PERFORMANCE PIPE
A DIVISION OF CHEVRON PHILLIPS CHEMICAL COMPANY LP

DRISCOPLEX® 6500 PE 2406 POLYETHYLENE PIPING

Bulletin: PP 300

PE 2406 MDPE Piping Products for
Natural Gas Distribution
LPG and Propane Gas Distribution
Yard Gas

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Performance Pipe

PERFORMANCE PIPE is the functional successor to the operations of Plexco[1] and Driscopipe[2]. On July 1, 2000, Chevron Chemical Company and Phillips Chemical Company joined to form Chevron Phillips Chemical Company LP. Performance Pipe, a division of Chevron Phillips Chemical Company LP, succeeds Plexco and Driscopipe as North America's largest producer of polyethylene piping products for gas, industrial, municipal, mining, oilfield, and utility applications.

Performance Pipe tenders more than thirty years of polyethylene pipe manufacturing experience, thirteen manufacturing facilities certified to ISO 9001 in nine states, and two manufacturing facilities in Mexico.

The unmatched quality and performance of Performance Pipe polyethylene piping products is enhanced and strengthened with over four decades of quality polyolefin plastic resin production from Chevron Phillips Chemical Company.

A Commitment to Quality and Performance

DRISCOPLEX® 6500 Piping - the Successor to YELLOWPIPE and 6500

Performance Pipe DriscoPlex® 6500 PE 2406 gas piping products succeed YELLOWPIPE and 6500 as the product of choice for medium-density polyethylene gas piping systems. DriscoPlex® 6500 PE 2406 gas pipe, tubing and fittings are manufactured in accordance with the latest published editions of ASTM D 2513, CSA B137.4, or applicable international standards. Performance Pipe manufactures 1/2" through 24" (16 mm through 600 mm) outside diameter controlled polyethylene pipe and tubing, molded butt, socket, and saddle fusion fittings, and fabricated fittings for domestic and international gas applications.

Research and Testing

Performance Pipe maintains ongoing testing and product improvement programs to ensure the highest quality polyethylene pipe and fittings. A complete quality assurance program assures continuing product quality, and new products and product improvements are thoroughly tested before release. Both incoming materials and outgoing products are evaluated to ensure that all Performance Pipe products meet our own exacting standards as well as current industry standards and governmental standards and regulations.

[1] Formerly - Plexco, a Division of Chevron Chemical Company
[2] Formerly - Phillips Driscopipe, A Division of Phillips Petroleum Company

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Training and Technical Service

Performance Pipe offers recommendations and technical assistance for DriscoPlex® 6500 gas pipe and fittings. Joining procedures, training materials, and on-location training in socket, saddle and butt fusion joining are available, as well as technical assistance in product capabilities, product design to meet gas system requirements, installation recommendations, and testing and operating procedures. Contact your Performance Pipe Sales Representative or Performance Pipe Distributor for information and assistance.

Available Certifications

Specific sizes of DriscoPlex® 6500 PE 2406 of gas pipe and fittings are available with CSA (Canadian Gas Association) certification[3] for gas distribution, or UPC (Uniform Plumbing Code) certification[4] by IAPMO (International Association of Plumbing and Mechanical Officials) for yard gas piping and LPG service.

APWA/ULCC Color Code

Performance Pipe DriscoPlex® 6500 PE 2406 gas pipe and fittings are produced in yellow color as permanent, highly visible identification of gas service and in compliance with APWA/ULCC standards for color coding of gas distribution lines.

Outdoor Storage

The recommended maximum for unprotected outdoor storage of DriscoPlex® 6500 PE 2406 gas pipe and fittings is four 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 DriscoPlex® 6500 gas pipe and fittings.

Fusion

During the heat fusion process the 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.

Static Electricity

High static electric 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.***

[3] CSA Certified DriscoPlex® 6500 PE 2406 pipe and fittings are manufactured in accordance with CAN/CSA B137.4, *Polyethylene Piping Systems for Gas Services,* and Listed by the Canadian Standards Association (CSA).
[4] UPC Certified DriscoPlex® 6500 2406 pipe and fittings are manufactured in accordance with ASTM 2513, applicable sections of the Unified Plumbing Code, and Listed by the International Association pf Plumbing and Mechanical Officials (IAPMO) for use in yard gas piping and LPG gas service.

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Weight, Unloading and Handling

Although polyethylene pipe is not as heavy as some other piping products, significant weight may be involved. Care should be exercised when handling and working around polyethylene pipe.

Polyethylene piping is a tough, robust material, but it is not immune to damage. Improper handling or abuse can damage piping and compromise system quality or performance or cause injury or damage. ***Observe the handling instructions provided by the delivery driver.*** Polyethylene piping should be moved with proper handling and lifting equipment. Use fabric slings. Lift truck forks should be padded. 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. Store piping so that the potential for mechanical damage is minimized. See the *Performance Pipe Engineering Manual* for additional information on handling and storage.

While polyethylene piping has excellent impact resistance, striking the pipe with an instrument such as a hammer may result in uncontrolled rebound.

Coils

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

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 making repairs. See the Performance Pipe Technical Note PP-802 *Leak Testing PE Piping Systems.*

Protection Against Shear and Bending Loads

Measures such as properly placed, compacted backfill, protective sleeves and structural support are necessary to protect plastic pipe against shear and bending loads. Connections should be protected where an underground polyethylene branch or service pipe is joined to a branch fitting such as a service saddle, branch saddle or tapping tee on a main pipe, and where pipes enter or exit casings or walls. Properly placed, compacted backfill and a protective sleeve or a structural support are generally used together, but whether or not a protective sleeve or a structural support is installed, the area surrounding the connection must be embedded in properly placed, compacted backfill to protect the polyethylene pipe against shear and bending loads.

For additional information about protecting against shear and bending loads at service or branch connections and where PE pipe penetrates a structure or enters or exits a casing, see the Performance Pipe Engineering Manual (Performance Pipe publication PP-150), and ASTM D 2774, *Underground Installation of Thermoplastic Pressure Piping.*

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Liquid Hydrocarbon Permeation

When present, liquid hydrocarbons may permeate (solvate) polyethylene pipe. Liquid hydrocarbon permeation may occur when liquid hydrocarbons are present in the pipe, or where soil surrounding the pipe is contaminated with liquid hydrocarbons, or when liquid hydrocarbon condensates form in gas pipelines. All types of liquid hydrocarbons (aromatic, paraffinic, etc.) have a similar effect, and the relative effect on different polyethylene pipe resins is essentially the same. Heat fusion joining to liquid hydrocarbon permeated pipes may result in a low strength joint.

CAUTION - Once polyethylene pipe has been permeated with liquid hydrocarbons, heat fusion or electrofusion joining is not recommended because liquid hydrocarbons can leach out during heating and contaminate the joint. Liquid hydrocarbon permeated polyethylene pipe should be joined using suitable mechanical connection methods.

Liquid hydrocarbon contamination is indicated by a rough, sandpaper-like, bubbly, or pockmarked surface when a fusion heating iron is removed from the pipe surface, and may be indicated by discoloration or by a hydrocarbon fuel odor. See the *Performance Pipe Engineering Manual* for additional information on permeation and chemical resistance.

Mechanical fittings must be installed in accordance with the fitting manufacturer's instructions. Obtain these instructions from the fitting manufacturer.

Locating

Most polyethylene materials are not detectable with standard magnetic locating equipment. To aid in the detection of underground PE piping, measures such as tracer wires, identification and detection tapes, line markers, electronic marker systems, acoustic pipe tracing, and "call before you dig" line location measures may be used. When installing PE piping, the method or methods for future pipeline detection should be considered. Where posted signs are used, the signs should indicate that the pipeline is polyethylene to alert locating personnel that the pipeline may not be detectable with standard locating equipment. 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 Fusion Joining Procedures* when making heat fusion joints with DriscoPlex® 6500 PE 2406 pipe and fittings. When 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. Contact your Performance Pipe Sales Representative or Distributor for a copy.

CAUTION - 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.

Squeeze-Off

See above Cautions on Static Electricity. Squeeze-off (pinch-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, ***but 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 F 1041 and tools meeting ASTM F 1563 with Performance Pipe polyethylene pipe. The combination of pipe, tool and squeeze-off procedure should be qualified in accordance with ASTM F 1734. 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. See Performance Pipe Technical Note PP-801 *Squeeze-Off.*

Performance Characteristics

Polyethylene Material Properties

DriscoPlex® 6500 PE 2406 pipe and fittings are manufactured from PE 2406 medium density polyethylene compound that is classified according to ASTM D 3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials. The cell classification number for Performance Pipe PE 2406 material is 234363E.

Performance Pipe PE 2406 polyethylene compounds are listed with the Plastics Pipe Institute and have PPI recommended Hydrostatic Design Basis (HDB) ratings of 1250 psi at 73°F (8.62 MPa at 23°C), and 1000 psi at 140°F (6.89 MPa at 23°C). Elevated temperature properties can be used to determine product capabilities for applications where products will be exposed to elevated temperatures.

Resistance to slow crack growth is a critical performance requirement because long-term stress can cause cracks to grow slowly through the 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).

For many years, environmental stress crack resistance (ESCR) tests such as ASTM D 1693 have been used to characterize resistance to cracking from long-term stress. But exceptional materials such as Performance Pipe PE 2406 rarely fails ESCR tests. For these superior materials, ESCR tests are incapable of indicating long-term resistance to SCG.

In recent years, new SCG tests have been developed. Predominant among these new tests is ASTM F 1473, the "PENT" test (for PEnnsylvania Notch Tensile test). Developed at the University of Pennsylvania, a razor-notched specimen is tested to failure under constant tensile load and elevated temperature. Research has shown that this stringent test is an excellent indicator of SCG performance, and further, that there may be an empirical correlation between PENT performance and long-term service.

Under ASTM F 1473, *Standard Test Method to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins,* typical performance for Performance Pipe PE 2406 piping materials is greater than 3500 hours before failure. ASTM D 2513 requires that PE materials average at least 100 hours before failure when tested per ASTM F 1473.

Lastly, over 9,245 production lots of gas pipe manufactured from Performance Pipe PE 2406 piping material have been tested against ASTM F 1248, *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.

ASTM Test Values

The chart below shows material physical properties, ASTM test methods for the property, and nominal values for Performance Pipe 2406 polyethylene materials. (Note - Per ASTM D 748, the brittleness temperature is less than <-180°F (<-118°C), therefore, Performance Pipe PE 2406 pipe and fittings may be used at operating temperatures down to or below <-40°F (<-40°C)).

Resin Material Property	ASTM Test Method	Nominal Values for Performance Pipe PE 2406 Materials
Density, gm/cm ^{3}	D 1505	0.941 (yellow)
Melt Index, gm/10 min	D 1238	0.2
Flexural Modulus, psi	D 790	>100,000
Brittleness Temperature, °F (°C)	D 748	<180 (<118)
Tensile Strength at Yield, psi	D 638	2800
ESCR, F_{20} hours	D 1693	>10,000
PENT, hours	F 1473	>3500
Hydrostatic Design Basis at 73° F (23°C), psi	D 2837	1250
Color & UV Stabilizer	D 3350	Yellow; UV stabilized for up to 4 years outdoor storage
NOTICE – This chart 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 es tablish 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 fr om piping products can vary from these typical values. Performance Pipe has made every reasonable effort to ensure the accuracy of this chart, but this chart may not provide all necessary information, particularly with respect to special or unusual applic ations.		

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 A.G.A. *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 SDR 11 PE 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. Liquid hydrocarbons will permeate (solvate) polyethylene pipe after several months' exposure. Liquid hydrocarbon permeated polyethylene may have slightly reduced long-term strength; therefore pressure rating may be reduced. At higher temperatures, liquid hydrocarbon permeation may cause some swelling. Liquid hydrocarbon permeation should be considered when the fluid in the pipe has a liquid hydrocarbon concentration, or where soil surrounding the pipe is contaminated with liquid hydrocarbons, or where liquid hydrocarbon condensates can form in gas pipelines. 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 above Cautions on Liquid Hydrocarbon Permeation.***

Design Pressure

The following formula is used to compute the Design Pressures for PE 2406 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.

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

where

P = Design Pressure in pounds per square inch gauge (psig);
S = Long Term Hydrostatic Strength (Hydrostatic Design Basis) psi, at pipeline operating temperature;
DR = Dimension Ratio (DR);

f = Design (Service) Factor

Hydrostatic Design Basis or Long Term Hydrostatic Strength , S	
Temperature	S, psi (MPa)
73 °F (23°C) 100°F (38°C) 120°F (49°C) 140°F (60°C)	1250 (8.62)‡ 1250 (8.62)† 1000 (6.90)† 1000 (6.90)‡
‡ HDB per ASTM D 2837 & PPI TR -3. † Interpolated in accordance with PPI TR-3.	

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 chart provides ***maximum allowable operating pressures (MAOP)*** and recommended maximum design pressure rating (PR) for PE 2406 pipes for gas distribution service at the indicated operating temperatures. PE 2406 pipes with the same DR 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).

MAOP & Maximum Design Pressure Rating (PR) for Dry Natural Gas Service – DRISCOPLEX® 6500 PE 2406
(Class 1, 2, 3, and 4 locations per U.S. federal regulations — Design (Service) Factor 0.32‡)

DR Number PE 2406 Pipe	**MAOP** (Max Design PR) at Operating Tempe ratures, psig			
	73°F (23°C)	100°F (38°C)	120°F (48°C)	140°F (60°C)
7.0	**125**†	**125**†	**107**	**107**
7.3	**125**†	**125**†	**107**	**107**
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**

‡ For pressure ratings at 0.40 design factor (Canada only), multiply by 1.25; for pressure ratings at 0.25 design factor, multiply by 0.78.
† Where the pipe can be rated at 125 psig or higher, U.S. Federal regulations limit gas pressures in plastic pipe to 125 psig maximum unless a waiver for higher pressure has been granted.

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Cold Bending Radius

The allowable cold bending radius for DriscoPlex® 6500 PE 2406 pipe is dependent upon the pipe OD, DR and the presence of fittings in the bend.

DR	*Allowable Cold Bending Radius*
9 or less > 9 to 13.5	20 times pipe OD 25 times pipe OD
Fitting or flange present in bend	100 times pipe OD

Fluid Flow

Formulas for high pressure and low pressure gas flow in polyethylene pipe are presented in the *Performance Pipe Engineering Manual.*

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 PE 2406 piping 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:

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 2406 or PE 3408 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 sys tems 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 . Also, experience with propane liquids on polyethylene shows that there is no cumulative effect of intermittent short duration exposure of propane condensate on polyethylene.
For additional information, see PPI Technical Report TR-22. Exposure to liquefied propane condensates for extended periods may affect joining. See Liquid Hydrocarbon Permeation and Permeability and Permeation earlier in this publication, and the Performance Pipe Engineering Manual for additional information.

Performance Pipe DriscoPlex® 6500 PE 2406 polyethylene gas pipe and fittings may be used in propane gas service when used in accordance with the above recommendations.