PERFORMANCE PIPE
A Division of Chevron Phillips Chemical Company LP

PERFORMANCE PIPE GAS DISTRIBUTION BROCHURE


Driscoplex® 6500
MDPE Gas Distribution Pipe


Yellowstripe® 8300
HDPE Gas Distribution Pipe


Driscopipe® 8100
HDPE Gas Distribution Pipe

Performance Pipe

Performance Pipe is a name you can trust in gas distribution piping. We specialize in natural gas distribution, liquid propane gas (LPG), propane gas distribution, and yard gas products and fittings.

With more than fifty years of polyethylene pipe manufacturing experience, Performance Pipe has nine ISO 9001 certified manufacturing facilities strategically located across the United States.

The unmatched quality and performance of Performance Pipe polyethylene piping products is further enhanced and strengthened by more than five decades of quality polyolefin plastic resin production from our parent company Chevron Phillips Chemical Company LP.

As active members of the American Gas Association, ASTM International, Gas Piping Technology Committee, Plastics Pipe Institute, American Society of Mechanical Engineers, and American Petroleum Institute, we provide technical expertise and service to these organizations on an ongoing basis.

When you select Performance Pipe gas pipe and fittings, in addition to receiving quality products, you also gain access to our team of experts for technical support and assistance. Topics range from assistance in product applications and capabilities to installation and handling to testing and operating procedures. We are here to help.
Our territory sales teams are dedicated to the gas distribution industry and to the service of Performance Pipe's gas distribution product customers.

Products

Performance Pipe's gas piping products are the material of choice for premium medium and high density natural gas distribution, LPG, propane gas and yard gas piping systems. Performance Pipe's products are produced to meet or exceed the manufacturing and material requirements of the latest edition of ASTM D2513 *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings*, or applicable international standards. The pipes meet the requirements of ANSI/NFPA 58 *Standard for the Storage and Handling of Liquefied Petroleum Gases*.

Performance Pipe offers the following gas distribution products:

Driscoplex® 6500 MDPE Gas Distribution Pipe These medium density polyethylene (MDPE) PE2708 (PE2406) pipes and fittings are used primarily in pressure-rated gas distribution systems. The product is also suitable for LPG, propane, yard gas and most after-meter applications. The product is a solid yellow medium density pipe that meets ASTM D3350 Cell Classification of PE234373E and APWA/ULCC Color Code Standards.

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Yellowstripe® 8300 HDPE Gas Distribution Pipe These high density polyethylene (HDPE) PE4710/PE100 (PE3408) pipes and fittings are used primarily in pressure rated gas distribution systems. The product is black pipe with four equidistant yellow stripes. The Yellowstripe® 8300 pipe series meets APWA/ULCC Color Code Standards and has an ASTM D3350 Cell Classification of PE445574C when using HDB or PE445576C using MRS.

Driscopipe® 8100 HDPE Gas Distribution Pipe These high density polyethylene (HDPE) PE4710/PE100 (PE3408) pipes and fittings are also primarily used in pressure rated gas distribution applications. The Driscopipe® 8100 pipe series is a black pipe with a co-extruded yellow-shell that complies with the APWA/ULCC Color Code Standards. The pipe has an ASTM D3350 Cell Classification of PE445574C when using HDB or PE445576C using MRS. The yellow shell helps reflect solar heat, enabling retention of higher strength ambient temperature properties. It also provides improved ability to detect damages and scratches.

Fittings

Performance Pipe manufactures medium density and high density molded butt, socket, and saddle fusion fittings.

Quality

Performance Pipe's polyethylene piping products for gas are unmatched in quality and performance. In addition to meeting the manufacturing and quality requirements of ASTM D2513 *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings,*. Performance Pipe's gas products also meet our own internal quality assurance (QA) and quality control (QC) requirements. These internal QA/QC requirements meet or exceed those required by industry standards. Each product line is continuously monitored throughout the manufacturing cycle to ensure that the product adheres to all internal quality control specifications and the manufacturing standard. All nine of Performance Pipe's manufacturing facilities are certified in accordance with the latest edition of ISO 9001. Individual plant certificates of conformance to ISO 9001 are available upon request.

Sizes

Performance Pipe manufactures its Driscoplex® 6500 pipe product through 12" IPS sizes. For larger diameter gas applications (8" though 24") we recommend our high density polyethylene pipes Yellowstripe® 8300 pipe and Driscopipe® 8100 pipe. Both products are available in 1/2" through 24" (16 mm through 630 mm) outside-diameter-controlled polyethylene pipe and tubing sizes. Specific sizes of pipe and fittings available for each product can be found on Performance Pipe's website at www.PerformancePipe.com.

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Available Certifications

Specific sizes of Driscoplex® 6500 (MDPE) pipe, Yellowstripe® 8300 (HDPE) pipe and Driscopipe® 8100 (HDPE) pipe and fittings are available with CSA (Canadian Gas Association) certification. Many sizes of Driscoplex® 6500 pipe are available with UPC (Uniform Plumbing Code) certification by IAPMO (International Association of Plumbing and Mechanical Officials) for yard gas piping, LPG and other after-meter applications.

Outdoor Storage

Performance Pipe polyethylene gas distribution piping products are protected from UV effects and outdoor exposure to ensure pipe performance requirements are maintained.

Yellow pipes, such as Driscopipe® 8100 HDPE gas distribution pipe and Driscoplex® 6500 MDPE gas distribution pipe, are protected against outdoor exposure through additive formulations and are defined as Code E materials in accordance with ASTM D3350. Yellowstripe® 8300 HDPE gas distribution pipe is defined as a Code C material and as such contains a minimum of 2-3 percent carbon black.

Accelerated laboratory weathering tests were conducted on the formulations that predict the yellow pipe materials are sufficiently protected to provide a service life of at least four years in outdoor exposure conditions.

Black pipe material weathering tests indicate an unlimited outdoor storage potential. The actual test data confirmed that there is no measurable change in pipe performance properties after four years of outdoor exposure for Code E materials and no measurable change for Code C materials after more than 40 years.

Based on the tests conducted, Performance Pipe provides the following specific unprotected outdoor storage recommendations for Performance Pipe's gas distribution piping products.

- Driscoplex® 6500 pipe 4 years
- Driscopipe® 8100 pipe 4 years
- Yellowstripe® 8300 pipe 10 years

Cautions

Polyethylene piping has been safely used in thousands of applications. However, there are general precautions that should be observed when using any product. In this respect, polyethylene piping is no different. Below is a list of some of the precautions that should be observed when using Performance Pipe's gas pipe and fittings.

- **Fusion**
  During the heat fusion process, equipment and products can reach temperatures in excess of 450°F (231°C). Caution should be taken 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 adhesives or solvent cement. Pipe-thread joining and joining by hot air (gas) welding or extrusion welding techniques are not recommended for pressure service.

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- **Static Electricity**

  High static electricity charges can develop on polyethylene piping products, especially during squeeze-off, when repairing a leak, purging, making a connection, etc.

  Where a flammable gas atmosphere and static electric charges may be present, observe all company (pipeline operator, utility, contractor, etc.) safety procedures for controlling and discharging static electricity and all requirements for personal protection. See website for: Performance Pipe Technical Note *Polyethylene Pipe Squeeze Off; PP 801-TN*.

- **Weight, Unloading and Handling**

  Although polyethylene pipe is not as heavy as some other piping products, significant weight may be involved. Care should be used when handling and working around polyethylene pipe. Improper handling or abuse may cause damage to piping, compromise system quality or performance, or cause personal injury. Observe the safe handling instructions provided by the delivery driver. See website for: *Pipe Loading/Unloading-Truck Driver Safety Video*.

- **Coils**

  Coiled PE pipe is restrained with strapping to contain the spring-like energy retained within the coil. Cutting or breaking strapping can result in an uncontrolled release. Take all necessary safety precautions and use appropriate equipment. Observe the safe handling instructions provided by the delivery driver.

Leak Testing

When testing is required, fuel gas distribution systems should be tested in accordance with applicable codes and regulations and distribution system operator procedures. Observe all safety measures, restrain pipe against movement in the event of catastrophic failure, and observe limitations of temperature, test pressure, test duration, and procedures for making repairs.

Protection against Shear and Bending Loads

Measures such as properly placed, compacted backfill, protective sleeves, and structural support are sometimes necessary to protect plastic pipe against shear and bending loads.

For additional installation information see ASTM D-2774, *Underground Installation of Thermoplastic Pressure Piping.*

Liquid Hydrocarbon Permeation

PE piping that has been in service conveying fuel gases that include heavier hydrocarbons can sometimes exhibit a bubbly appearance when melted for heat fusion. This bubbling is the result of the rapid expansion (by heat) and passage of heavier, adsorbed hydrocarbon gases through the heated and molten polyethylene material. Studies* have shown that propane concentrations under 0.2% is sufficient to sometimes show some bubbling, but is not high enough to effect any significant degradation in strength of the pipe or fusion joint. However, since there currently are no field tests to readily determine the amount of adsorbed hydrocarbons in PE pipe and their potential effect on the fusion joint, the heat fusion process should be abandoned and mechanical connections should be used if bubbles are encountered during a heat fusion process.

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(*)S.M. Pimputkar, J.A. Stets, and M.L. Mamoun, “Examination of Field Failures”, Sixteenth International Plastics Pipe Symposium, New Orleans, Louisiana, November 1999.

Locating

Most polyethylene materials are not detectable with standard magnetic locating equipment. When installing PE piping, a method or methods for future pipeline detection should be considered. Gas utilities in the area should always be contacted before the start of any underground installation work such as excavation, trenching, directional boring, etc.

Joining

- D.O.T. Regulations require that each joint in a gas piping system must be made in accordance with written procedures that have been proved by test or experience to produce strong gastight joints (49 CFR, Part 192, §192.273(b)).
- D.O.T. Regulations require that written procedures for butt fusion, saddle fusion, and socket fusion joining of polyethylene gas piping must be qualified before use by subjecting specimen joints to required test procedures (CFR 49, Part 192, §192.283(a)).
- D.O.T. Regulations require that all persons who make joints in polyethylene gas piping must be qualified under the operator's written procedures (CFR 49, Part 192, & §192.285(a)). ·
- D.O.T. Regulations require that the gas system operator must ensure that all persons who make or inspect joints are qualified (CFR 49, Part 192, §192.285(d) & §192.287).

Performance Pipe recommends using Performance Pipe’s Fusion Joining Procedures Bulletin *PP-750 Heat Fusion Joining Procedures and Qualification Guide* when making heat fusion joints with our gas piping products. When PP-750 is used to join Performance Pipe polyethylene gas pipe and fittings, Performance Pipe fusion joining procedures are qualified in accordance with U.S. Department of Transportation Regulations. A copy of PP-750 may be obtained from our website at: www.performancepipe.com

Other qualified procedures used for butt and saddle fusion of polyethylene gas piping products are the Plastic Pipe Institute’s, PPI TR-33/2006 *Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe* and PPI TR-41 *Generic Saddle Fusion Joining Procedure for Polyethylene Gas Piping*.

Squeeze-Off

Squeeze-off is used to control flow in PE pipe by flattening the pipe between parallel bars. Squeeze-off is used for routine and emergency situations. ***Do not squeeze-off more than once at the same point on the pipe.*** For repeated flow control, throttling, or partial flow restriction, install a valve or an appropriate flow control device.

Complete flow stoppage will not occur in all cases. For larger pipes, particularly at higher pressures, some seepage is likely. If seepage is not permissible, the pipe should be vented in between two squeeze-offs.

Use squeeze-off procedures meeting ASTM F1041 and tools meeting ASTM F1563 with Performance Pipe polyethylene pipes. The combination of pipe, tool, and squeeze-off procedures should be qualified in accordance with ASTM F1734. Correct tool closure stops and closing and opening rates are key elements to squeezing-off without damaging the pipe. Tool closure stops must be correct for the pipe size and wall thickness (SDR). It is necessary to close slowly and release slowly, with slow release being more important.

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See Performance Pipe Technical Note *PP-801 Squeeze-Off* on our website at: *www.performancepipe.com*.

Performance Characteristics

Cell Classification

ASTM D3350 *Standard Specification for Polyethylene Plastics Pipe and Fittings Materials* standard cell classification covers the identification of polyethylene materials for pipe and fittings according to a cell classification system. Performance Pipe's gas piping products are listed below.

Table 1: Cell Classifications

Performance Pipe Product Series	Material Designation Code		ASTM D3350 Cell Classification
	Present	Past	
Driscoplex® 6500 Pipe (MDPE)	PE2708	(PE2406)	234373E
Driscopipe® 8100 Pipe (HDPE)	PE4710-PE100	(PE3408)	445574C (445576C*)
Yellowstripe® 8300 Pipe (HDPE)	PE4710-PE100	(PE3408)	445574C (445576C*)

* When using the Minimum Required Strength (MRS) classification.

Long-Term Strength (HDB)

Performance Pipe's polyethylene piping products for gas distribution are listed with the Plastics Pipe Institute (PPI) and have PPI recommended Hydrostatic Design Basis (HDB) ratings as follows:

Table 2: Hydrostatic Design Basis

Performance Pipe Product Series	Hydrostatic Design Basis (HDB) 73°F (23°C)	Hydrostatic Design Basis (HDB) 140°F (60°C)
Driscoplex® 6500 Pipe (MDPE)	1250 psi (8.62 MPa)	1000 psi (6.89 MPa)
Driscopipe® 8100 Pipe (HDPE)	1600 psi (11.03 MPa)	1000 psi (6.89 MPa)
Yellowstripe® 8300 Pipe (HDPE)	1600 psi (11.03 MPa)	1000 psi (6.89 MPa)

HDB by Temperature Interpolation

Elevated temperature properties can be used to determine product capabilities for applications where products will be exposed to elevated temperatures. The Hydrostatic Design Stress for polyethylene is established by testing at 73°F. As with all thermoplastics, when operating temperature increases, pressure capacity decreases.

When determining HDB values, use the interpolation protocol of PPI TR-3-2006 D.2 *Policy for Determining Long-Term Strength (LTHS) By Temperature Interpolation*.
The policy states that, for thermoplastic pipe that is going to be installed at a service temperature greater than 73ºF and less than that at which the next HDB has been established, the HDB at the anticipated service temperature can be determined by interpolation.

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Table 3: HDB in PSI by Temperature Interpolation

Service Temperature (°F)	73 Determined	100 interpolated	110 interpolated	120 interpolated	130 interpolated	140 Determined
Driscoplex® 6500 Pipe (MDPE)	1250	1250	1000	1000	1000	1000
Driscopipe® 8100 Pipe (HDPE)	1600	1250	1250	1000	1000	1000
Yellowstripe® 8300 Pipe (HDPE)	1600	1250	1250	1000	1000	1000

Slow Crack Growth (SCG) Resistance

Resistance to slow crack growth is a critical performance requirement because long-term stress can cause cracks to grow slowly through polyethylene pipe resin material. Polyethylene gas pipe is under long-term stress from internal pressure and earthloading. Thus gas distribution service requires materials that have superior long-term resistance to stress cracking and slow crack growth (SCG).

Resistance to slow crack growth is measured using ASTM F1473 *Standard Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins*. Studies* have shown that a 150 hour PENT test could be compared to several centuries of leak free performance in the field.

(* PENT Quality Control Test for PE Gas Pipes and Resins: Dr. Norman Brown and X. Lu; Presented at the 12th Plastic Fuel Gas Pipe Symposium, Sept. 24-26, 1991.)

Table 4: Typical PENT Values

Performance Pipe Product Series	PENT, hours (ASTM F1473)
Driscoplex® 6500 Pipe (MDPE)	>2,000
Driscopipe® 8100 Pipe (HDPE)	>2,000
Yellowstripe® 8300 Pipe (HDPE)	>2,000

ASTM D2513 requires that all PE materials used in gas distribution service meet a minimum of at least 100 hours for two tests before failure when tested per ASTM F1473. Performance Pipe's gas products are tested to over twenty times these minimum testing requirements.

Recent research* has revealed various failure modes for pipes under long term PENT testing. Some doubt has been cast on the correlation between brittle and ductile failure in pressurized pipes and the laboratory established PENT failure times. The research lends credibility to limiting testing times of the PENT test.

(*) R.K Krishnaswamy, Asish M. Sukhadia and Mark J. Lamborn "Is PENT a True Indicator of PE Pipe Slow Crack Growth Resistance", Performance Pipe Technical Note PP-818-TN, Chevron Phillips Chemical Company, LP.

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Over 9,245 production lots of gas pipe manufactured from Performance Pipe PE2708 (PE2406) piping material have been tested against ASTM F1248, *Standard Test Method for Determination of Environmental Stress Crack Resistance (ESCR) of Polyethylene Pipe.* These production lots have amassed a performance history that cumulatively represents over 105 years of testing without failure.

Rapid Crack Propagation

When a pressurized polyethylene pipe is subjected to an instantaneous and intense impact, a pre-existing or consequently initiated crack or flaw can propagate axially at extremely high speeds. Such an impact is referred to as Rapid Crack Propagation, or RCP. It is a property inherent in fracture mechanics of many pipe materials, including polyethylene. Similarly, Rapid Crack Arrest (RCA) is a fast fracture property of the pipe material that arrests the travel of the crack after initiation or before RCP can occur.

While RCP occurrences in PE pipes are extremely rare, the consequences can be significant. Because of the catastrophic nature of a potential RCP event, pipe producers have begun to design pipes and applications such that RCP may be avoided in most circumstances. This has led to the development of several tests, of which the Full-Scale (FS) and Small-Scale Steady State (S4) tests are most relevant.

Full Scale Test (FST) ISO 13478

Polyethylene pipes that are approximately 40 times the diameter in length are pressurized at low temperatures, and failure is initiated through blunt force impact with a striker at one end to initiate a crack. The critical pressure and temperature are directly determined. There are no Full-Scale Test facilities in the United States.

Small-Scale Steady State (S4) ISO 13477 and ASTM F1589

The S4 test pipe specimens are typically a minimum of seven times the diameter in length. Specimens are conditioned at the test temperature externally, and then moved to the S4 test rig where they are sealed at both ends and pressurized with air. A sharp chisel-edged striker impacts the pipe at one end to initiate a fast-running crack. A containment cage around the specimen and a series of baffles constrain the outside diameter of the pipe. The results are correlated to the critical temperature and pressure.

Performance Pipe's gas piping products are all tested to ISO 13477 Small-Scale Steady State with exceptional RCP resistance.

ASTM Test Values

The charts below show material physical properties, ASTM test methods for the property, and nominal values for Performance Pipe materials used for gas pipe. (Note - Per ASTM D 748, the brittleness temperature is less than <-180°F (<-118°C), therefore, Performance Pipe's Yellowstripe® 8300 pipe, Driscopipe® 8100 pipe and Driscoplex® 6500 pipe series may be used at operating temperatures down to or below <- 40°F (<-40°C)). Typical physical properties for each pipe are included below.

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Yellowstripe® 8300 HDPE Gas Distribution PIpe PE4710-PE100 / (PE3408) Typical Physical Property Pipe Data Sheet			
Property	**Unit**	**Test Procedure**	**Typical Value**
Material Designation	--	**PPI TR-4**	**PE4710 PE100**
Cell Classification	--	**ASTM D3350**	**445574C 445576C**
Pipe Properties			
Density	gms / cm^3	ASTM D1505	0.961 (black)
Melt Index (MI) Condition 190/2.16	gms / 10 minutes	ASTM D1238	0.08
Melt Index (HLMI) Condition 190/21.6	gms / 10 minutes	ASTM D1238	7.5
Hydrostatic Design Basis, (73°F)	psi	ASTM D2837	1,600
Hydrostatic Design Basis, (140°F)	psi	ASTM D2837	1,000
Minimum Required Strength	Mpa (psi)	ISO 9080	>10 (>1450)
Rapid Crack Propagation Critical Pressure (Pc), 0°C (32°F)(1)	Bar (psi)	ISO 13477	>12 bar (>174)
Color; UV Stabilizer [C]	%	ASTM D3350	Min. 2% Carbon Black UV stabilized 10 years
Pipe Test Category	---	ASTM D2513	CEE
Material Properties			
Flexural Modulus @2% strain	psi	ASTM D790	>150,000
Tensile Strength at Yield	psi	ASTM D638 (Type IV)	>3,500
Elongation at Break 2 in/min., Type IV bar	%	ASTM D638	>800
Hardness	Shore D	ASTM D2240	65
PENT	hrs	ASTM F1473	>2,000
Manufactured to ASTM D2513 for pipe. Fittings comply with ASTM D2513 and ASTM D3261.			
Thermal Properties			
Vicat Softening Temperature	^oF	ASTM D1525	255
Brittleness Temperature	^oF	ASTM D746	-180
Thermal Expansion	in / in / ^oF	ASTM D696	1.0×10^{-4}

(1) Determination made using Small-Scale Steady state. Pc calculated in accordance with ISO 13477

(2) NOTICE: This data sheet provides typical physical property information for polyethylene resins used to manufacture PERFORMANCE PIPE polyethylene piping products. It is intended for comparing polyethylene piping resins. It is not a product specification, and it does not establish minimum or maximum values or manufacturing tolerances for resins or for piping products. Some of these typical physical property values were determined using compression molded plaques. Values obtained from tests of specimens taken from piping products can vary from these typical values. This data sheet may be changed from time to time without notice. Contact Performance Pipe to determine if you have the most recent edition.

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DRISCOPIPE® 8100 HDPE Gas Distribution Pipe PE4710-PE100 / (PE3408) Typical Physical Property Pipe Data Sheet			
Property	**Unit**	**Test Procedure**	**Typical Value**
Material Designation	**--**	**PPI TR-4**	**PE4710 PE100**
Cell Classification	**--**	**ASTM D3350**	**445574C 445576C**
Pipe Properties			
Density	gms / cm^3	ASTM D1505	0.961 (black)
Melt Index (MI) Condition 190/2.16	gms / 10 minutes	ASTM D1238	0.08
Melt Index (HLMI) Condition 190/21.6	gms / 10 minutes	ASTM D1238	7.5
Hydrostatic Design Basis, (73°F)	psi	ASTM D2837	1,600
Hydrostatic Design Basis, (140°F)	psi	ASTM D2837	1,000
Minimum Required Strength	Mpa (psi)	ISO 9080	>10 (>1450)
Rapid Crack Propagation Critical Pressure (Pc), 0°C (32°F)(1)	Bar (psi)	ISO 13477	>30 bar (>435)
Color; UV Stabilizer	---	ASTM D3350	Co-extruded yellow shell UV stabilized for 4 years outdoor storage
Pipe Test Category	---	ASTM D2513	CEE
Material Properties			
Flexural Modulus @2% strain	psi	ASTM D790	>140,000
Elastic Modulus @ Secant 2% strain (2in/min, Type IV bar)	Psi	ASTM D638	>200,000
Tensile Strength at Yield	psi	ASTM D638 (Type IV)	>3,700
Elongation at Break 2 in/min., Type IV bar	%	ASTM D638	>800
Hardness	Shore D	ASTM D2240	65
PENT	hrs	ASTM F1473	>2000
Pipe is manufactured to ASTM D2513. Fittings comply with ASTM D2513 and ASTM D3261.			
Thermal Properties			
Vicat Softening Temperature	^oF	ASTM D1525	255
Brittleness Temperature	^oF	ASTM D746	-180
Thermal Expansion	in / in / ^oF	ASTM D696	1.0×10^{-4}

(1) Determination made using Small-Scale Steady state. Pc calculated in accordance with ISO 13477

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Driscoplex® 6500 MDPE Gas Distribution Pipe PE2708/2406 Typical Physical Property Pipe Data Sheet			
Property	**Unit**	**Test Procedure**	**Typical Value**
Material Designation	**--**	**PPI TR-4**	**PE2708/2406**
Cell Classification	**--**	**ASTM D3350**	**234373E**
Pipe Properties			
Density	gms / cm^3	ASTM D1505	0.939
Melt Index (MI) Condition 190/2.16	gms / 10 minutes	ASTM D1238	0.18
Melt Index (HLMI) Condition 190/21.6	gms / 10 minutes	ASTM D1238	---
Hydrostatic Design Basis, (73°F)	psi	ASTM D2837	1,250
Hydrostatic Design Basis, (140°F)	**psi**	**ASTM D2837**	**1,000**
Minimum Required Strength	Mpa (psi)	ISO 9080	>8.0 (>1160)
Rapid Crack Propagation Critical Pressure (Pc), 0°C (32°F)(1)	Bar (psi)	ISO 13477	>8.5 bar (>123)
Color; UV Stabilizer	---	ASTM D3350	Yellow UV stabilized for 4 years outdoor storage
Pipe Test Category	---	ASTM D2513	CEE
Material Properties			
Flexural Modulus @2% strain	psi	ASTM D790	>100,000
Elastic Modulus @ Secant 2% strain (2in/min, Type IV bar)	Psi	ASTM D638	>86,000
Tensile Strength at Yield	psi	ASTM D638 (Type IV)	>2,800
Elongation at Break 2 in/min., Type IV bar	%	ASTM D638	>800
Hardness	Shore D	ASTM D2240	63
PENT	hrs	ASTM F1473	>2000
Thermal Properties			
Vicat Softening Temperature	^oF	ASTM D1525	227
Brittleness Temperature	^oF	ASTM D746	-180
Thermal Expansion	in / in / ^oF	ASTM D696	1.0×10^{-4}
Manufactured to ASTM D2513 for pipe. Fittings comply with ASTM D2513 and ASTM D3261.			

(1) Determination made using Small-Scale Steady state. Pc calculated in accordance with ISO 13477

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Permeability and Permeation

Plastics are permeable to gases to varying degrees. Although the constituents of natural gas can permeate through polyethylene, the volume of gas lost through permeation is generally so low as to have an insignificant effect on the handling of natural gas in a piping system. The American Gas Association (AGA) *Plastic Pipe Manual for Gas Service* lists the permeability of PE 2406 polyethylene pipe to methane, the primary constituent of natural gas, as 4.2×10^{-3}. Using the AGA factor, one mile of 2" SDR 11 PE2708/2406 pipe carrying 100% methane at 60 psi would lose less than 0.27 ft^3 per day.

Other constituents of natural gas are typically heavier than methane, thus less permeable through polyethylene. Hydrogen is the exception; however, the concentration of hydrogen in most natural gas is so low that the actual amount of hydrogen permeation would be insignificant. At low temperatures and higher pressures, heavier hydrocarbon gases such as propane or butane may condense and liquefy in the pipe. Such condensates are known to permeate polyethylene pipe. All types of hydrocarbons (aromatic, paraffinic, etc.) have a similar effect, and the relative effect on different polyethylene pipe resins is essentially the same. Liquid hydrocarbon permeation will affect joining. ***See Cautions on Liquid Hydrocarbon Permeation, page 5.***

Design Pressure

The following formula is used to compute the design pressures for polyethylene piping systems for natural gas service at operating temperatures up to but not over 140°F (60°C). For operating temperatures below 73°F (23°C), use 73°F (23°C) Design Pressures.

$$P = \frac{2S}{(SDR - 1)} \times f$$

Where:

P = Design Pressure in pounds per square inch gauge (psig);

S = Long Term Hydrostatic Strength (Hydrostatic Design Basis) psi, at pipeline operating temperature; See Table 5.

f = Design factor (specified in CFR 192.121); See Table 6.

SDR= Standard Dimension Ratio

$$SDR = \frac{\textit{Pipe Nominal Outside Diameter}}{\textit{Pipe Minimum Wall Thickness}}$$

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Table 5: Hydrostatic Design Basis

Hydrostatic Design Basis or Long Term Hydrostatic Strength, S				
Performance Pipe Product Series	**73.4F Data**	**100F Interpolated**	**120F Interpolated**	**140F Data**
Driscoplex® 6500 Pipe (MDPE)	1250	1250	1000	1000
Driscopipe® 8100 Pipe (HDPE)	1600	1250	1000	1000
Yellowstripe® 8300 Pipe (HDPE)	1600	1250	1000	1000

Table 6: Design Service Factor

Application	Design (service) Factor, f
Gas distribution and transmission per CFR 49 Part 192, §192.121	0.32
Gas distribution and transmission in Canada per CSA Z662-96	0.40
Gas distribution or transmission piping that is permeated by solvating chemicals such as liquid hydrocarbons or liquefied gas condensate	0.25

Operating Pressures (psig)

The following tables provide ***maximum allowable operating pressures (MAOP)*** and recommended maximum design pressure rating (PR) for PE2708 (PE2406) pipes and PE4710/PE100 (PE3408) pipes for gas distribution service at the indicated operating temperatures. PE pipes of the same DR and Material Designation Code but different outside diameters have the same Design (Working) Pressure Ratings. Pipe minimum wall thickness is determined by dividing the pipe average outside diameter (O.D.) by the DR number.

Pressure ratings are calculated in accordance with applicable federal codes. A check should be made to determine if these pressures apply under the state and/or local codes governing the specific application. Use 73°F (23°C) pressure ratings for operating temperatures below 73°F (23°C).

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Table 7: MAOP Driscoplex® 6500 MDPE Gas Distribution Pipe (PE2708)

MAOP & Maximum Design Pressure Rating (PR) for Dry Natural Gas Service --				
PE2708 (PE2406)	**Drisciplex® 6500 Pipe PE2708 (PE2406) (Class 1, 2, 3, and 4 location per U.S. federal regulations CFR 192.121 – Design (Service) Factor 0.32‡)**			
SDR	**73ºF (23ºC) *(PSIG)***	**100ºF (38ºC) *(PSIG)***	**120ºF (48ºC) *(PSIG)***	**140ºF (60ºC) *(PSIG)***
7.0	125†	125†	107	107
7.3	125†	125†	102	102
9.0	100	100	80	80
9.3	96	96	77	77
10.0	89	89	71	71
11.0	80	80	64	64
11.5	76	76	61	61
12.5	70	70	56	56
13.5	64	64	51	51

‡ Class 1, 2, 3, & 4 locations per U.S. federal regulations.
† 49 CFR Part 192.123(e) allows and limits design pressure to 125psig, provided the pressure is calculated in accordance with 49CFR 192.121.

Table 8: MAOP Driscopipe® 8100 Pipe & Yellowstripe® 8300 Pipe (PE4710)

MAOP & Maximum Design Pressure Rating (PR) for Dry Natural Gas Service --				
PE4710/PE100 (PE3408)	**Driscopipe® 8100 pipe and Yellowstripe® Pipe PE4710-PE100 (Class 1, 2, 3, and 4 location per U.S. federal regulations CFR 192.121 – Design (Service) Factor 0.32‡)**			
SDR	**73ºF (23ºC) *(PSIG)***	**100ºF (38ºC) *(PSIG)***	**120ºF (48ºC) *(PSIG)***	**140ºF (60ºC) *(PSIG)***
7.0	125†	125†	107	107
7.3	125†	125†	102	100†
9.0	125†	100	80	80
9.3	123†	96	77	77
11.0	102	80	64	64
12.5	89	70	56	56
13.5	82	64	51	51

‡ Class 1, 2, 3, & 4 locations per U.S. federal regulations.
† 49 CFR Part 192.123(e) allows and limits design pressure to 125psig, provided the pressure is calculated in accordance with 49CFR 192.121.

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Cold Bending Radius

The allowable cold bending radius for DriscoPlex® 6500 pipe 2406 is dependent upon the pipe OD, DR and the presence of fittings in the bend. See Performance Pipe's Technical Note *PP-819-TN Field Bending of DriscoPlex® PE Piping*.

Table 9: Allowable Cold Bending Radius

Pipe Dimension Ratio	Allowable Cold Bending Radius
9 or less	20 times the pipe OD
>9 to 13.5	25 times the pipe OD
13.5 or greater	27 times the pipe OD
Fitting or flange present in the bend	**100 times the pipe OD**

Special Considerations for 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. The shoe or chute feeds the pipe into the bottom of the cut. The minimum bend radius of the pipe through the shoe may be tighter than the minimum bend radius of the pipe used for a permanent long-term installation, but it must not be so tight that the pipe kinks. Table 10 presents the minimum short-term bend ratio for applications such as plowing and planting. The pipe's path through the shoe or chute should be as friction free as practicable to reduce additional outerfiber tensile stresses. Generally plowing and planting is limited to 12" and smaller pipes.

Table 10: Minimum Short-term Cold Bending Radius

Pipe Dimension Ratio	Minimum Short-Term bending Radius
9	10
>9 to 13.5	13
>13.5 to 17	17

Propane (LPG) Gas Service

The Office of Pipeline Safety Advisory Bulletin No. 73-4, dated April 1973, states, "It is the operator's responsibility to assure the integrity of the plastic pipe selected for use in the piping system, and this should be based on a favorable recommendation from the manufacturer. Therefore, the Federal minimum safety standards do permit the use of plastic in a properly engineered underground system of LPG distribution conforming to the limitations of these regulations." DriscoPlex® 6500 pipe (PE2708), Driscopipe® 8100 pipe (PE4710) and Yellowstripe® 8300 pipe (PE4710) series products meet the requirements of ANSI/NFPA 58 *Standard for the Storage and Handling of Liquefied Petroleum Gases.*

The Plastics Pipe Institute has made the following "Use Recommendation" for polyethylene piping systems for commercial propane systems:

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PPI Use Recommendation (Technical Report TR-22)

The information collected indicates that polyethylene plastic piping is satisfactory for transporting LPG and its major component, propane gas. This information also indicates that pressure design parameters based on propane gas should be adequate and reasonable. However, until more information is available, these use recommendations cover only commercial propane vapor in detail.

1. The polyethylene plastic pipe, tubing and fittings should be only those specific types designated as PE 2708 or PE 4710 and meeting the appropriate requirements of ASTM D 2513.
2. A Hydrostatic Design Basis of 1000 psi should be used in the design of polyethylene pipe systems for propane gas distribution at pipe temperatures of 73°F or lower. The long-term hydro static strength measurements should be made in accordance with ASTM D 2837.
3. Polyethylene should be used only in underground propane gas distribution systems designed to operate at internal pressures and temperatures such that condensation will not occur.

It is also recommended that operating pressures be limited to 30 psig or less.

In cases where condensation does occur in a propane system or propane enriched system and the presence of condensation is of relatively short duration, there is no indication of loss of physical integrity or observable change in polyethylene pipe. Under actual operating conditions, in a properly designed system, the pressures and temperatures are such that revaporization of any propane condensates will usually occur. Experience with propane liquids in polyethylene shows that there is no cumulative effect of intermittent, short duration exposure of propane condensate in polyethylene. For additional information, see PPI Technical Report TR-22. Exposure to liquefied propane condensates for extended periods may affect joining.

Mercaptans

Mercaptans are a group of organic compounds containing a Sulfur-Hydrogen bond that have a distinct odor in small concentrations. Natural gas is an odorless hydrocarbon. Natural gas carriers and distributors add mercaptans to natural gas to warn of leaks and to alert the presence of natural gas atmospheres. New plastic pipes have the tendency to absorb mercaptans, causing the odor to fade or become faint. The effect is not long term and after a period of time the distinctive odor of mercaptan is readily detected when released.

Mercaptan enriched natural gas has the possibility of inducing a phenomenon known as “odor fatigue.” The condition can cause nasal passages to become saturated with the smell of gas over time, making it difficult to continue to detect the mercaptan odor.

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