel. Tightening misaligned flanges can cause leakage or flange failure.**

Before fit-up, lubricate flange bolt threads, washers, and nuts with a non-liquid lubricant grease. Gasket and flange sealing surfaces must be clean and free of significant cuts or gouges. Fit the flange components together loosely. Tighten all bolts by hand and recheck alignment. Adjust alignment if necessary.

Flange bolts are tightened uniformly in a 4-bolt index pattern to the appropriate torque value by turning the nut. A torque wrench is recommended for tightening.

4-Bolt Index Pattern Tightening Sequence–Use a 4-bolt index pattern as follows: 1) Select and tighten a top bolt; 2) tighten the bolt 180° opposite the first bolt; 3) tighten the bolt 90° clockwise from the second bolt; 4) tighten the bolt 180° opposite the third bolt. 5) Index the pattern one bolt clockwise and repeat the 4-bolt pattern. 6) Continue tightening in a 4-bolt index pattern until all bolts are tightened to the specified torque level. 7) Increase the tightening torque to the next level and repeat the entire 4-bolt index pattern for all flange bolts.

Tightening Torque Values– Bolts should be tightened to the gasket manufacturer's recommended torque for the selected gasket and the particular application conditions. If the gasket manufacturer's recommended torque exceeds the maximum recommended value in Table 24 a different gasket may be required. The effectiveness of the seal is strongly dependent on the field assembly technique.

Establish an initial sealing surface pressure by tightening to an initial torque value of 5 ft-lbs; then increase tightening torque in increments not more than 1/4 of the final torque value. Maximum recommended bolt tightening torque values for inch-size, coarse thread bolts are presented in Table 24.

The final tightening torque value can be less than the maximum, especially with large diameter piping systems, with systems operating at low pressures and where experience shows that a sufficiently tight joint can be obtained with a lower torque value. Higher final torque values may be required for higher pressures, but recommended bolt torque values in Table 24 should not be exceeded.

Table 24 Typical Flange Bolt Torque (Lubricated Bolts)

Dia – tpi	Typical Torque* Rubber Gasket Lubricated Bolts Ft-lbs	Typical Torque No Gasket (PE to PE only) Max Press. 100 psi Lubricated Bolts Ft-lbs	Maximum Torque** Non-rubber Gaskets* Lubricated Bolts Ft-lbs
½-13	20	30	60
5/8 – 11	40	60	100
3/4 – 10	65	100	125
7/8 – 9	120	150	150
1 – 8	150	150	200
1-1/8 – 8	160	160	250
1-1/4 – 8	220	220	300

Caution – *Retightening. Polyethylene and the gasket (if used) will undergo some compression set that may loosen the bolts. About an hour or so after the first tightening to the final torque value, retighten each flange bolt nut to the final torque value. As before, retighten in pattern sequence and in increments of 15 ft-lbs or less. For 12" and smaller flange adapters a second retightening after 4 hours is recommended. For flange adapters greater than 12", environmentally sensitive, or critical pipelines, the second retightening is recommended after an additional 12 to 24 hours.*

Notes: Verify with the gasket supplier that the torque meets the minimum clamping force for the gasket.

**Maximum torque based on Convoluted Ductile Iron Back-up Rings supplied by Performance Pipe. Other style back-up rings may have different torque limits.

FLANGING TO BRITTLE MATERIALS

When flanging to brittle materials such as cast iron, accurate alignment and careful tightening are necessary. Tightening torque increments should not exceed 10 ft-lbs. Polyethylene flange adapters and stub ends are not full-face, so tightening places a bending stress across the flange face. Over-tightening, misalignment, or uneven tightening can break brittle material flanges.

BUTTERFLY VALVES

When joining a polyethylene flange adapter or stub-end to a flanged butterfly valve, the inside diameter of the pipe flange should be checked for valve disk rotation clearance because the open valve disk may extend into the pipe flange. Valve operation may be restricted if the pipe flange interferes with the disk. If disk rotation clearance is a problem, a tubular spacer may be installed between the mating flanges. Increase the length of the flange bolt or stud by the length of the spacer. Beveled (chamfered) flange adapters are available for some sizes.

Butterfly valves must be centered in the flange for proper operation. Installing a butterfly valve with the valve disk rotated open may assist with alignment. After fitting up and tightening flange bolts to the 5 ft-lbs initial torque value, operate the valve to insure that the valve disk can rotate without interference. Realign if necessary, then tighten to the final torque value using the 4-bolt index pattern.

Figure 16 Butterfly Valve Connections
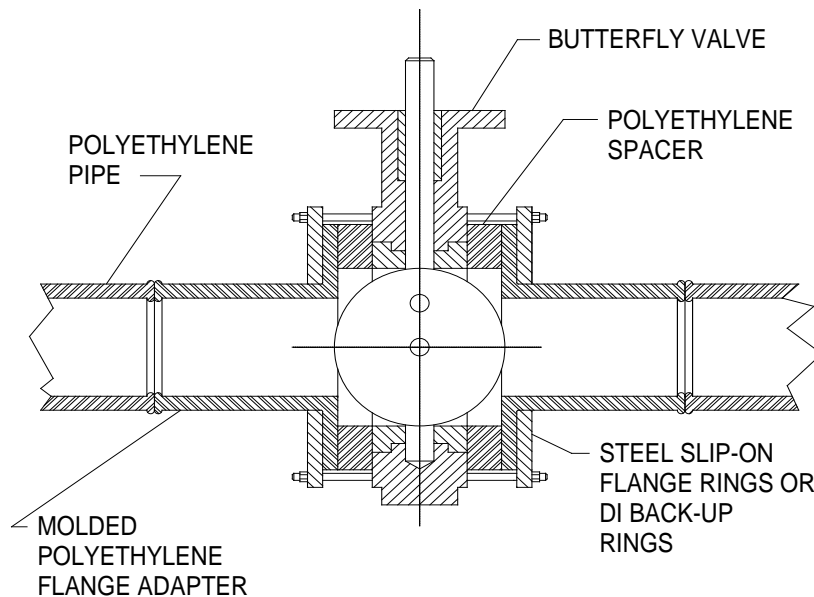
PIPE THREADS

Pipe threads are not recommended for joining DriscoPlex® OD controlled pipe or for joining components to OD controlled pipe.

Threaded polyethylene pipe is easily stripped or cross-threaded, and the thread depth reduces wall thickness. Threaded holes in PE pipe are easily striped or cross-threaded.

Pullout Resistant Mechanical Joints

For pressure service, mechanical joints to polyethylene pipe must be resistant to pullout loads that develop in PE piping systems. Some smaller service-size joints can resist pullout until the PE pipe yields, but most provide pullout resistance that counteracts Poisson effect and thermal contraction tensile loads. Pullout resistant mechanical joints typically compress the pipe wall between an OD compression sleeve and a rigid tube or stiffener in the pipe ID. See Figure 17.

Figure 17 Mechanical Coupling with Insert Stiffeners
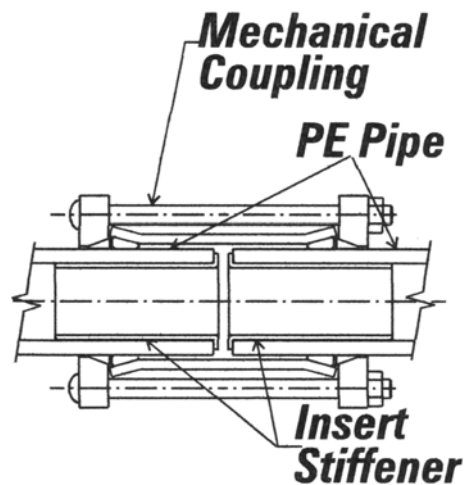
ID STIFFENERS FOR OD CONTROLLED PIPE

OD controlled pipe is manufactured to standards that control the OD and the wall thickness, but do not control the inside diameter. The pipe ID will vary much more than the OD or wall thickness because the ID is subject to the combined tolerances for OD and wall thickness. Depending upon the piping standard, the actual ID dimension can vary significantly. Adjustable stiffeners or stiffeners made to fit measurements taken from the actual pipe are recommended especially for larger diameters.

Insert fittings are pushed into the mating pipe bores and use individual compression sleeves on the pipe OD's. Compression couplings fit over the pipe ends, and use individual insert stiffeners in the pipe bores that are either custom manufactured for the actual pipe ID measurement or adjustable. Adjustable stiffeners usually feature a tapered wedge or a mechanical design that allows a reduced-diameter stiffener sleeve to be expanded and locked into the actual pipe ID.

Insert fittings are commercially available for DriscoPlex® OD controlled pipe through 2" IPS. Larger sizes may be available. Compression couplings are commercially available for DriscoPlex® OD controlled pipe through 12" IPS. Larger sizes may be available. Sizes above 4" IPS may not be fully restrained. See Figure 18.

Figure 18 Insert Coupling
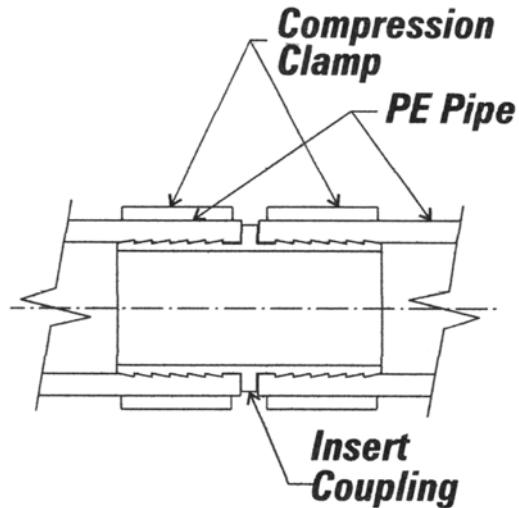

Partially Restrained Joints

A partially restrained joint is one that may withstand some longitudinal tensile load, but not completely prevent pullout. Partially restrained couplings typically are a split housing that clamps around the pipe end, but without an insert stiffener in the pipe bore. The housing clamp surface will usually have sharp edged grooves or teeth to grip the pipe OD. A gasket provides a leak seal between the pipe ends. See Figure 19.

Figure 19 Partially Restrained Compression Coupling
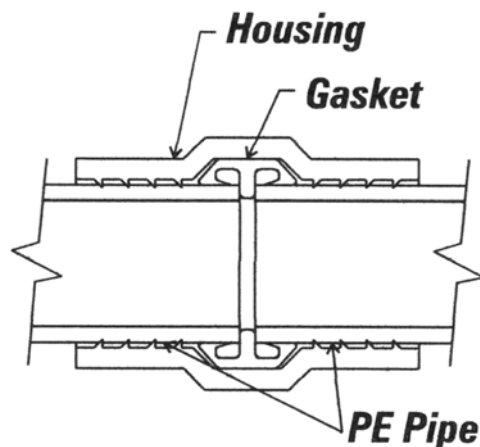
When joining plain end polyethylene pipe to bell-and-spigot or mechanical-joint type fittings or pipe in a pressure piping system, an internal stiffener must be installed in the polyethylene pipe end, and an external joint restraint (such as clamps and tie rods) must be used to restrain against pullout loads. Typically, external joint restraints use external clamps behind the bell and around the PE pipe end, and tie rods between the clamps. See Figure 20. The stiffener in the PE pipe end extends under the external clamp.

Figure 20 External Joint Restraint
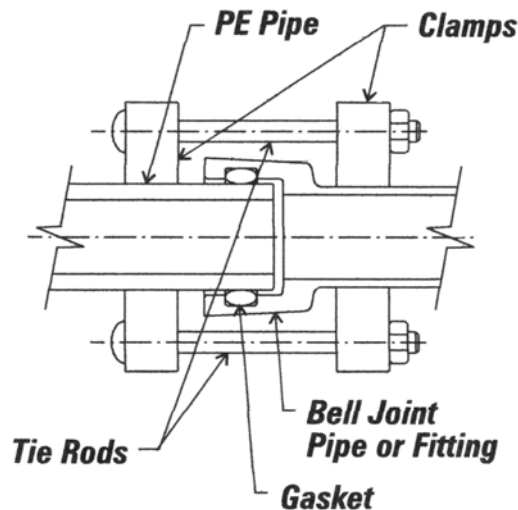
Branch Connections

Branch connections may be made with equal outlet and reduced outlet tees, wyes and crosses that are installed in the line during construction. During or after laying the main, service saddles, tapping tees and branch saddles may be saddle fused or mechanically connected to the main. Field saddle fusion fittings are usually limited to 4" IPS and smaller branch connections on 12" IPS and smaller mains. **Mechanical saddle or branch fittings that clamp around the main and seal with gaskets, should be limited to applications where service temperatures are relatively constant and stable.** Consult the fitting manufacturer for usage recommendations and limitations.

When 16" IPS or larger fabricated equal outlet or reduced outlet tees are installed in the main during construction, two of the three field connections to the tee should be flanged. See Figure 21. The tee is usually butt fused to the end of a pipe run, then set into location. The mating run and branch pipes are then connected to the fitting flanges. *When a 16" IPS or larger fabricated fitting is joined to more than one pipe, field handling can break the fitting.*

Figure 21 Large Diameter Tee Installations
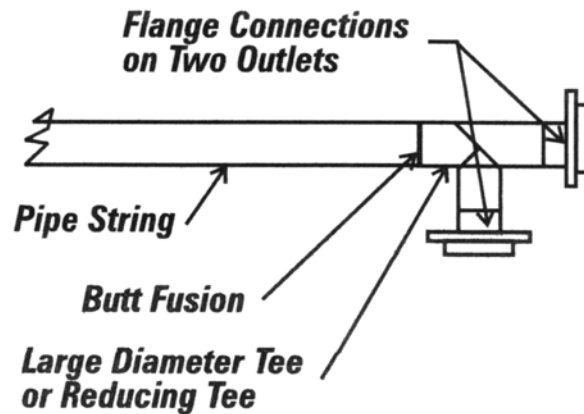
After a system has been installed, large diameter branch taps may be made with commercially available tapping sleeves for IPS outside diameter pipe. See Figure 22. Tapping sleeves must be installed in accordance with manufacturer's instructions. Hole saws must be sized in accordance with the tapping sleeve manufacturer's instructions and should be designed for cutting polyethylene pipe. Smaller service connections can be made by saddle fusing a Service Saddle or Tapping Tee to the main. Commercially available strap-on service saddles may be used. *Mechanical strap-on Service Saddles must secure over a wide bearing area such as wide straps over a curved plate or double band straps. U-bolt type service saddles are not recommended.* Full encirclement band style service saddles may also be used. Service saddles may also be used for connections to gauges, vacuum breakers, and air release valves.

Figure 22 Tapping Sleeve
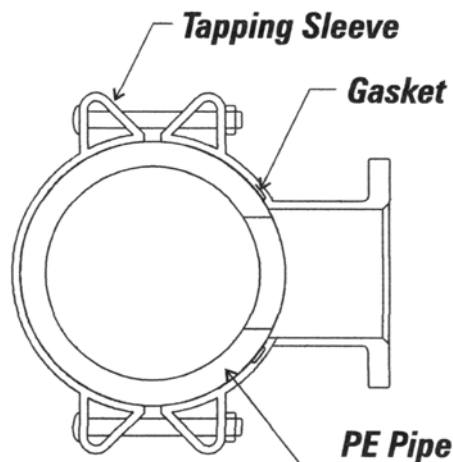
Repair Sleeves

A repair sleeve is a wrap-around sheet metal sleeve with a bolted seam. An elastomeric gasket is used between the sleeve and the pipe. Repair sleeves are used to restore leak-tightness where a pipe has been holed, but repair sleeves do not provide thrust restraint and should not be used to join pressure pipe.

A repair sleeve should never be used to repair a leak at a fusion joint. Correctly made fusion joints do not leak. A leak at a fusion joint indicates a faulty fusion that must be cut out and redone.

WARNING: A leak at a fusion joint indicates a faulty joint that could separate completely without warning at any time, and cause injury or damage. Do not approach a leaking fusion joint. Depressurize the line before making repairs.

Repair Connections

Installed systems may be repaired. Repairs typically involve replacing a pipe section. In some cases, pipe ends may be deflected laterally and electrofused, mechanical compression couplings with insert stiffeners or flanges may be used. In other cases, a flanged spool may be installed. See Figure 23.

Figure 23 Repair Connections
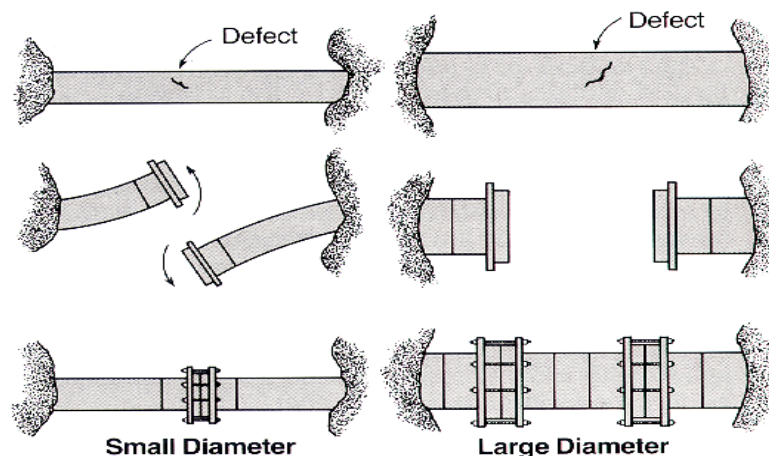
UNDERGROUND INSTALLATION

WARNING: To prevent injury to persons and property damage, safe handling and construction practices must be observed at all times. The installer must observe all applicable local, state, and federal safety codes and any safety requirements specified by the owner or the project engineer.

Buried installations generally involve trench excavation, placing pipe in the trench, placing embedment backfill around the pipe, then placing backfill to the required finished grade. Pipe application, service requirements and size, soil conditions, backfill soil quality, burial depth and joining requirements will all affect the installation.

The care taken by the installer during installation will dramatically affect system performance. A high quality installation in accordance with recommendations and engineered plans and specifications can ensure performance as designed, while a low quality installation can cause substandard performance.

At a minimum, non-pressure and gravity flow DriscoPlex® polyethylene piping systems should be installed in accordance with ASTM D 2321, *Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications*, and pressure systems should be installed in accordance with ASTM D 2774, *Standard Practice for Underground Installation of Thermoplastic Pressure Piping.* System plans and specifications may include additional requirements. The installer should be familiar with this information before installing Performance Pipe DriscoPlex® piping products.

PIPE EMBEDMENT TERMINOLOGY

The backfill materials surrounding a buried pipe are explained below. See Figure 24.

Foundation – A foundation is required only when the native trench bottom does not provide a firm working platform, or the necessary uniform and stable support for the installed pipe. If a foundation is installed, bedding is required above the foundation.

Initial Backfill – This is the critical zone of embedment surrounding the pipe from the foundation to at least 6" over the pipe. The pipe's ability to support loads and resist deflection is determined by the quality of the embedment material and the quality of its placement. Within this zone are bedding, haunching, primary and secondary zones.

Bedding – In addition to bringing the trench bottom to required pipe bottom grade, the bedding levels out any irregularities, and ensures uniform support along the pipe length. Bedding is required when a foundation is installed, but a foundation may not be required to install bedding.

Haunching – The embedment under the pipe haunches supports the pipe and distributes the load. The quality of the haunching backfill and its placement are the most important factors in limiting flexible pipe deformation.

Primary Initial Backfill - This embedment zone provides primary support against lateral pipe deformation. It extends from pipe bottom grade to at least 3/4 of the pipe diameter height, or to at least 6" over the pipe crown if the pipe is installed where the pipe will be continuously below normal groundwater levels.

Secondary Initial Backfill - Embedment material in this zone distributes overhead loads, and isolates the pipe from any adverse effects from placing final backfill material. Where the ground water level may rise over the pipe, the secondary initial backfill should be a continuation of the primary initial backfill.

Final Backfill – Final backfill is not an embedment material, however, it should be free of large rocks, frozen clods, lumps, construction debris, stones, stumps, and any other material with a dimension greater than 8".

Figure 24 Embedment Terminologies
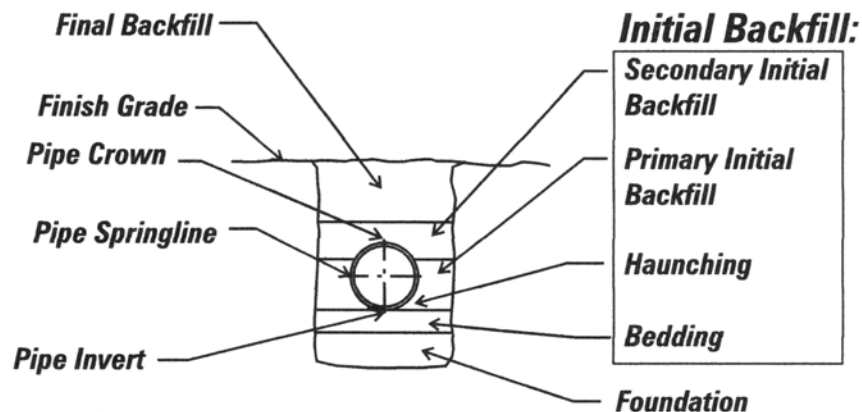
Trenching

In stable ground, minimum trench width, B_d, will vary by the pipe diameter as illustrated in Figure 25 and Table 25. The trench must be wide enough to place and compact backfill soils in the haunch areas below the pipe springline. To minimize the load on the pipe, the maximum trench width should not exceed the minimum trench width by more than 18" plus the thickness of any sheeting, shoring or shielding, unless approved by the engineer. For trenches containing multiple pipes, the distance between parallel pipes should be the same as the

clearance distance between the pipe and the trench wall. See
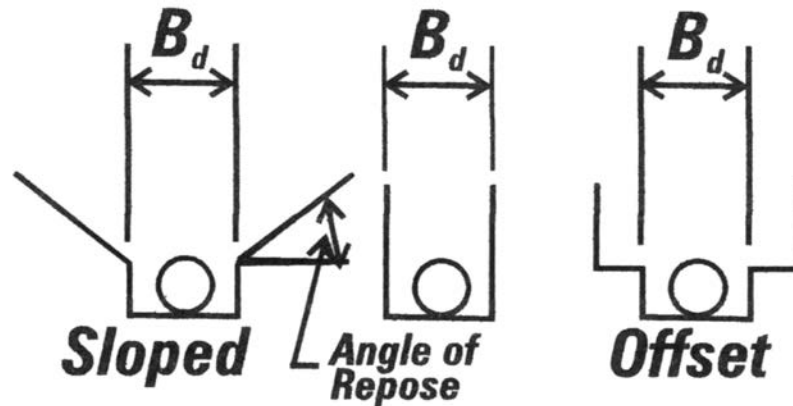Table 25.

Figure 25 Trench Width

Sloped Angle of Repose Offset

Table 25 Minimum Trench Widths

Nominal Pipe OD, in	Minimum Trench Width, B_d, in	Parallel Pipe Clearance, in
<3	12	4
3 – 16	Pipe OD + 12	6
18 – 34	Pipe OD + 18	9
36 – 63	Pipe OD + 24	12
72 - 96	Pipe OD + 36	18

Depending upon trench soil stability and depth, trench sides above the pipe crown may need to be sloped or stepped as illustrated in Figure 25. When trenching in ground not considered to be stable, the trench width above the pipe crown should be sloped and/or widened. Trench sidewall bracing such as trench shield or sheeting should always be used wherever required by site safety conditions, by OSHA, or by other regulatory agencies. When using a trench box, a trench offset should be excavated at a depth between the pipe crown and 1/4 pipe diameter below the pipe crown; then the trench box should be installed on the offset shelf. See Figure 26. Further excavation of the pipe zone trench down to the foundation grade should be performed within the protection of the trench box.

Figure 26 Trench Box Installations
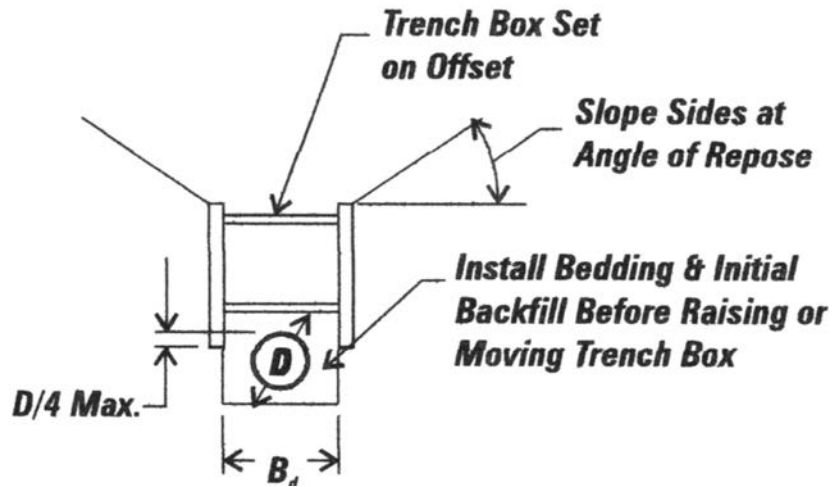
For pressure piping systems such as water mains, gas mains, or sewage force mains, the grade of the trench bottom is not critical. The trench bottom may undulate, but must support the pipe continuously and be free from ridges, hollows, lumps and the like. Any significant irregularities must be leveled off and/or filled with compacted embedment backfill. If the trench bottom is reasonably uniform, and the soil is stable and free of rock, foundation or bedding may not be required.

For gravity drainage systems the trench bottom determines the pipe grade, so the trench bottom must be constructed to the required grade, usually by installing foundation and bedding, or bedding. If the trench bottom is reasonably uniform and the soil is stable and free of rock, foundation or bedding may not be required.

The pipe should be laid on a stable foundation. Where water is present in the trench, or where the trench bottom is unstable, excess water should be removed before laying the pipe. Ground water should be lowered to below the level of the bedding material. During dewatering, take care not to remove sand or silt, and not to displace foundation or bedding soil material.

Where an unstable trench bottom exists such as in mucky or sandy soils with poor bearing strength, trench bottom stabilization is required by excavating the trench below the pipe bottom grade, and installing a foundation and bedding, or a bedding of compacted Class I or Class II materials to the pipe bottom grade. When required, the minimum foundation thickness is 6". When bedding and foundation are both required, the minimum bedding thickness is 4". Without a foundation, the minimum bedding thickness is 6". All materials used for bedding, haunching, primary and secondary backfill should be installed to at least 90% Standard Proctor Density, or as specified by the engineer. Mechanical compaction, which may be as simple as shovel slicing Class I material, is usually required to achieve 90% Standard Proctor Density.

When the pipe is laid in a rock cut or stony soil, the trench should be excavated at least 6" below pipe bottom grade, and brought back to grade with compacted bedding. Remove ledge rock, boulders, and large stones to avoid point contacts, and to provide a uniform bed for the pipe.

PLACING PIPE IN THE TRENCH

OD controlled pipe up to about 8" diameter and weighing roughly 6 lbs per foot or less can usually be placed in the trench manually. Heavier, larger diameter OD controlled pipe will require appropriate handling equipment to lift, move, and lower the pipe into the trench. **Pipe must not be dumped, dropped, pushed, or rolled into the trench. Appropriate safety precautions must be observed whenever persons are in or near the trench.** Requirements for handling and lifting equipment are discussed earlier in this handbook.

Controlling Shear and Bending Loads

DriscoPlex® pipes that enter or exit a casing or a structure wall such as a building wall, vault, or manhole, must be protected against shear and bending loads that can develop from settlement and embedment consolidation. This also applies to socket and sidewall fusions.

A compacted foundation and compacted bedding should be installed below the pipe where it exits the casing or structure as illustrated in Figure 29. At a casing entry or exit, the pipe should be wrapped with an elastomeric sheet material; then the annulus between the pipe and the casing should be sealed either mechanically or with a cement grout. The seal prevents backfill migration into the annulus.

Where OD controlled pipe is flanged at a wall such as a building or vault wall, a structural support as illustrated in Figure 30 is recommended to prevent shear and bending loads. Within the clamp, the pipe is protected against chafing by wrapping it with an elastomeric sheet.

Cold Field Bending

Coiled lengths and long strings of OD controlled pipe may be cold bent in the field. Allowable bend radius is determined by the pipe diameter and dimension ratio. See Table 26. Because fittings and flange connections are rigid compared to pipe, the minimum field-bending radius is 100 times the pipe OD when a fitting, socket, saddle or a flange connection is present in the bend.

Temporary blocks or restraints must be removed before installing final backfill, and any voids must be filled with compacted initial backfill material.

Considerable force may be required to field bend the pipe, and the pipe may spring back forcibly if the restraints slip or are inadvertently released while bending. Observe appropriate safety precautions during field bending.

Bend radius of 100 times pipe OD also applies to socket and saddle fusions. Care must be taken to prevent curve due to soil settlement.
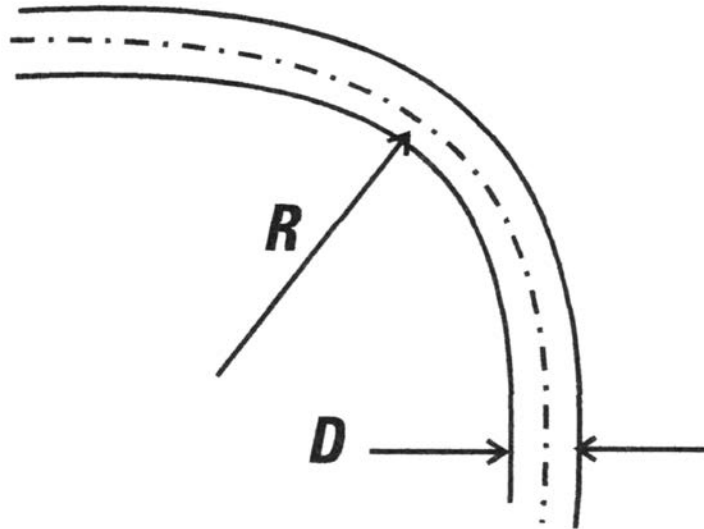
Figure 27 Bend Radius

Table 26 Minimum Cold (Field) Bending Radius (Long-Term)

Pipe DR	Minimum Cold Bending Radius
≤ 9	20 times pipe OD
> 9 – 13.5	25 times pipe OD
> 13.5 – 21	27 times pipe OD
26	34 times pipe OD
32.5	42 times pipe OD
41	52 times pipe OD
Fitting or flange present in bend (ex: Socket Fitting, MJ Adapter, Tee, etc)	100 times pipe OD

The approximate length of pipe needed to achieve a given directional change at the minimum bend radius may be determined by using:

$$S = \theta \, \frac{\pi}{180} R$$

Where:

S = Approximate Length of Pipe Needed to make θ bend, ft

θ = Angle of Bend (degrees)

R = Minimum Cold Bending Radius, ft

INSTALLING FABRICATED FITTINGS

To avoid field damage, large diameter (16" IPS and above), do not join fabricated directional fittings such as elbows, tees, wyes, and crosses to more than one pipe before placement in the trench. The remaining outlet connections are made with flanges or mechanical couplings after placement in the trench. Connecting pipes to more than one outlet, then attempting to lift, move, and lower the assembly into the trench frequently results in fitting breakage and is not recommended. See Figure 21.

Pipe Embedment Soils

Preferred embedment materials for Performance Pipe OD controlled pipe are Class I and Class II angular gravels and sands classified as meeting soil types GW, GP, SW or SP and dual classifications beginning with one of these symbols as defined in ASTM D 2487. These materials should be used for bedding, haunching, and for primary and secondary initial backfill. The maximum particle size should be limited to 1/2" for pipes to 4" diameter, 3/4" for pipes 6" to 8" diameter, 1" for pipes 10" to 16" diameter and 1-1/2" for larger pipes.

EMBEDMENT BACKFILLING

The haunch areas should be completely filled and void free to the extent possible. For the lower half of the haunch area, materials should be shoveled evenly into the area on both sides of the pipe in layers not more than 4" thick, and compacted with an angled haunch-tamping tool like that illustrated in Figure 28. Layers can then be increased to 6" and flat-tamping tools can be used.

Figure 28 Haunch Tamping Tool
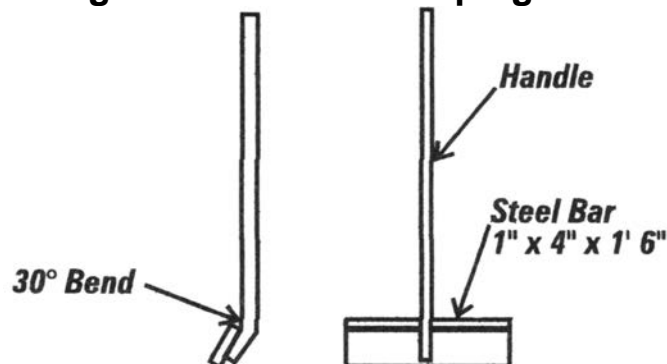
Following haunching, primary and secondary initial backfill materials should be

placed in 6" layers and compacted with flat tamping tools. If mechanical tampers are used, take care not to damage the pipe. If sheeting has been used, the sheeting should be lifted progressively for each layer.

Joint Restraining with Thrust Blocks

DriscoPlex® polyethylene pressure pipe systems must be assembled with fully restrained joints, or with partially restrained joints AND external joint restraints. Such systems are fully restrained, and do not require thrust block restraints.

Figure 29 Controlling Shear and Bending Loads
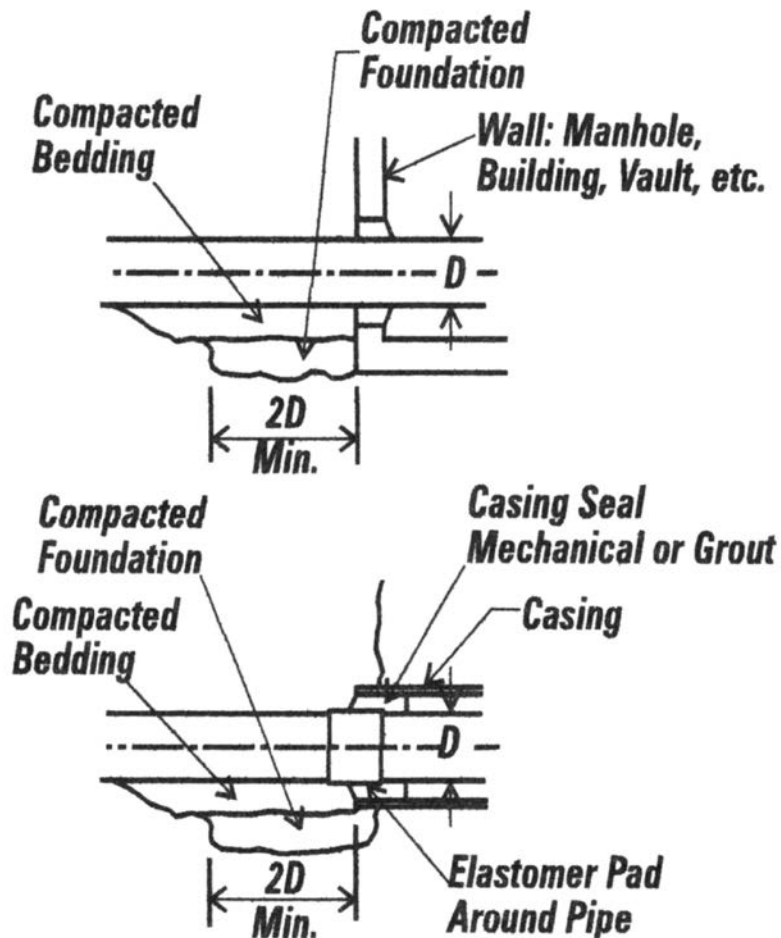
Where DriscoPlex® pipe or fittings are joined to valves, hydrants, other heavy devices, or rigid pipes, a support pad as illustrated in Figure 32 should be provided below the device or rigid pipe, and for at least two pipe diameters length under the connecting pipes. Support pad materials should be at least compacted Class I or II soil, or cement stabilized Class I, II, or III soils, or poured concrete. Embedment soils around the connecting pipes, the device, and in any bell holes must be compacted.
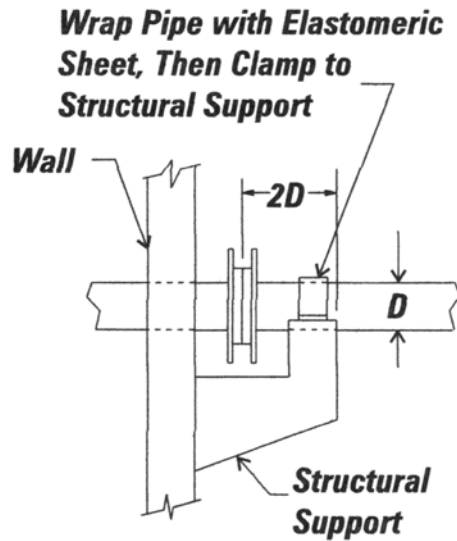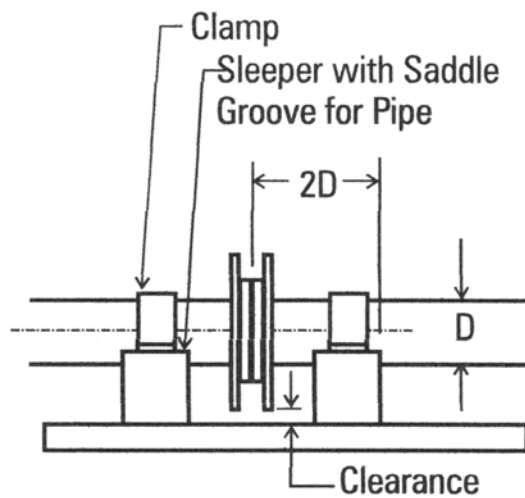
Figure 30 Flange Support at Wall

Figure 31 Protecting Connections to Flanges and Fittings

Where pipe is connected to rigid devices such as fabricated directional fittings or where flanges or other rigid connections are employed, the pipe must be protected from shear, flexing and bending. Flanges laid on the surface can become anchored in the soil, and should be supported on sleepers. Figure 31 illustrate a method for protecting connections to directional fittings and flanged connections to other appurtenances. Wrap elastomeric or rubber sheet material around the pipe under the clamps.

Figure 32 Appurtenance Support Pad
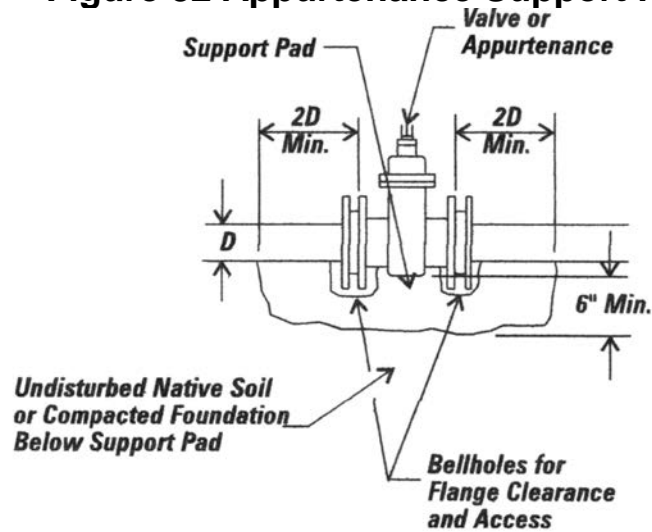
FINAL BACKFILLING

In general, final backfill may be material excavated from the trench provided it is free of unsuitable matter such as lumps, stones, frozen clods, construction debris, boulders, and other materials exceeding 8" in their longest dimension.

Where the trench is subject to surcharge loads such as H-20 or E-80 live loads, or building foundations or footings, or paved parking or storage areas, final backfill should be an angular Class I or Class II granular material, compacted to at least 95% Standard Proctor density or as specified by the engineer.

Poisson Effects

When non-PE pipe and components are installed in the same pressure pipeline with PE pipe, or when PE pipe is connected to unrestrained joint piping such as bell and spigot joint PVC or ductile iron, unrestrained joints in the transition area should be protected against pullout disjoining.

When pipes made from ductile materials are pressurized, the diameter expands slightly and the length decreases in accordance with the Poisson ratio of the material. With unrestrained bell and spigot joined lengths, the effect is limited to the individual pipe lengths, but with fully restrained pipes such as fusion-joined PE pipe, the effect is cumulative over the entire restrained length of pipe. When fusion-joined polyethylene pipe is connected to unrestrained mechanical couplings or bell and spigot joint PVC or ductile iron piping, Poisson effect pipe shortening can cause pullout disjoining of unrestrained joints where the PE pipe transitions to the unrestrained non-PE pipe. To prevent Poisson effect pullout disjoining in the transition area, provide protection by installing external joint restraints at unrestrained bell and spigot joints, or by installing an in-line anchor in the HDPE pipeline, or by a combination of both techniques.

Conventional thrust blocks at directional fittings are not effective against

Poisson effect pullout because conventional thrust blocks are intended to resist thrust forces that would push the fitting off the end of the pipe, where Poisson effect forces pull the pipe out of the joint, a force that thrust blocks cannot counteract. As well, snaking pipe in the trench is generally not effective.

THE POISSON EFFECT

When a tensile stress is applied to a material, the material elongates in the direction of the applied stress, and draws in at right angles to the direction of the applied stress. This relationship, called the Poisson effect, is a natural response to applied stress that occurs with all materials, but is particularly apparent with ductile materials. For example, when a metal bar is pulled in a tensile test, it stretches out and necks down on the sides. Likewise, a rubber band elongates and necks down on the sides when it is pulled. When pipes such as polyethylene, PVC and metal pipes are pressurized, the diameter will expand slightly, and due to the Poisson effect, the pipe will shorten in length.

A pipe section with fully restrained joints such as a long string of butt-fused HDPE pipe will transmit Poisson effect pipe shortening from length to length through the restrained joints along the pipe string. Restrained joints include fusions, bolted flange connections, MJ adapter connections or other restrained mechanical connections. If an unrestrained bell and spigot or mechanical sleeve joint is in-line with the restrained section, the cumulative Poisson effect shortening may cause in-line unrestrained joints or connections to be pulled apart. Therefore, unrestrained joints or mechanical connections that are in-line with fully restrained HDPE pipe must be either restrained or otherwise protected against pullout disjoining.

Connection Restraint Techniques

ADAPTERS FOR FLANGES AND MECHANICAL JOINTS

Adapters are available for connecting DriscoPlex® HDPE pipe to flanges and to Mechanical Joints. DriscoPlex® Flange Adapters and MJ Adapters are fully pressure rated and fully restrained. Flange Adapters and MJ Adapters are butt fused to the HDPE pipe, then connected to the mating flange or mechanical joint. See Performance Pipe fittings literature and technical notes for information and installation instructions.

PLAIN-END HDPE PIPE CONNECTIONS

When a plain-end HDPE pipe is inserted into a PVC or ductile iron bell or into a mechanical joint bell or component, a stiffener inside the HDPE pipe end and an external mechanical joint restraint are required. The internal stiffener must extend into the HDPE pipe end so that the stiffener supports the HDPE pipe under the seal and under the joint restraint clamp. The external restraint provides pullout resistance.

An ID stiffener and external mechanical restraint are required when plain end

HDPE pressure pipe is connected to:

- Bell and spigot (push-on) joint in PVC pipe and ductile iron fittings, valves, hydrants and pipe;
- Bolted sleeve couplings;
- Mechanical joint pipe, fittings, valves and hydrants (when a DriscoPlex® MJ adapter is not used).

For PE butt fusion and where DriscoPlex® Flange Adapter and DriscoPlex® MJ Adapter fittings are used, ID stiffeners and external joint restraints are *NOT* required.

PULLOUT PREVENTION TECHNIQUES

The transition region where a long HDPE pipe string is connected in-line to unrestrained piping can extend several joints into the non-PE pipe system because a restrained connection at the transition joint can transmit Poisson shortening to the next in line unrestrained joint in the non-PE pipe. Typical pullout prevention techniques include restraining several non-PE pipe joints down line from the transition connection, or restraining the transition connection and installing an in-line anchor in the HDPE pipe close to the transition connection. Figure 33 and Figure 34 illustrate typical pullout prevention techniques.

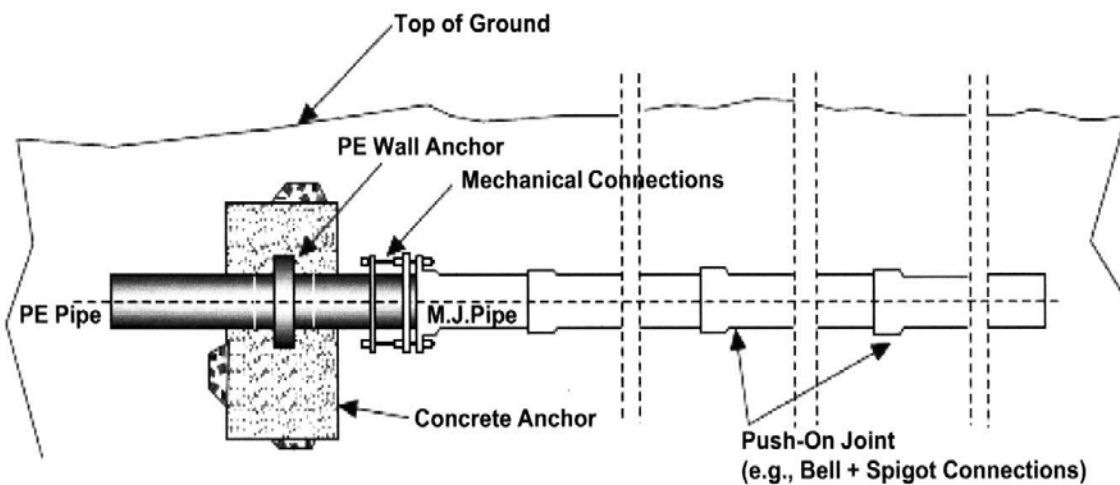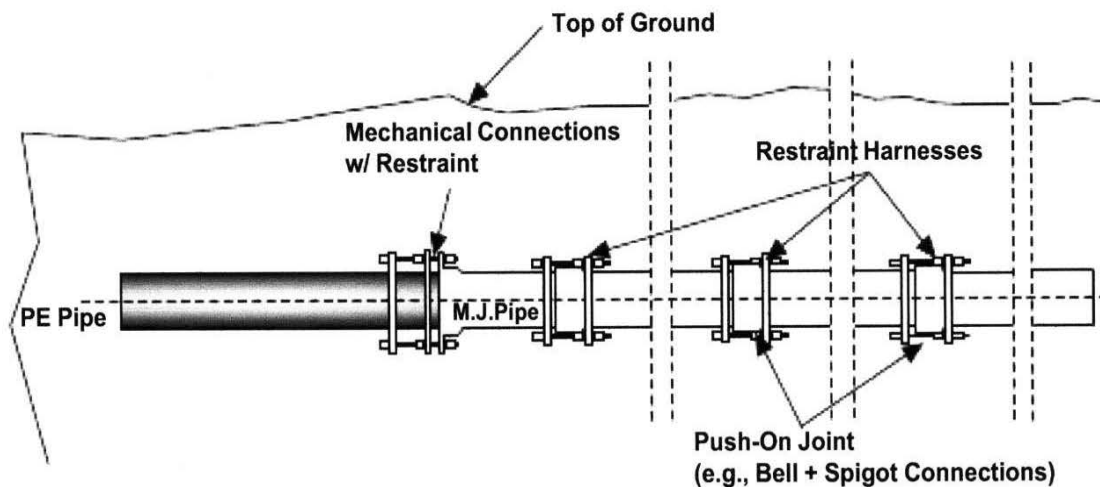### Figure 33 Pullout Prevention Technique #1

Figure 34 Pullout Prevention Technique #2

Pullout Force

Poisson effect pipe shortening will occur whenever the pipe is pressurized. Because internal pipe pressures are higher during pressure testing and surge events, Poisson effect pipe shortening can be greater at these times compared to normal steady pressure operation.

Caution – Before pressure testing, all mechanical joint restraints must be completely installed and secured per manufacturer's instructions, and concrete at in-line anchors and thrust blocking (if used) must be sufficiently cured and properly backfilled. See Performance Pipe Technical Note PP-802-TN Leak Testing.

The Project Design Engineer should determine the Poisson Effect pullout force conditions that are appropriate for his application; then determine the appropriate techniques to protect unrestrained in-line mechanical connections against disjoining from Poisson effect pullout forces.

For a given PE pipe diameter and DR, approximate Poisson effect pullout force may be determined by multiplying the end area of the PE pipe by the product of the internal pressure hoop stress and the appropriate Poisson ratio.

$$F = S \; \mu \; \pi \, D_O{}^2 \left[\frac{1}{DR} - \frac{1}{DR^2} \right]$$

Where F = pullout force, lbs
       S = internal pressure hoop stress, lb/in^2

$$S = \frac{P(DR-1)}{2}$$

P = internal pressure, lb/in^2

DR = dimension ratio

μ = Poisson ratio (for PE, 0.45 for long-term, 0.35 for short-term stress)

π = Pi (approximately 3.142)

D$_O$ = pipe outside diameter, in

Table 27 presents approximate Poisson effect pullout forces for DR11 DIPS sized pipe while operating at AWWA C906 rated pressure of 160 psi, during leak testing at 150% of rated pressure and during a severe water hammer event that causes a pressure surge to 200% of rated pressure. For DR11 pipe operating at 200 psi (ASTM F714 rated pressure), increase values in Table 27 by 25%.

Table 27 Approximate Poisson Effect Pullout Force

DIPS Pipe Size (DR 11)	Approximate Pullout Force, lbs (a)		
	Operating at AWWA C906 Working Pressure Rating of 160 psi (b)	During Pressure Tests at 150% of Rated Pressure (c)	Operating at Full Pressure Plus Maximum Allowable Occasional Surge Pressure (d)
4"	2154	2512	3829
6"	4450	5192	7911
8"	7655	8931	13610
10"	11516	13436	20474
12"	16286	19000	28954
14"	21880	25527	38899
16"	28299	33015	50310

(a) Values for water at 73°F.
(b) Rated pressure for DR 11, Class 160 = 160 psi. Pullback force determined using long-term Poisson ratio of 0.45.
(c) Pullback force determined using short-term Poisson ratio of 0.35.
(d) Total pressure in pipe during surge event = 160 psi steady pressure + 160 psi surge pressure = 320 psi. Values determined by combining pullback force for steady pressure (long-term Poisson ratio of 0.45) plus pullout force for surge event (short-term Poisson ratio of 0.35).

Other longitudinal forces from thermal expansion and contraction, fluid thrust, or installation are not incorporated into table values. See the PPI Handbook of Polyethylene Pipe for information on additional loads.

ANCHOR BLOCK SIZING

Anchor blocks are not required for restrained connections such as fusion welds and transitions to restrained systems but are used when PE pipe connects to other materials that use unrestrained joints such as bell and spigot. Anchor blocks stop the movement of the pipe end by transferring the force from the PE pipe to the soil. The design of an anchor block is based on the force at the end of the PE pipe (pullout force). The force can be caused by changes in temperature (See PP 814-TN), soil movement or Poisson effect (See PP 813-TN). For a properly installed pipeline, soil movement is usually a minor force and can typically be ignored. Also, the temperature of water in most pipelines changes slightly over the year and the resulting force is low. In fact, for a small temperature change, the friction between the soil and pipe is often sufficient to restrain contraction. Hence, the primary force to consider is due to the Poisson effect. After the force is determined, anchor block sizing may be determined from the equation below:
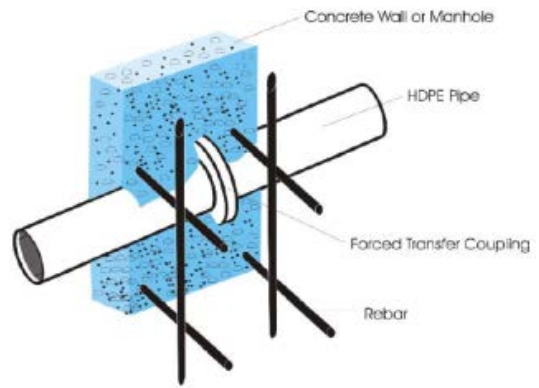
$$A = 1.5\frac{F}{\rho}$$

Where:

A = Anchor Block Area in contact with soil, ft^2
F = Pullout Force, lbs
ρ = Soil Bearing Strength, lbs/ft^2

Approximate soil bearing strengths are given in various texts. Note that soil support strength can vary and may require actual geotechnical measurements.

SPECIAL UNDERGROUND INSTALLATION TECHNIQUES

Because of its flexibility and the high integrity of properly made butt fusion joints, special installation techniques may be employed to install DriscoPlex® OD controlled pipe. Special techniques include plowing, planting or pulling pipe into a narrow trench, horizontal boring, and directional boring. These techniques minimize excavation by making a tight fitting trench cut or hole for the pipe, and either pulling or placing the pipe in the cut. They require suitable native soil conditions that are free of large rocks, and except directional boring, are generally limited to shallower depths.

PLOWING AND PLANTING

Plowing and planting involve cutting a narrow trench, and feeding the pipe into the trench through a shoe or chute fitted just behind the trench cutting equipment. Trench cuts for pipes around 1-1/2" IPS and smaller are frequently made with vibratory plows. Larger sizes use wheel or chain type trenchers with semi-circular cutters. The trench width should be only slightly larger than the pipe outside diameter.

The shoe or chute should feed the pipe into the bottom of the cut. The short-term pipe bending radius through the shoe may be tighter than the long-term cold bending radius (Table 26

Table 26), but it must not be so tight that the pipe kinks. Table 28 presents minimum short-term bending radii for applications such as plowing and planting. The pipe's path through the shoe or chute should be as friction free as practicable.

Table 28 Minimum Short-Term Bending Radius

Pipe Dimension Ratio	Minimum short-Term Bending Radius
≤ 9	10 times pipe OD
> 9 – 13.5	13 times pipe OD
> 13.5 – 21	17 times pipe OD

Pipe is usually fed over the trenching equipment and through the shoe or chute from coils or straight lengths that have been butt fused into a long string. Pipe up to 12" IPS has been installed using this method.

Pulling-In

Pulling-in involves cutting a trench, then pulling the pipe in from one end of the trench. Pulling-in may be accomplished as a simultaneous operation by attaching the leading end of the pipe behind the trench cutter, or as a separate operation after the trench has been opened. In either case, pulling-in requires a relatively straight trench and the pulling force applied to the pipe must not exceed the Allowable Tensile Load, ATL, (safe pull strength) for the pipe. Therefore, this method is limited to shorter runs.

Allowable Tensile Load (safe pull strength) may be determined by:

$$ATL = \pi\, D^2\, f_Y\, f_T\, T_Y \left(\frac{1}{DR} - \frac{1}{DR^2} \right)$$

Where

ATL = allowable tensile load, lb
D = pipe outside diameter, in
f_Y = tensile yield design (safety) factor, Table 29
f_T = time under tension design (safety) factor, Table 29
T_Y = pipe tensile yield strength, lb/in^2 (Table 30)
DR = pipe dimension ratio (DR or SDR)

When polyethylene pipe is subjected to a significant short term pulling stress, the pipe will stretch somewhat before yielding. However, if the pulling stress is limited to about 40% of the yield strength, the pipe will usually recover undamaged to its original length in a day or less after the stress is removed.

Table 29 Recommended Design Factors for ATL

Factor	Parameter	Recommended Value		
f_Y	Tensile yield design factor†	0.40		
f_T	Time under tension design factor	1.0 for up to 1 h	0.95 for up to 12 h	0.91 for up to 24 h
† Design and safety factors are the inverse of each other. Multiplying by a 0.40 design factor is the same as dividing by a 2.5 safety factor.				

Pipe yield strengths may be estimated by using the values from Table 30. Unlike more brittle materials, polyethylene pipe materials can stretch over 400% between tensile yield and tensile break. Further, tensile yield strength and tensile break strength are about the same value, so pulling load gauges will not show that a pipe has yielded because the pipe will stretch to the breaking point with little change in pulling force. The only indication will be that the trailing end stops while the pulling end continues to move.

Table 30 Approximate Tensile Yield Strength Values for PE4710

Material	Tensile Yield Strength at Pipe Temperature
	73°F (23°C)
HDPE	3500 lb/in^2
MDPE	2800 lb/in^2
Temperature Factor	Table 5

When pulling-in polyethylene pipe, especially smaller diameters, the pulling force should be monitored and kept below the ATL value for the pipe size, and both the pulling end and trailing end should be monitored for continuous, smooth movement. **When pulling equipment can exceed the ATL value of the pipe, install a weak-link device at the lead end of the polyethylene pipe**. The weak-link device should be set to disengage at the ATL value or lower.

Because pull-in loads will cause the pipe to stretch, the leading end should be pulled past the termination point by 3-5% of the total pulled-in length, and the trailing end should be left long by the same amount. Final tie-ins should be made a day after the pull to allow the pipe to recover from the pulling stress and contract to its original pre-pull length. The extra length at both ends assures that the pipe won't recede back past the tie-in points as it recovers from the pull.

Table 31 Approximate Allowable Tensile Load for HDPE Pull Duration between 1 and 12 Hours at 73°F

IPS Size	ATL[A], lb			
	SDR 17	SDR 13.5	SDR 11	SDR 9
2"	1,305	1,616	1,948	2,328
3"	2,834	3,511	4,230	5,055
4"	4,684	5,803	6,993	8,357
6"	10,153	12,578	15,156	18,112
8"	17,208	21,319	25,688	30,699
10"	26,733	33,118	39,906	47,690
12"	37,605	46,587	56,135	67,085
14"	45,340	56,169	67,682	80,884
16"	59,219	73,364	88,401	105,644
18"	74,949	92,852	111,882	133,706
20"	92,530	114,632	138,126	165,069
22"	111,962	138,704	167,133	199,734
24"	133,244	165,069	198,902	237,700

[A] ATL values in table are at 73°F and for pull duration of 1 to 12 hours using an allowable tensile pull stress of 1330 psi. Depending on the application, adjust the ATL value for temperature or pull duration or both. For elevated temperature, multiply ATL value by temperature factor from Table 5; for pull duration of 1 hour, multiply ATL value by 1.08; and for pull duration between 12 and 24 hours, multiply ATL value by 0.91.

Horizontal Boring

Horizontal boring or road boring is usually performed to install a casing below existing roadways or structures where opening a trench may be impractical or undesirable. Polyethylene pipe is then installed in the casing. Typically, entry and exit pit excavations are required. Horizontal bores are usually performed using a rotating auger within a steel casing. The auger projects just ahead of the casing, and the auger and casing are advanced together across to the exit pit. Typically, either the auger casing is left in place or a new casing is installed by pulling it in from the exit pit while withdrawing the bore casing.

When installed in a casing, OD controlled polyethylene pipe does not require centering spacers (centralizers) for electrical isolation to a metal casing. Polyethylene is non-conductive and will not affect casing cathodic protection. Allowing the pipe to snake inside the casing can usually accommodate minor thermal length changes of the polyethylene pipe in the casing. If used, centering spacers will force thermal expansion thrust loads to the pipe ends, which may weaken or break casing end seals.

Unless groundwater pressure could cause pipe collapse (see Table 14), grouting the casing annulus is not required. The PE pipe must be protected against shear and bending loads at the casing entry and exit. When pulling PE pipes into the casing, the Allowable Tensile Load (ATL) for the pipe must not be exceeded.

HORIZONTAL DIRECTIONAL DRILLING (HDD)

Horizontal directional drilling uses directional drilling techniques to guide a drill string along a borepath around obstacles such as under rivers or lakes or through congested underground infrastructure. As with horizontal boring, horizontal directional drilling may be used to install a casing, or to directly install long strings of DriscoPlex® OD controlled pipe.

As the hole is bored, a steel drill string is extended behind a cutting head. Drilling mud is used to cool the cutter, flush excavated soil from the borehole and lubricate the borehole. At the end of the borepath, the drill string is angled upwards and through the surface. The cutting head is removed and a backreamer attached. The pipe string is attached to the backreamer. When the pullback force exceeds the ATL for the PE pipe, a weak-link or breakaway device is installed between the backreamer and the PE pipe. As the drill string is withdrawn to the drilling rig, the backreamer enlarges the borehole and the pipe string is drawn in. To prevent damage to the PE pipe during pullback, the movement of the pipe string and the pulling load on the polyethylene pipe must be monitored, and the pulling load on the pipe string must not exceed the ATL value for the pipe. Information on horizontal directional drilling is available in ASTM F 1962 and the *PPI Handbook of Polyethylene Pipe.*

SLIPLINING

In sliplining or insertion renewal rehabilitation, a smaller diameter DriscoPlex® slipliner pipe is installed in the ID of an existing host pipe. Table 9 provides comparative flows for clay and concrete pipes rehabilitated by sliplining with DriscoPlex® piping.

Sliplining installations may be subject to thermal length changes. Thin wall sewer liners may collapse if external hydrostatic load due to high water table or flood conditions is too high. Resistance to collapse from external hydrostatic load may determine the minimum wall thickness for the slipliner. See Table 14.

Figure 35 illustrates sanitary sewer sliplining. Before sliplining, the sewer must be cleaned and cleared of roots and debris. Video inspection is also used to locate service connections, offsets and structural deterioration. In general, service connections; the pulling pit, badly deteriorated areas, significant offsets and bends tighter than 11-1/4° will require excavation. Manhole locations are commonly used as pulling pit locations. For more information, see ASTM F 585 *Standard Practice for Insertion of Flexible Polyethylene Pipe Into Existing Sewers* and the *PPI Handbook of Polyethylene Pipe.*Sliplining with DriscoPlex® OD controlled pipe may be used for pressure or non-pressure service and may be installed by pulling or pushing or a combination of both. For pulling-in, the usual diametrical clearance between the original pipe inside diameter and the renewal pipe outside diameter should be 10% or more of the original pipe ID. For push-in sliplining, the diametrical clearance should be between 10% and 30%. When pulling-in, the tensile load on the liner must not exceed the ATL for the pipe.
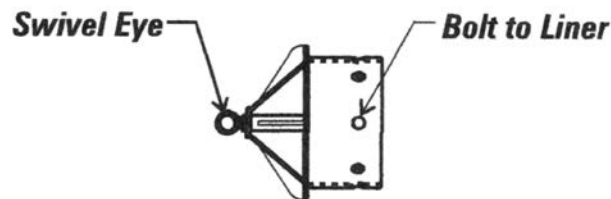
DriscoPlex® OD controlled slipliners may also be pushed in using a fabric choker sling around the liner, hooked to a backhoe bucket as illustrated in Figure 37.

Figure 35 Sliplining Sewer Rehabilitation

After liner installation, service connections are reestablished. Point excavations are usually required. Any branch connection appropriate for the service may be used. For a mechanical branch connection such as a strap-on saddle or an Inserta-Tee® (Figure 38), the casing crown down to the springline must be removed to expose the top of the liner. For saddle fusion or to install an electrofusion saddle to the liner, the entire casing must be removed for complete access to the liner. The point excavation and casing removal must provide clearance for equipment and personnel.

Figure 36 Pulling Heads for Sliplining

(These pulling heads are not suitable for HDD)
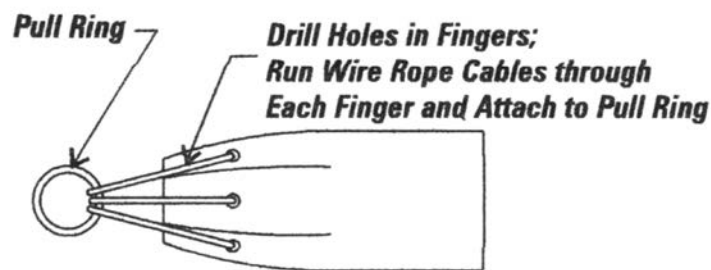
Fabricated Steel Pulling Head

Swivel Eye — — Bolt to Liner

PE Cap or Reducer Pulling Head

Swivel Eye — — Fuse to Liner

— Equal Widths—Fingers and Wedges

1 1/2 D Min.

— Fuse to Liner

D

— Mark and Remove Wedges

Pull Ring — Drill Holes in Fingers; Run Wire Rope Cables through Each Finger and Attach to Pull Ring
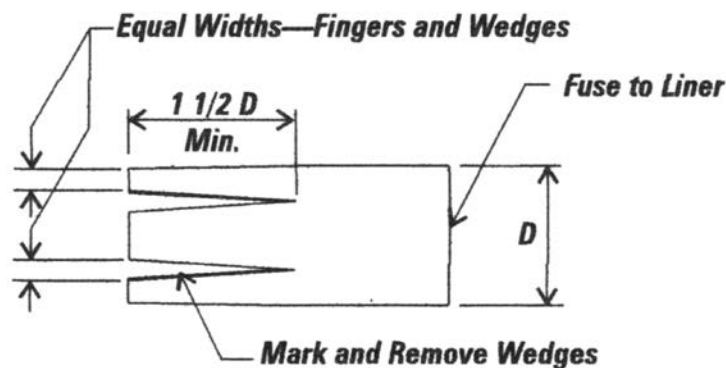
Figure 37 Backhoe Slipliner Push-In Technique

Fabric Choker Sling Around Liner & Hooked to Bucket

Slipliner

Figure 38 Inserta-Tee®

Inserta-Tee Hub

Band Clamp

Gasket

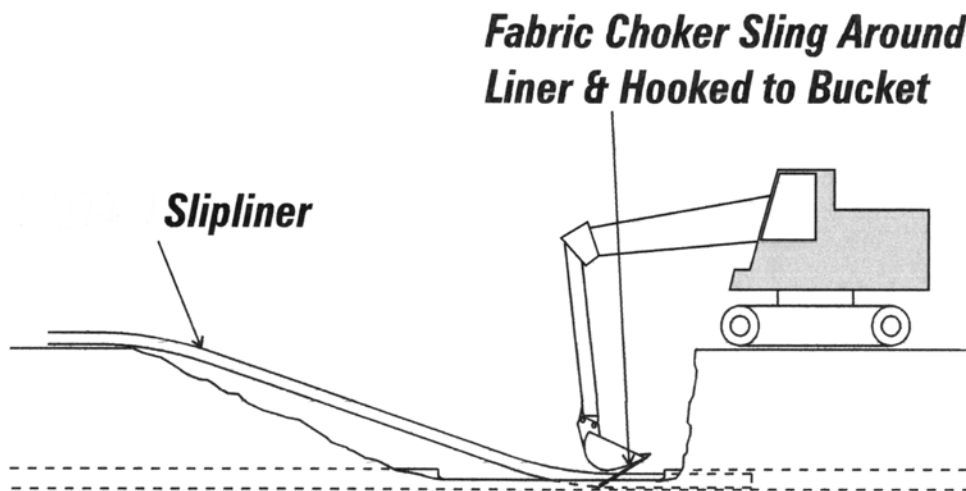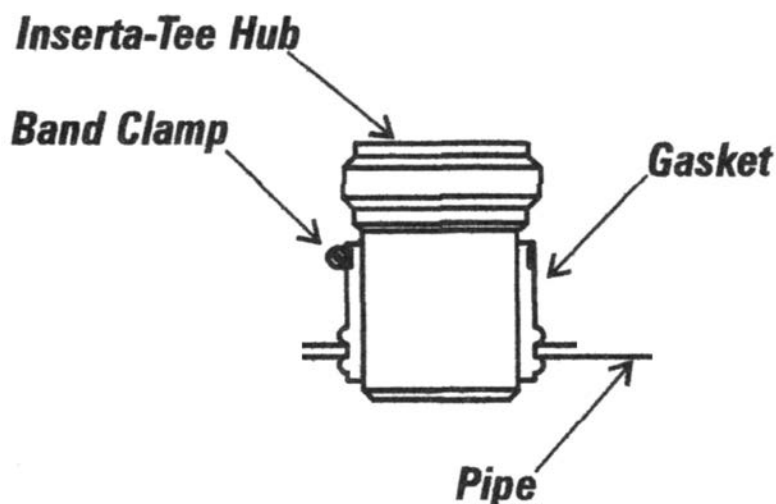**Pipe**

Once the service connection is completed, the casing to liner annulus must be sealed to prevent backfill migration and the area must be backfilled. The annulus may be sealed using a mechanical seal, grout, concrete or cement-stabilized Class I or Class II soil. The point excavation initial backfill is commonly cement-stabilized Class I or Class II soils, compacted Class I or Class II soils, or concrete. Care should be taken to ensure the haunch areas are filled and compacted.

Proprietary Trenchless Rehabilitation

Proprietary trenchless rehabilitation techniques typically employ patented or licensed technologies and equipment to either replace a pipe (pipe bursting) or rehabilitate a host pipe (tight-fitting liners).

DISCLAIMER: Because proprietary trenchless rehabilitation techniques can apply significant and unusual stresses during installation and because installation is beyond Performance Pipe's control, Performance Pipe assumes no responsibility for and expressly disclaims all liability relating to products installed using proprietary trenchless technologies.

PIPE BURSTING

In pipe bursting, a bursting head is attached to a polyethylene pipe string. When pulled into the host pipe, the bursting head breaks the host pipe into pieces, enlarges the hole and installs the new pipe. Pipe bursting can provide increased capacity where the host pipe can be used as a guide path to install a larger pipe. Since the original host pipe is destroyed during installation, the new pipe must be structurally designed for the necessary static and dynamic loads. Pipe bursting is limited to host pipes that can be fractured and appropriate soil conditions.

TIGHT-FITTING LINERS

Tight-fitting liner techniques generally employ a means to temporarily reduce the diameter of the liner by mechanical technologies such as swaging, rolling-down, or deforming or other technologies. The reduced diameter liner is pulled into the host pipe, and then expanded to fit closely to inside diameter of the host pipe. The liner restores leak tightness, but the condition of the host pipe determines the structural integrity of the rehabilitated pipeline. Tight fitting liners maximize the flow potential through the rehabilitated line and minimize excavation, however, service connections may not be leak tight.

SURFACE INSTALLATIONS

Surface installations of DriscoPlex® OD controlled pipe normally require fully restrained joints such as heat fusion, flanges and fully restrained mechanical couplings. Primary installation considerations are to accommodate thermal expansion and contraction and to control bending stresses and strains at rigid structures. **Sunlight heating may require elevated temperature pressure ratings.**

Under the summer sun, black polyethylene pipe may reach temperatures up to 140° F and may be cooled to sub-zero temperatures in wintertime. In response to these temperature extremes, polyethylene pipe will expand and contract, both diametrically and longitudinally. For long piping runs, thermal length changes can be very significant. See the *PPI Handbook of Polyethylene Pipe* for design information.

Thermal length change may be accommodated with lateral deflection expansion loops that allow the pipe to snake side to side. **Expansion joints are not recommended.**

Surface pipelines should be placed on a smooth, uniform bed, wide enough to accommodate lateral deflection movement. The bed should be free of large rocks, clumps, clods and projecting stones or debris. Continuous support is preferred, however, small ditches, and open spaces may be crossed if they are less than the minimum support spacing distance for the pipe (Table 13). Greater spans require structural support.

Rigid structures and connections must be protected against excessive bending stresses or failures may occur. Fabricated fittings 16" IPS and larger are rigid structures and must be protected against bending stresses. Rigid connections such as paired flanges, or flanged connections to rigid pipe, valves, or other rigid structures or devices must be protected against bending stresses at the connection. See Figure 39.

Figure 39 Surface Tee Bending Protection
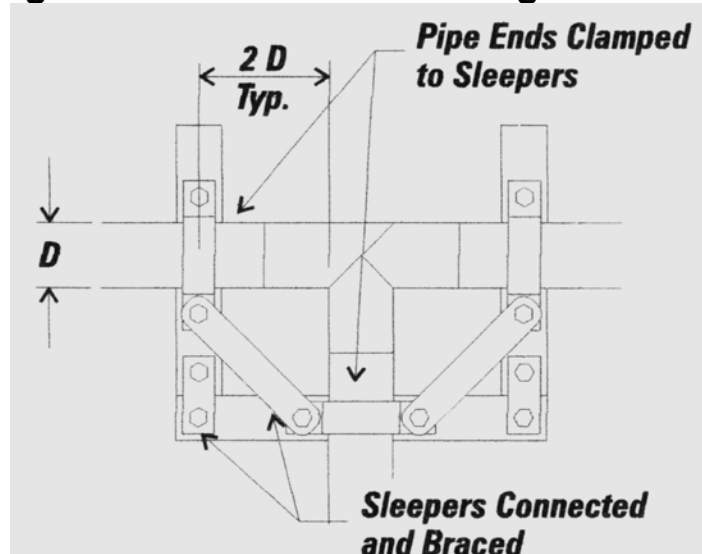
Valves and other such heavy devices must be structurally supported exclusive of the pipe and the connections must be protected against excessive bending stresses. The device should be mounted to foundation structure such as sleepers or a concrete slab, then provide bending protection such as that shown in Figure 31 and Figure 32.

A pipe run along the surface will expand and contract with temperature changes, and will snake side to side. If it is necessary to confine pipe movement to a general right-of-way, the pipe should be laid between paired posts spaced about every 50 feet along the run. The distance from post to post across the pipe should be 2 pipe diameters or more. In some cases, a berm or embankment on one side of the line and posts on the other will serve the same purpose.

Occasionally, a surface pipe may be laid to run along the side of an embankment. To support the pipe, posts or support structures spaced at the recommended support spacing may be installed upslope above the pipe. The pipe is tethered to the posts with wire rope connected to clamps at least 1/2 pipe diameter wide around the pipe.

Tethering may also be used to support a pipe running vertically up an embankment. The top connection should be a structurally supported flange with bending protection. At an appropriate supporting distance below the top flange, a flange pair should be installed for tether rope connections. At appropriate points to the side and above the tether connection flange, install posts or structures, and connect tether ropes from the posts to the tether flange. Tether ropes, flanges and support posts can be installed as required along the vertical run.

ABOVE GRADE INSTALLATIONS

Like surface installations, above grade installations of DriscoPlex® OD controlled pipe normally require fully restrained joints. Primary considerations are to accommodate thermal expansion and contraction and to control bending stresses at rigid structures. **Sunlight heating may require elevated temperature pipe pressure ratings.**

Above grade piping may be either supported in racks or hung from overhead supports. Racks must be wide enough to accommodate deflection from thermal expansion. If the rack is too narrow, the pipe may expand enough to fall off, or jump out, or damage adjacent piping or structures. Expansion joints generally provide unsatisfactory service with polyethylene pipe and are not recommended. Polyethylene pipe tends to deflect laterally rather than generate reactive thrust that would close the expansion joint. In pressure service, expansion joints simply expand out and cause further pipe deflection.

Rack beams supporting the pipe must be spaced at the recommended support spacing or less (Table 13). See the *PPI Handbook of Polyethylene Pipe* for information on rack design and thermal expansion and contraction.

Figure 40 and Figure 41 illustrate example rack designs. Center anchored pipes deflect to either side of the centerline. Pipe anchors must pivot with pipe deflection. Side anchored pipes deflect to one side only and anchors can be fixed to one side.
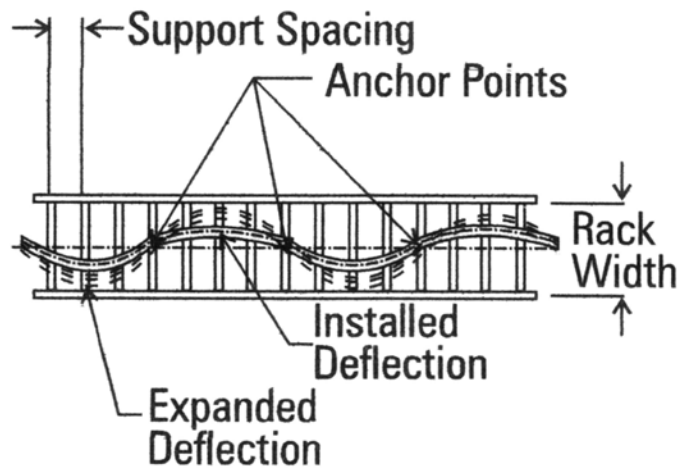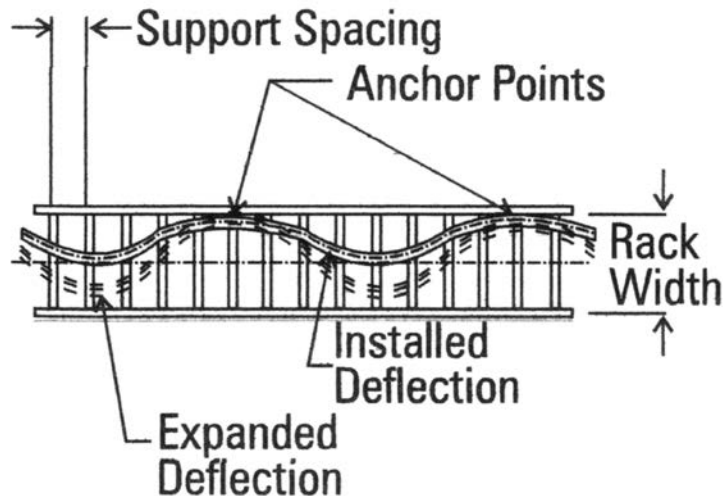
Figure 40 Pipe Rack, Center Anchored

Figure 41 Pipe Rack, Side Anchored

When installing in racks, pipes are usually laid with an initial lateral deflection so additional deflection will continue to the same side. Some deflection should exist when the pipe has contracted and is at the lowest anticipated temperature.

Additional pipe length should be provided so contraction at low temperature will not completely straighten out the pipe. Determine the length change, ΔL, for the change from ambient temperature at the time of installation, to the minimum expected temperature, add approximately 10% as a safety factor; then add this length to the anchor point distance, L. The length of the expanded pipe may be determined from:

$$L_p = L + 1.1\Delta L$$

Where
  L_p =   expanded pipe length, ft

Figure 42 Deflected Pipe Installation
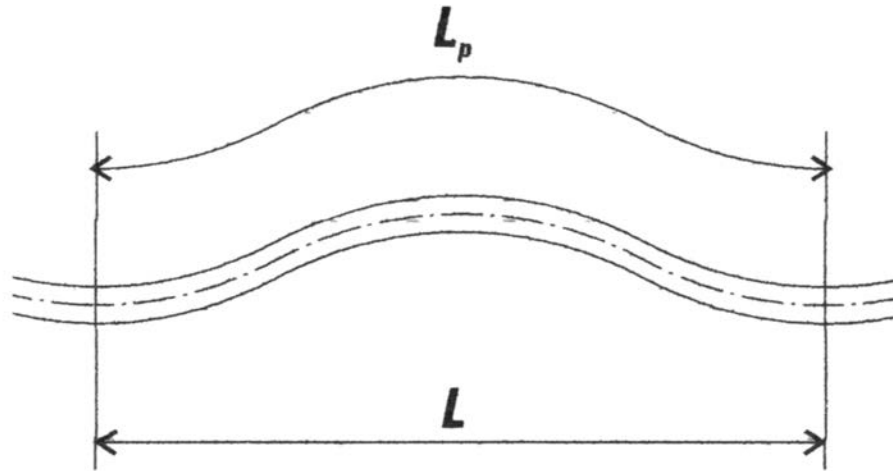
UNDERWATER INSTALLATION

Underwater lines must be ballast weighted to prevent floatation. See Submergence Weighting earlier in this handbook or ballast weight design in the *PPI Handbook of Polyethylene Pipe.*. Ballast weights may be installed on shore or on barges over water. The line is then floated into location and sunk into position. Typical ballast weight design allows an air-filled pipeline to float with ballast weights attached if both ends of the pipeline are capped.   Temporary floats such as barrels tethered to the line may be required to control sinking if the line is designed with heavy ballast weights.

On shore, ballast weight installation can be eased with a skid way to slide ballasted pipe into the waterway. Over water, barge mounted cranes may be used to lift and move ballast weights and pipe. Care must be taken not to kink the pipe.

Once ballasted, the pipeline is moved into position with marine craft or pulled into position with cables. Temporary anchoring may be used to maintain position during sinking. Water is introduced from the shore end, and air bled out slowly from the opposite end. Water must not be allowed to run the full length of the pipe. The shore end should be raised slightly to create a u-bend of water that moves down the line as the line sinks. The floating air bleed end should be elevated above the water to prevent water entry. Bleeding air from the floating end controls the water entry rate. Sinking rate must be controlled so the pipe does not bend too tightly and kink.

If the pipeline is to be buried, all trench excavations must be performed before sinking. To aid in placement, underwater backfill should be coarse soil such as gravel or crushed rock. If additional erosion protection is necessary, riprap, such as large stones or broken pavement, may be placed over the initial backfill.

INSPECTION AND TESTING

DAMAGE ASSESSMENT

Damage may occur during construction handling and installation. Significant damage may impair the future performance of the pipeline. Damaged pipe or fittings should be inspected and evaluated to determine if the damage impairs serviceability. The following guidelines may be used to assess damage significance.

For DriscoPlex® pressure piping systems, damage or butt fusion misalignment in excess of 10% of the minimum wall thickness required for pipeline operating pressure may be significant. If the pipeline is to operate at the maximum permissible pressure for the material and DR, the damage allowance is 10% of the pipe minimum wall thickness. On the other hand, if the pipe is to operate at lower pressure, damage depth may be greater.

The shape of the damage should also be considered. For small damage areas where the depth is not excessive, sharp notches and cuts should be dressed smooth so the notch is blunted. Blunt scrapes or gouges should not require attention. Minor surface abrasion from sliding on the ground or insertion into a casing should not be of concern.

- **Pipe or fittings that have sustained service impairing damage should not be installed.** Post-installation damage may require that the damaged pipe or fitting be removed and replaced.
- **Scrapes or gouges cannot be repaired by filling-in with extrusion or hot air welding. The damaged section should be removed and replaced.**
- **Improperly made fusion joints cannot be repaired.** Improper or misaligned butt fusions must be cut out and re-done from the beginning. Poorly joined socket or electrofusion fittings must be removed and replaced. Poorly joined saddle fittings must be removed by cutting out the main pipe section, or, if the main is undamaged, made unusable by cutting the branch outlet or chimney off the saddle fitting, and installing a new saddle fitting on a new section of main. Socket fusion fittings cannot be reused.
- **Broken or damaged fittings cannot be repaired.** They must be removed and replaced.
- **Kinked pipe must not be installed and cannot be repaired.** Kinked pipe must be removed and replaced.
- **Pipe damaged during an emergency squeeze-off cannot be repaired.**

Squeeze-off damaged pipe must be removed and replaced.

LEAK TESTING

Part 1 – Pre-Test Considerations

Leak testing may be used to find leaks in a newly constructed or newly modified piping system or in an established system where an apparent loss of integrity has been experienced. If they exist, leaks typically occur at joints or connections in the system.

Leak testing does not verify pressure rating or potential long-term performance, nor is it intended to supplement or replace product standard test requirements. The system design and the pressure ratings of the installed components are the sole determinants of system pressure rating and long-term performance.

For M&I applications, leak testing of pressure piping systems is done by filling the piping system or a section of the piping system with a liquid and applying a pressure. Pneumatic (air) testing of pressure piping systems is not within the scope of this technical note. Information on testing with a compressible fluid such as air is discussed in ASTM F2786.

The common hydrostatic leak test used for polyethylene pipe is a "modified pressure rebound method." In this testing method, the test section is filled with water and pressurized to a specified test pressure. The pressure is maintained for a certain duration, then slightly reduced and observed for one hour to assure the pressure remains essentially constant (within 5% variation) to achieve an acceptable test. Slightly reducing the test pressure suspends expansion of the PE piping, allowing a leak-free PE system to maintain a steady test pressure. This leak testing method and procedure is described in ASTM F2164, "Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure." Additional information on leak testing can be found in PPI TN-46 "Guidance for Field Hydrostatic Testing of High Density Polyethylene Pressure Pipelines: Owner's Considerations, Planning, Procedures, and Checklists."

SAFETY

Safety is of paramount importance when performing leak tests. Leak tests can apply high stress to untried joints and parts in the system. Failure can occur by leaking or by catastrophic rupture that can cause sudden, violent movement. In some cases, leakage may immediately precede catastrophic rupture.

WARNING – Death or serious injury and property damage can result from failure at a joint or connection during pressure leak testing. Keep all persons a safe distance away during testing. The test section is to be supervised at all times during the test.

Ensure that all piping is restrained against possible movement from catastrophic failure at a joint or connection. When pressurized, faulty joints or connections may separate suddenly, causing violent and dangerous movement of piping or parts. Correctly made joints do not

leak. Leakage at a joint or connection may immediately precede catastrophic failure. Never approach or attempt to repair or stop leaks while the test section is pressurized. Always depressurize the test section before making repairs.

RESTRAIN AGAINST MOVEMENT

Before applying pressure, all piping and all components in the test section must be restrained. This means that if piping or parts move or separate during the test, any movement of components or parts is sufficiently constrained such that it will not result in damage or injury. Common restraints include backfill, anchors, external clamps and tie rods, pipe guides, etc. **Never conduct leak tests on unrestrained piping.**

Additional guidance for preparing connections and joints for leak tests include:
Heat fusion joints must be properly cooled before testing.
Mechanical connections must be completely installed and tightened per manufacturer's instructions.

If backfill provides restraint, it must be properly placed and compacted. Joints and connections may be exposed for inspection.
End closures must be suitable for pressure service and pressure-rated for the test pressure.

Ensure that all connections to test equipment are secure. Disconnect or isolate all low-pressure filling lines and all other parts that are not to be subjected to test pressure. Restrain, isolate or remove expansion joints before leak testing. Testing against closed valves is not recommended due to the potential for leakage and/or trapped air. Best practice is to blind-flange before the closed valve.

TEST SECTION

Testing may be conducted on the full piping system or in sections. Test section length is generally limited by the capacity of the testing equipment. Lower capacity pressurizing or filling equipment may not be capable of completing the test within permissible time limits. In addition, the test section should be filled at a slow rate (typically less than 10-feet per minute) to minimize air entrapment. Considering test time limits and fill rate, pipelines longer than 3000 feet may need to be tested in several sections (see PPI TN-46).

Before applying test pressure, allow time for the test fluid and the test section to equalize to a common temperature.

TEST PRESSURE

The maximum test pressure should be measured at the lowest elevation in the test section. For pressure piping systems that include polyethylene pipe or fittings, the maximum permissible test pressure is the lower of:

- 150% of the PE pipe system's design pressure rating for the application and application service temperature, provided that all components in the test section are rated for the test pressure.
- The pressure rating of the lowest pressure rated component in the test

section. Lower pressure-rated components or devices may include pipe or fittings made from other plastics or metals, appurtenances such as valves, hydrants, regulators, and pressure relief devices, or some types of mechanical connections such as lower pressure-rated compression couplings or flanges with lower pressure-rated back-up rings.

Do not subject lower pressure rated, non-polyethylene parts or devices to pressures above their pressure rating. Lower pressure rated parts may be removed or isolated from the test section to avoid damage or failure. Vent isolated parts or equipment to atmosphere.

TEST TEMPERATURE

The pipe should be allowed to thermally stabilize and equalize before pressurizing the pipe to test pressure. All thermoplastic pipes have reduced strength at elevated temperature. Test pressure must be reduced when the test section is at elevated temperature either from service conditions or from environmental conditions such as being warmed by the sun. Multiply the test pressure by the Table 32 multiplier to determine the allowable elevated temperature test pressure.

Table 32 Elevated Temperature Multiplier

Test Section Temperature °F (°C)	≤ 80 (≤ 27)†	≤ 90 (≤ 32)	≤100 (≤ 38)	≤110 (≤ 43)	≤ 120 (≤ 49)	≤ 130 (≤ 54)	≤ 140 (≤ 60)‡
Multiplier	1.0	0.9	0.8	0.8	0.7	0.7	0.6
† Use the 80°F (27°C) multiplier for 80°F (27°C) and lower temperatures. ‡ The maximum service temperature for Performance Pipe PE pressure piping is 140°F (60°C).							

TEST DURATION

When testing at pressures above the system design pressure up to 150% of the system design pressure, the maximum test duration is eight (8) hours including time to pressurize, time for initial expansion, time at test pressure, and time to depressurize the test section. If the test is not completed due to leakage, equipment failure, or for any other reason, depressurize the test section completely, and allow it to relax for at least eight (8) hours before pressurizing the test section again. **CAUTION – Testing at excessive pressure or for excessive time may damage the piping system.**

When testing at the system design pressure or less, test duration including time to pressurize, time for initial expansion, time at test pressure, and time to depressurize should be limited to a practical time period (72 hours or less is suggested) given that the test section is not to be left unsupervised at any time during leak testing.

TEST FLUID

Hydrostatic Testing

The test liquid should meet appropriate industry standards for safety and quality so that the environment, system, test equipment and disposal (if necessary) are

not adversely affected. The recommended test liquid is water.

Pneumatic Testing

WARNING – Failure during a pneumatic (compressed gas) leak test can be explosive and result in death or serious bodily injury.

If failure occurs when using compressed gas as the test fluid, both the pressure stress on the system and the energy used to compress the gas are released. Such failure can be explosive and dangerous. Compared to hydrostatic testing, pneumatic testing can be more dangerous because failure during pneumatic testing releases more energy. For safety reasons, pneumatic testing is not within the scope of this technical note. Refer to ASTM F2786.

Part 2 – Hydrostatic Leak Testing Procedure
Read all of this publication and observe all safety precautions before conducting any leak test.

HYDROSTATIC LEAK TESTING
This hydrostatic leak test procedure consists of filling, an initial expansion phase, a test phase, and depressurizing.

Filling

Fill the restrained test section completely with test liquid. The test section is usually filled from the lowest point of the pipeline and at a slow fill rate to minimize air entrainment. A fill rate of 10-feet per minute axial velocity or less is suggested in PPI TN-46. After filling, allow time for the system to reach thermal equilibrium and allow for any dissolved air to exit the system air vents.

WARNING – Ensure that there is no air trapped in the test section. Failure with entrapped air can result in explosive release and result in death or serious bodily injury. Use equipment vents at high points to remove air. A firm urethane foam pig or swap, pushed by the fill water, may be used to assist in air removal.

Initial Expansion Phase

Gradually pressurize the test section to test pressure, and add make-up water as necessary to maintain maximum test pressure for four (4) hours. During the initial expansion phase, polyethylene pipe will expand slightly due to elasticity and Poisson effects. Additional test liquid will be required to maintain pressure. The amount of additional test liquid will vary because expansion in the PE pipe is not linear. It is not necessary to monitor the amount of water added during the initial expansion phase.

If test pressure cannot be attained, or if it takes an unreasonably long time to reach test pressure, there may be faults such as excessive leakage, entrapped air, or open valving, or the pressurizing equipment may be inadequate for the size of the test section. If such faults exist, discontinue pressurizing and correct them before continuing.

Test Phase

Immediately following the initial expansion phase, reduce test pressure by 10 psi and stop adding test liquid. Monitor the pressure for 1 hour.
If no visual leakage is observed and test pressure remains steady (within 5% of the target value) for one (1) hour, no leakage is indicated.

Depressurization

Depressurize the test section by reducing pressure or releasing test liquid at a controlled rate. Sudden depressurization can cause water hammer.

Part 3 – Additional Leak Testing Procedures

LOW PRESSURE AIR TESTING OF GRAVITY FLOW SYSTEMS

For gravity flow and low or intermittent pressure applications such as sewer and odor control, leak testing in accordance with ASTM F1417 is recommended.

HIGH PRESSURE AIR TESTING

For applications requiring high pressure air (pneumatic) testing, leak testing in accordance with ASTM F2786 is recommended.

INITIAL SERVICE LEAK TESTING

An initial service leak test may be acceptable when other types of tests are not practical, when leak tightness can be demonstrated by normal service, or when an opportunity is afforded by performing initial service tests of other equipment. An initial service leak test may apply to systems where isolation or temporary closures are impractical, or where checking out pumps and other equipment allows the system to be examined for leakage prior to full-scale operations.

The piping system should be gradually brought up to normal operating pressure, and held at normal operating pressure for at least ten (10) minutes. During this time, joints and connections may be examined for leakage. At the conclusion of the test, depressurize the test section by the controlled release of fluid from the test section. Controlled release avoids the potential for pressure surge.

SYSTEMS THAT ARE NOT SUITABLE FOR PRESSURE LEAK TESTING

Some systems may not be suitable for pressure leak testing. These systems may not be designed or intended for internal pressure such as vacuum systems, or they may contain parts that cannot be isolated, or temporary closures to isolate the test section may not be practical.

Systems that are not suitable for pressure leak testing should not be pressure tested, but should be carefully inspected during and after installation. Inspections such as visual examination of joint appearance, mechanical checks of bolts and joint tightness, and other relevant examinations should be performed.

OPERATIONAL GUIDELINES

Disinfecting Water Mains

Applicable procedures for short term disinfection of new and repaired potable water mains are presented in standards such as ANSI/AWWA C651, *Disinfecting Water Mains*. ANSI/AWWA C651 uses liquid chlorine, sodium hypochlorite, or calcium hypochlorite to chemically disinfect the main. Disinfecting solutions containing chlorine should not exceed 12% active chlorine, because greater concentration can chemically attack and degrade polyethylene.

Operational disinfection practices should limit available chlorine levels to <=5ppm for temperatures up to 75°F. At temperatures between 75°F and 90°F the active chlorine levels should be reduced further. DriscoPlex® piping systems are not recommended for potable hot water applications.

CLEANING

Pipelines operating at low flow rates (around 2 ft/sec or less) may allow solids to settle in pipe invert. Polyethylene has a smooth, non-wetting surface that resists the adherence of sedimentation deposits. If the pipeline is occasionally subject to higher flow rates, much of the sedimentation will be flushed from the system during these peak flows. If cleaning is required, sedimentation deposits can usually be flushed from the system with high-pressure water. Water-jet cleaning is available from commercial services. It usually employs high-pressure water sprays from a nozzle that is drawn through the pipe system with a cable.

Pressure piping systems may be cleaned with the water-jet process or may be pigged. Pigging involves forcing a resilient plastic plug (soft pig) through the pipeline. Usually, hydrostatic or pneumatic pressure is applied behind the pig to move it down the pipeline. Pigging should employ a pig launcher and a pig catcher.

A pig launcher is a wye or a removable spool. In the wye, the pig is fitted into the branch, then the branch behind the pig is pressurized to move the pig into the pipeline and downstream. In the removable pipe spool, the pig is loaded into the spool, the spool is installed into the pipeline, and then the pig is forced downstream. A pig catcher is a basket or other device at the end of the line to receive the pig when it discharges from the pipeline. **A pig may discharge from the pipeline with considerable velocity and force. A pig catcher provides a means of safe pig discharge from the pipeline.**

Soft pigs must be used with polyethylene pipe. **Scraping finger type or bucket type pigs will severely damage the pipeline, and must not be used.** Commercial pigging services are available if line pigging is required.

CAUTIONS AND NOTICES

Observe all local, state and federal codes and regulations, and general handling, installation, and construction and operating safety precautions. The following cautions should also be observed when using Performance Pipe polyethylene piping products.

FUSION AND JOINING

During heat fusion, equipment and products can exceed 400°F (204°C). Take care to prevent burns. *Do not bend pipes into alignment against open butt fusion machine clamps.* The pipe may spring out and cause injury or damage.

Performance Pipe polyethylene piping products cannot be joined with adhesive or solvent cement. Pipe-thread joining and joining by hot air (gas) welding or extrusion welding techniques are not recommended for pressure service.

LEAKAGE AT FUSION JOINTS

WARNING–Correctly made fusion joints do not leak. When pressurized, leakage at a faulty fusion joint may immediately precede catastrophic separation and result in violent and dangerous movement of piping or parts and the release of pipeline contents under pressure. Never approach or attempt to repair or stop leaks while the pipeline is pressurized. Always depressurize the pipeline before making corrections.

Faulty fusion joints must be cut out and redone.

LIQUID HYDROCARBON PERMEATION

Liquid hydrocarbon permeation may occur when liquid hydrocarbons are present in the pipe, or where soil surrounding the pipe is contaminated with liquid hydrocarbons. *Polyethylene pipe that has been permeated with liquid hydrocarbons should be joined using suitable mechanical connections* because fusion joining to liquid hydrocarbon permeated pipes may result in a low strength joint. Mechanical fittings must be installed in accordance with the fitting manufacturer's instructions. Obtain these instructions from the fitting manufacturer.

WEIGHT, UNLOADING AND HANDLING

Although polyethylene piping is lightweight compared to some other piping products, significant weight may be involved. Move polyethylene piping with proper handling and lifting equipment of sufficient size and capacity to handle the load. Inspect handling equipment before use. *Do not use worn or damaged equipment.*

Use fabric slings. Do not use chains or wire ropes. *Do not roll or drop pipe off the truck, or drag piping over sharp rocks or other abrasive objects.* Improper handling or abuse can damage piping and compromise system performance or cause injury or property damage.

Obtain and observe the handling instructions provided by the delivery driver.

Striking the pipe with an instrument such as a hammer may result in uncontrolled rebound. Store DriscoPlex® piping products so that the potential for damage or injury is minimized. See the *Performance Pipe Loading and Unloading guidance and videos at* www.PerformancePipe.com *.*

Inclement weather can make pipe surfaces especially slippery. Do not walk on pipe, especially when footing is unsure.

TESTING

When testing is required, observe all safety measures, restrain pipe against movement in the event of catastrophic failure, and observe limitations of temperature, test pressure, test duration and making repairs. See Performance Pipe Technical Note PP-802 *Leak Testing PE Piping Systems.*

PROTECTION AGAINST SHEAR AND BENDING LOADS

Where a polyethylene branch or service pipe is joined to a branch fitting and where pipes enter or exit casings or walls, structural support such as properly placed, compacted backfill and a protective sleeve should be used. Whether or not a protective sleeve is installed, the area surrounding the connection must be structurally supported by embedment in properly placed compacted backfill or other means to protect the polyethylene pipe against shear and bending loads. See the PPI Handbook of Polyethylene Pipe, and ASTM D 2774.

SUBFREEZING TEMPERATURES

Water can be frozen solid in polyethylene pipe without damaging the pipe, but an ice plug in the pipe will stop flow. *Do not apply pressure to a frozen line that has an ice plug.* Allow ice plugging to thaw before applying pressure to the line. **Severe water hammer (such as from an ice plug stopping suddenly at an obstruction) in a frozen, surface or above grade pipeline can rupture and possibly fragment the pipeline and cause injury or property damage.**

Temperatures near or below freezing will affect polyethylene pipe by increasing stiffness and vulnerability to damage from suddenly applied stress or impact. *Significant impact or shock loads against a polyethylene pipe that is at freezing or lower temperatures can fracture the pipe.* Polyethylene pipe will be more difficult to uncoil or field bend in cold weather. Cold temperatures will cause the pipe length and diameter to decrease.

STATIC ELECTRICITY

Polyethylene pipe does not readily conduct electricity. Under dry conditions such as dry gas flow inside the pipe, a static electric charge can buildup on inside and outside pipe surfaces, and stay on the surface until some grounding

device such as a tool or a person comes close enough for the static electricity to discharge to the grounding device.

Discharging one part of the pipe surface will not affect other charged areas because static electricity does not flow readily from one area to another. Polyethylene pipe cannot be discharged by attaching grounding wires to the pipe.

WARNING–_Fire or Explosion–Static electric discharge can ignite a flammable gas or combustible dust atmosphere._

A static electricity discharge to a person, a tool, or a grounded object close to the pipe surface can cause an electric shock or a spark that can ignite a flammable gas or combustible dust atmosphere causing fire or explosion.

- In gas utility applications, static electricity can be a potential safety hazard. ***Where a flammable gas- air mixture may be encountered and static charges may be present, such as when repairing a leak, squeezing off an open pipe, purging, making a connection, etc., arc preventing safety precautions are necessary. Observe all Company (pipeline operator, utility, contractor, etc.) procedures for static electricity safety and control, including procedures for discharging static electricity and requirements for personal protection.***

- Take steps to discharge static electricity from the surface of a polyethylene gas pipe. Such steps include wetting the entire exposed pipe surface with a conductive anti-static liquid or a dilute soap and water solution, then covering or wrapping the entire wetted, exposed pipe surface with grounded wet burlap, conductive poly film, or wet tape conductor. The external covering should be kept wet by occasional re-wetting with anti-static solution. The covering or tape should be suitably grounded such as to a metal pin driven into the ground.

- Procedures that discharge the outer surface do not discharge the inner surface of the pipe. Squeeze-off, purging, venting, cutting, etc., can still result in a static electricity discharge. When appropriate, ground tools and remove all potential sources of ignition.

- Appropriate personal safety equipment should be used.

Do not use polyethylene pipe for handling dry grain or coal where a static electricity discharge may ignite a combustible dust atmosphere and cause an explosion or fire.

Polyethylene pipe is not recommended for pneumatic slurry (pneumatic transport) applications.

COILS

Coiled HDPE pipe may contain energy as a spring. Uncontrolled release, i.e. cutting of straps, can result in dangerous uncontrolled forces. All safety precautions must be taken, and proper equipment used.

LOCATING

Polyethylene materials are generally not detectable by standard magnetic locating equipment. There are several methods available to aid in the detection of polyethylene pipelines. These include tracer wires, identification tape, detection tape, line markers, electronic marker systems, acoustic pipe tracing and "call before you dig" line location. When installing a polyethylene pipe system, consideration should be given to a method or methods that will allow the pipeline to be located in the future. If posted signs are used to indicate the location of buried pipe, it is recommended that the signs indicate that the buried line is polyethylene. This alerts the locating personnel that the pipeline may not be identifiable by standard locating equipment. The company listed should always be contacted prior to any excavation or trenching.

Application Limitations

Dry pneumatic transport of combustible materials such as coal or food grains is not recommended, and can be extremely dangerous. Polyethylene is non-conductive. Dry, sliding friction will cause a static electric charge to build on the pipe surface. ***Static electric discharge can ignite combustible dust and cause an explosion, property damage, or possible personal injury.***

Pneumatic transport of non-combustible solids is not recommended. Particles sliding on the surface will heat and may melt the surface, and will cause static electric charges to build on the pipe surface. ***Static electric discharge can be dangerous to property or persons.***

Above grade compressed gas (compressed air) lines are a possible safety concern. When installed on or above grade, polyethylene may be subject to external mechanical damage. Severe damage could cause rupture and possible uncontrolled whipping. If used for compressed gas service, polyethylene pipe should be completely restrained by burial, encased in shatter-resistant materials, or otherwise protected against external mechanical damage.

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