filed electronically in docket office 7/21/2008

BEFORE THE TENNESSEE REGULATORY AUTHORITY
NASHVILLE, TENNESSEE

In the Matter of:

Application of Memphis Light Gas and Water a Division of the City of Memphis for a waiver with respect to 49 CFR Part 192.7, Appendix B, and ASTM D 2513 . The requested waiver would allow for continued operation of plastic pipe, which is in service and had a storage period in excess of 2 years prior to installation.	)))))))))	**DOCKET NO.** 08-00124

1 Memphis Light Gas and Water (MLGW), a Division of the City of Memphis, is a municipal corporation under the laws of Tennessee and is engaged in the business of transporting, distributing and selling natural gas in Shelby County, Tennessee.

2. The Gas Division of MLGW is subject to regulation and supervision by the Tennessee Regulatory Authority pursuant to Chapter 4 of Title 65 of the Tennessee Code Annotated.

3. MLGW has its principal office at 220 South Main Street, Memphis, Tennessee and it is engaged in the business of furnishing natural gas to customers located in Shelby County and in certain incorporated towns and cities located therein.

4. It is respectfully requested that any notices or any other communications with respect to this petition be sent to:

Charlotte Knight Griffin
Acting General Counsel
220 South Main Street
Memphis, TN 38103

5. MLGW operates and maintains over 4,792.1 miles of distribution mains and 181.6 miles of gas transmission lines, which operate between 0.25 to 900 psig using pipe diameters between 5/8 to 30 inches. These mains and transmission lines meet the requirements set forth in 49 CFR 192. In this application, MLGW proposes, subject to the approval by the Tennessee Regulatory Authority, to allow for continued operation of plastic pipe, used in the MLGW gas distribution system, which is in service and had a storage period in excess of 2 years prior to installation.

6. Federal safety standards have been adopted by the Tennessee Regulatory Authority. Tennessee Code Annotated § 65-28-104, *et seq*. Under the provisions of

applicable law, including 49 U.S.C. § 60118 and 49 CFR § 192.7, Appendix B, and ASTM D 2513, the Authority may waive compliance with any part of an applicable standard on terms it considers appropriate if the waiver is not inconsistent with pipeline safety. MLGW requests the Tennessee Regulatory Authority to grant a waiver from both sections 49 CFR § 192.7, Appendix B, and ASTM D 2513 to allow for continued operation of plastic pipe, which is in service and had a storage period in excess of 2 years prior to installation.

7. References:

a) 49 CFR § 192.7

b.) Appendix B-Qualification of Pipe
I. *Listed Pipe Specification*
ASTM D 2513 Thermoplastic pipe and tubing, "Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings"

c) ASTM D 2513
A1.5 Requirements for Pipe and Fittings.
A1.5.7 *Outdoor Storage Stability*-PE pipe stored outdoors and unprotected and unprotected for at least two years from date of manufacture shall meet all the requirements of this specification. PE pipe is suitable for use if it meets the requirements of this specification.

8. All PE pipe installed in the MLGW gas distribution and transmission systems has been installed in accordance with the manufacturer's recommended procedures although, in the gas distribution system, the cumulative aboveground exposure, in some instances, may have exceeded 2 years.

9. All pipe installed was tested, patrolled and leak surveyed, in accordance with 49 C.F.R. §§ 192.511, 192.513, 192.721 and 192.723, respectively and no incidence of pipe fatigue or failure has been recorded. MLGW reports monthly to the American Gas Association Plastic Pipe Failure Database and has never had to report a pipe failure. Those records are available for the Agency's inspection.

10. Outdoor storage limit recommendations and sufficient safeguards to public safety have been implemented, in accordance with 49 C.F.R. § 192.7, Appendix B and ASTM D 2513, to mitigate future occurrences.

11. All PE pipe in the MLGW gas distribution system contains a minimum of 2% finely dispersed carbon black as an ultraviolet stabilization package for prolonged outdoor use as required by ASTM D 3350. It has been demonstrated by the Plastic Pipe Institute that this amount of well-dispersed very fine particle carbon black is sufficient protection for continuous outdoor service.

12. Manufacturer and Industry Organizations Recommendations:

Performance Pipe

Performance Pipe continues to support that all of it's black pipe products are produced from black compounds that meet the requirements of ASTM D3350 to be classified as a C code for stability to UV stability. This is the highest degree of protection possible, and requires a minimum of 2% of finely dispersed carbon black in the pipe. Based on Performance Pipe (and its predecessors, Plexco and Driscopipe) producing black pipes out of ASTM D3350 code C materials they state that their black pipe materials are suitable for extended outdoor service life. Performance Pipe also states that medium density and yellow shell products are limited in their outdoor storage service life.

Performance Pipe states that the use of finely dispersed carbon black to absorb potentially harmful UV rays has been documented since the 1960's initially based on work by Bell Laboratories on protecting polyethylene jacketed cable. There are many industry published documents available documenting the long-term outdoor storage life of this class of black polyethylene materials.

"ASTM material standard D3350 requires a minimum concentration of 2 percent carbon black. It has been demonstrated that this amount of well-dispersed very fine particle carbon black is sufficient protection for continuous outdoor service."

Performance Pipe polyethylene gas distribution piping products are protected from UV effects and outdoor exposure to ensure pipe performance requirements are maintained during a reasonably handling time prior to installation. ASTM D2513 requires that all polyethylene gas distribution pipes produced to the standard must be able to withstand a minimum of 2 years outdoor storage without affecting the pipe's ability to meet the requirements of the standard. ASTM D2513 allows outdoor storage times in excess of 2 years if the pipes can still meet the requirements of ASTM.

For black high density pipes, the presence of a minimum of 2% carbon black finely dispersed in the polyethylene piping material provides long term protection from the potentially damaging affects of UV and outdoor exposure. 'Weathering studies have shown that pipe produced with a minimum 2.0% concentration of finely divided and evenly dispersed carbon black is protected from the harmful effects of UV radiation for indefinite periods of time.

Polypipe

Polypipe states that the maximum unprotected above ground storage time for PolyPipe® gas products is dependent upon the type of polyethylene pipe. For medium density yellow gas pipe, the recommended above ground storage should not exceed three years. However, black gas products are suitable for above ground storage up to 50 years. Refer to DOT CFR Title 49, Part 192, § 192.321 (g) (1) and (3) for additional information.

Plastic Pipe Institute

The Plastic Pipe Institute Handbook of Polyethylene Pipe 1st Edition 2006 states in the "Exposure to UV and Weather" section that polyethylene pipe products are protected against deterioration from exposure to ultraviolet light and weathering effects. Color and black products are compounded with antioxidants, thermal stabilizers, and UV stabilizers. Color products use sacrificial UV stabilizers that absorb UV energy and are eventually depleted. In general, non-black products should not remain in unprotected outdoor storage for more than 2 years; however, some manufacturers may allow longer unprotected outside storage. Black products contain at least 2% carbon black to protect the material from UV deterioration. Black products with and without stripes are generally suitable for unlimited outdoor storage and for service on the surface or above grade.

In the Plastic Pipe Institute report "Weatherability of Thermoplastic Piping Systems" TR-18/2005 it is stated in Section 4.0 "WEATHERING OF POLYETHYLENE (PE) PIPE", the basic polyethylene polymer has limited outdoor life. However, most polyethylene pipe manufactured today contains an ultraviolet stabilization package. For typical outdoor storage, ultraviolet stabilized non-black systems are satisfactory, but for prolonged outdoor use, polyethylene should be formulated with a minimum of 2 % finely dispersed carbon black.

Incorporating carbon black in polyethylene compounds greatly increases their weather resistance (1,2). Carbon black acts as a UV absorbent and screens the polyethylene from damaging ultraviolet radiation. The aging resistance imparted by the carbon black depends upon its type, particle size, concentration, and degree of dispersion in the polyethylene (3).

ASTM material standard D 3350 requires a minimum concentration of 2 percent carbon black. It has been demonstrated that this amount of well-dispersed very fine particle carbon black is sufficient protection for continuous outdoor service.

PHMSA

MATERIALS AND EQUIPMENT QUALIFIED FOR USE IN NATURAL GAS SYSTEMS

Plastic pipe and tubing should be protected at all times from damage by crushing, piercing, or extended exposure to direct sunlight. As a rule of thumb, never store plastic pipe outdoors for more than six months. It should be placed inside or covered to protect it from exposure to direct sunlight. It is a good idea to obtain the manufacturer's recommendation on how long the pipe can be exposed to sunlight before it loses physical strength (see 49 CFR §192.321 for more information).

Attached are Adobe pdf documents that support these recommendations.

13. Petitioner has tested polyethylene pipe that has had prolonged outdoor storage of more than two years. Test data confirms that the polyethylene piping materials with the presence of a minimum 2% carbon black properly dispersed in the polyethylene piping material provides long term protection from the potentially damaging effects of UV and outdoor exposure and continues to meet and exceed the requirements of the ASTM D2513 storage outdoor storage requirements minimum of two years.

Performance Pipe performed tests on MLGW PE pipe that was manufactured in 1999 and had outdoor exposure of at least nine years to confirm conformance to ASTM D2513. Performance Pipe recommended the following tests: melt flow, carbon black percent, density, thermal stability, ID ductility and ring tensile strength to confirm that the 1999 PE pipe does meet ASTM D2513 requirements and the following table lists the actual test results.

Test Results Confirmation Conformance to ASTM D2513 Specifications After Extended Outdoor Storage				
Pipe Size and Type:		4" DR 11 Yellowstripe® Pipe		
Date of Manufacturing:		January 9, 1999		
Date of Testing:		June 18, 2008		
Test	Test Method	Test Value	Requirement	Result
Melt Flow	ASTM D3350 and ASTM D1238 190/5.0	0.3663 g/10min	0.34 g/10min nominal	Pass (Within expected variation)
Carbon Black %	Microwave Furnace	2.11%	>2.0 %	Pass
Density	ASTM D3350 and ASTM D1505	0.954 g/cc black 0.945 g/cc (natural calculated)	0.946 g/cc (nominal natural)	Pass (Within expected variation)
Thermal Stability	ASTM D2513 and ASTM D3350	245 deg C	>220 deg C	Pass
ID Ductility	ASTM D2513 A.1.5.11.1	Pass	Pass	Pass
Ring Tensile Strength	ASTM D2513 and ASTM D2290	3794 psi	>2920 psi	Pass

Petitioner is obtaining additional test data by coordinating with MLGW construction to remove samples of PE pipe in service that had prolonged outdoor storage of more than two years before installation and is also working with the PE pipe resin manufacturer to obtain test data that confirms that PE pipe that is manufactured with 2% carbon black meets the outdoor storage requirements of ASTM D2513. This additional data will be submitted when it becomes available.

14. Although not yet in force or effect, modifications to ASTM D 2513 have been proposed and are being considered to specifically allow longer outdoor storage periods of more than two years for PE pipe manufactured with 2% finely dispersed carbon black.

WHEREFORE, based on manufacturer and industry recommendations, testing, patrolling and leak surveying of all installed pipes, Petitioner respectfully requests the Tennessee Regulatory Authority to promptly grant a waiver for 49 CFR § 192.7, Appendix B, and ASTM D 2513. The requested waiver would allow for continued operation of plastic pipe, which is in service and had a storage period in excess of 2 years prior to installation.

Respectfully submitted this the 9th day of July 2008.

Memphis Light Gas and Water

Charlotte Knight Griffin
Charlotte Knight Griffin
Acting General Counsel
220 South Main Street
Memphis, TN 38103
(901) 528-4721

Performance Pipe Letter
03-26-2008

Outdoor Storage Limits

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March 26, 2008

Mr. Ray Ward
Memphis Gas Light & Water
RWard@MGLW.com

Re: Outdoor storage limits

Dear Ray,

Performance Pipe continues to support that all of it's black pipe products are produced from black compounds that meet the requirements of ASTM D3350 to be classified as a 'C' code for stability to UV stability. This is the highest degree of protection possible, and requires a minimum of 2% of finely dispersed carbon black in the pipe. Based on Performance Pipe (and its predecessors, Plexco and Driscopipe) producing black pipes out of ASTM D3350 code 'C' materials we state that our black pipe materials, which include Driscoplex® 6800, 8300, Yellowstripe®, Plexstripe II, and Driscopipe® 8000 pipes are suitable for extended outdoor service life. Performance Pipe medium density and yellow shell products (Driscoplex® 6500 and Driscopipe® 8100 pipes) are limited in their outdoor storage service life.

The use of finely dispersed carbon black to absorb potentially harmful UV rays has been documented since the 1960's initially based on work by Bell Laboratories on protecting polyethylene jacketed cable. There are many industry published documents available documenting the long term outdoor storage life of this class of black polyethylene materials. Attached is Technical Report TR18 – 'Weatherability of Plastic Pipe' that is available from the Plastic Pipe Institute's website, www.plasticpipe.org, which states:

"ASTM material standard D 3350 requires a minimum concentration of 2 percent carbon black. It has been demonstrated that this amount of well-dispersed very fine particle carbon black is sufficient protection for continuous outdoor service."

You have indicated that local regulatory bodies have asked MGLW to provide information on specific lots of black pipes that may have exceeded two years of outdoor storage. Attached are documents published by Chevron Phillips Chemical Co. and by Performance Pipe to document service life of outdoor pipes. We hope that this information is useful.

Sincerely,

Karen Lively

cc: Mary Lee McDonald

Chevron Phillips Chemical Company LP
PE TIB-3
Weatherability Report

Effects of Adding Pigments to Resins

Marlex® POLYETHYLENE

Premium Extrusion and Rigid Packaging Resins

CPChem

PE TIB-3 WEATHERABILITY

INTRODUCTION

Pigments are major contributors to the aesthetic appeal and marketability of plastics. In addition to improved plastic part appearance, pigments are often used in plastics to draw attention to safety concerns - such as bright markings for danger areas on machinery, color-coding wires, or illuminating highway markers. Pigments are also used to prolong the outdoor life of plastic parts. The effect of pigments on the weatherability of plastics and their interaction with antioxidants and light stabilizers are areas of great importance to part manufacturers. Chevron Phillips Chemical Company LP (formerly Phillips Chemical Company) has conducted numerous evaluations of pigments incorporated into Marlex® high density polyethylene resins. That data will be presented in this Technical Information Bulletin.

TEST PROCEDURES

The methods used for measuring plastic degradation by ultraviolet exposure are extremely important. A variety of techniques have been and are still used as criteria for resin degradation. These methods include: determination of tensile properties, carbonyl absorption, flex testing, brittleness temperature, flexural strength, melt index, surface crazing, and aging of stressed specimens.

Since tensile properties are the most commonly used criteria for determining plastic weatherability, tensile strength was measured at crosshead speeds of both 2 in. and 20 in./minute. No attempt was made to define outdoor use life of the pigment systems since this study was concerned with the relative effect of various additives with respect to each other.

For this study, both UV stabilized and unstabilized ethylene butene-1 copolymers were used. Unless otherwise noted, UV stabilized copolymers contained 0.5% of a hydroxybenzophenone. Tensile specimens were Type IV ASTM D638. The weathering devices used were the Atlas Weather-Ometer and an accelerated outdoor weathering device, EMMA (equatorial mount with mirrors). The Weather-Ometer was operated under standard conditions described in ASTM D1499. The EMMA test accelerated weathering by using aluminum mirrors to reflect and concentrate the sunlight on exposed specimens in Phoenix, Arizona.

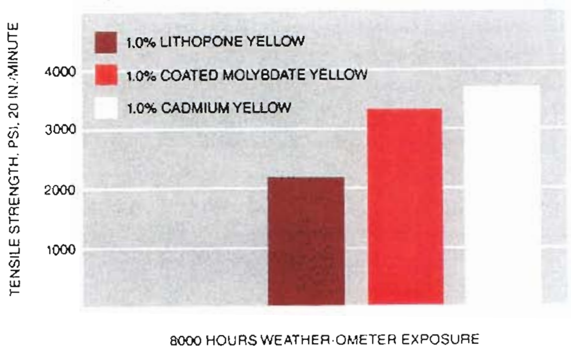
Outdoor Weathering Device

YELLOW PIGMENTS

To study the effect of yellow pigments on HDPE weatherability, three were selected and incorporated at a 1% concentration in an ethylene-butene copolymer containing 0.5% of a UV stabilizer. The pigments chosen were cadmium yellow, lithopone yellow and a coated molybdate (Figure 1).

FIGURE 1

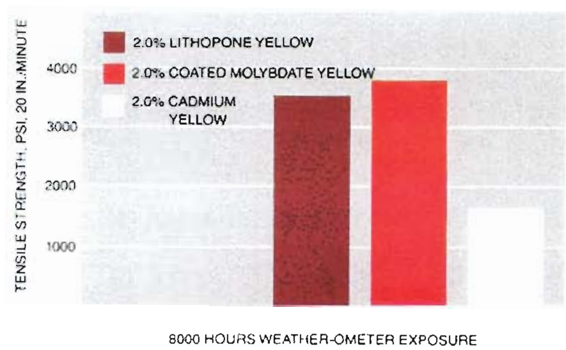
Effect of Yellow Pigments on UV Stabilization of 0.95 Density Stabilized Polyethylene Resins



After Weather-Ometer exposure for 8,000 hours, the cadmium yellow had the best performance, followed by coated molybdate, then lithopone yellow. Figure 2 shows the effects of aging on these same pigments at 2% concentration, also after 8,000 Weather-Ometer hours. Increasing the concentration of coated molybdate and lithopone yellow improved the weathering performance of the compound, but increased cadmium yellow concentration decreased its overall weathering effectiveness. Since this phenomenon has been demonstrated repeatedly, an assumption can be made that a reaction must occur between pigment and stabilizer at higher pigment concentrations. This apparently does not happen, or at least not as much with coated molybdate or lithopone yellow pigment.

FIGURE 2

Effect of Yellow Pigments on UV Stabilization of 0.95 Density Stabilized Polyethylene Resins

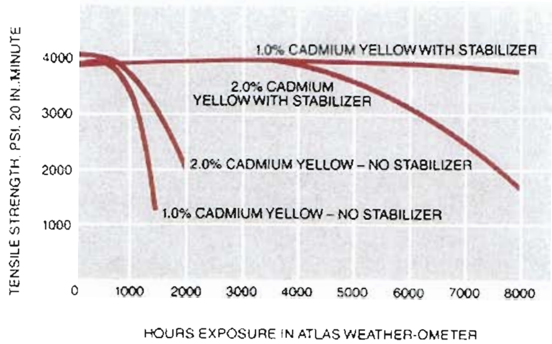


The interaction of UV absorber and pigment is reinforced by Figure 3, which illustrates the effect of UV stabilizer in systems containing 1% and 2% cadmium yellow pigments. Results indicate that when no stabilizer is used, the 2% system is somewhat better than the 1% cadmium yellow system. However, formulations with stabilizer have the opposite effect occur.

To further study this interaction between stabilizers and cadmium yellow in a polyethylene system, samples were prepared containing two nickel complexes furnished by two suppliers. These nickel complexes are known to perform as light stabilizers, whereas hydroxybenzophenone acts primarily as a UV absorber. As seen in Figure 4, the system containing 2% cadmium yellow and hydroxybenzophenone was brittle at 10,000 hours exposure. However, the 2% cadmium yellow system containing both the nickel Complex A and B exhibited only a modest decrease in tensile strength after this same exposure period. The hindered amine light stabilizer (HALS) would appear to be marginally better than the nickel complex, but does not exhibit the green color inherent with nickel stabilizers. This further illustrates the complex interrelationships between stabilizers and pigments.

FIGURE 3

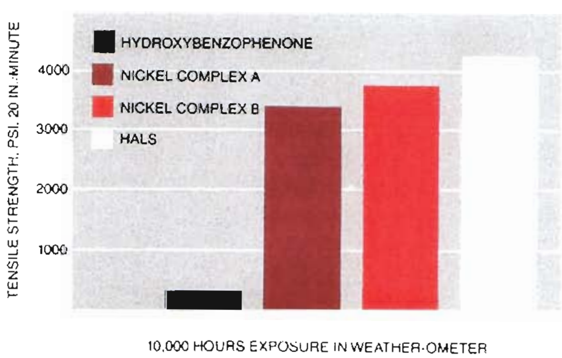
Effect of Stabilizer on UV Stabilization of 0.95 Density Polyethylene Resins



Both the lithopone and cadmium yellow will fade during extended outdoor exposure. Although this is not a problem with single pigment color formulations, the color change can be significant when cadmium yellow is combined with a more light-stable pigment, such as ultramarine blue, to produce a green color.

FIGURE 4

Effect of Stabilizers on 0.95 Density Polyethylene Resins Containing 2% Cadmium Yellow



RED PIGMENTS

The weathering performance of three commonly used red pigments, quinacridone red, mercury-cadmium red and lithopone red is shown in Figure 5. It is apparent that after 10,000 hours exposure, the 1% quinacridone red formulation is considerably better than either of the other two. There appears to be less difference between the lithopone red and mercury-cadmium red than between these pigments and the quinacridone red.

FIGURE 5

Effect of Red Pigment on UV Stabilization of 0.95 Density Stabilized Polyethylene Resins

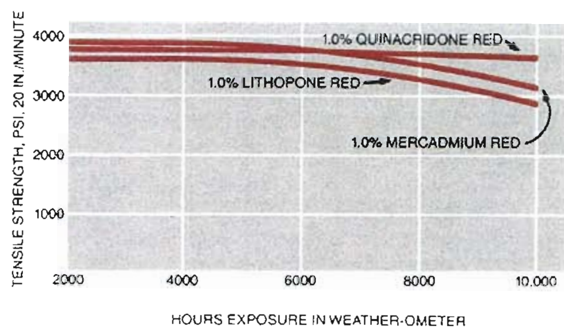
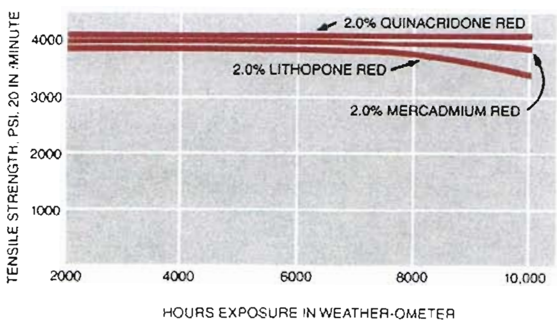


Figure 6 shows that at 2% pigment level, the same relationship persists. The 2% quinacridone red is still marginally better than 2% mercury-cadmium red, and both are considerably better than 2% lithopone red after 10,000 hours exposure. This indicates that as the pigment concentration increases from 1% to 2%, the mercury-cadmium red shows most improvement. This is in contrast to the yellow pigment data in that the degree of interaction between pigments and stabilizers is apparently not the same. Furthermore, 1% quinacridone red provides better stability than 2% lithopone red.

Previous studies indicated that CP cadmium red would offer virtually the same protection against UV degradation as the mercury-cadmium red. Although the quinacridone and cadmium red pigments extend the outdoor weatherability of HDPE, they have limited use due to lack of color stability. The tint strength of both quinacridone and CP cadmium pigments will weaken when accelerated by a high humidity atmosphere. The most light-stable red is a combination of CP cadmium red and mercury cadmium red pigments.

FIGURE 6
Effect of Red Pigment on UV Stabilization of 0.95 Density Stabilized Polyethylene Resins



Earlier studies indicate that the iron oxide is excellent or use in high density polyethylene outdoor applications. Figure 7 shows that at low levels of pigment, an unstabilized system with iron oxide was virtually unchanged after 2,000 hours in the Weather-Ometer, while the tensile strength of the 0.5% CP cadmium red started to decay considerably. Since both these formulations were unstabilized, this further demonstrates the significant screening effect of iron oxide in polyethylene. From past experience, iron oxide can be considered to be second only to carbon black in its ability to stabilize HDPE against UV degradation.

FIGURE 7
Effect of 0.5% Iron Oxide versus 0.5% Cadmium Red on UV Stabilization of 0.95 Density Unstabilized Polyethylene Resins

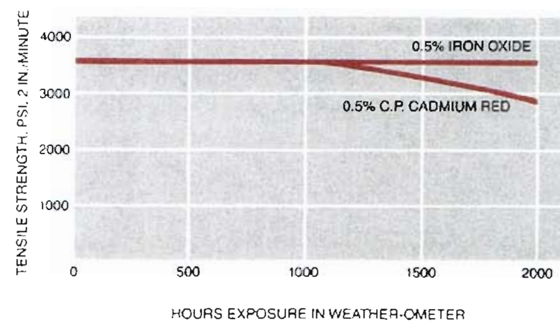
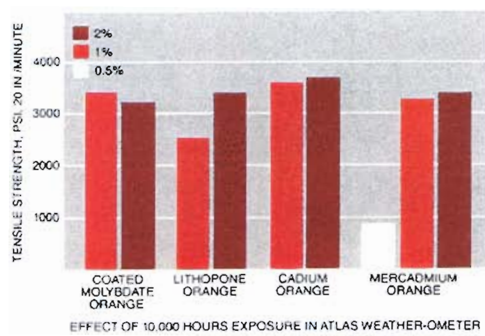


FIGURE 8
Effect of Pigments on UV Stabilization Of 0.95 Density Stabilized Polyethylene resins



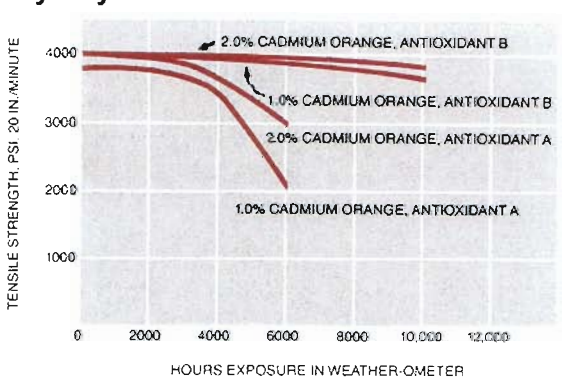
ORANGE PIGMENTS

Four pigments - coated molybdate, lithopone, CP cadmium and mercury-cadmium were exposed for 10,000 hours in the Weather-Ometer at levels of 1 and 2% (Figure 8). At a concentration of 1 %, the CP cadmium orange appears to be 10-20% better than the other pigments used in this study. Less difference can be seen among the pigments at the 2% level, although cadmium orange is still approximately 10% better than the others. It does appear that the coated molybdate pigment is somewhat better at 1 % than at 2%, but this slight increase falls within experimental error range and can be considered negligible. The only pigment to show a significant difference between the two concentrations is lithopone orange. Since this pigment contains less cadmium than CP cadmium, the overall effect is much the same as a reduced level of cadmium.

Figure 9 illustrates that the antioxidant system plays a major role in outdoor performance of pigmented HDPE formulations. Two different types of antioxidants were compounded with a UV stabilizer and 1 and 2% cadmium orange. Antioxidant B imparted much more resistance to UV degradation than antioxidant A. This was true for either 1 or 2% pigment levels, and illustrates the need for selecting formulations with the proper antioxidants for outdoor applications.

FIGURE 9

Effect of Antioxidants on UV Stabilization of 0.95 Density Stabilized Polyethylene Resins

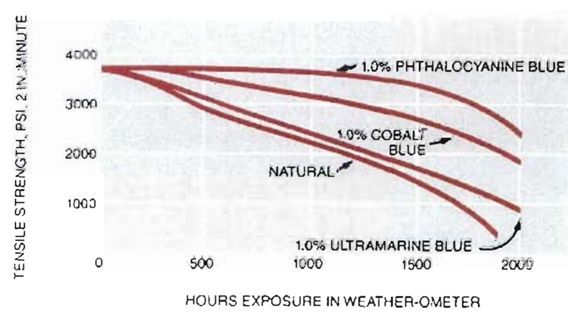


BLUE AND GREEN PIGMENTS

One percent levels of phthalocyanine blue, cobalt blue and ultramarine blue were incorporated in an unstabilized polyethylene system and exposed for 2,000 hours in a Weather-Ometer. Figure 10 indicates that the phthalocyanine blue pigment provided 2 to 3 times as much UV protection as ultramarine blue. This level of protection in an unstabilized system is quite good; however, cobalt blue appears only moderately effective when compared to phthalocyanine blue.

FIGURE 10

Effect of Blue Pigments on UV Stabilization of 0.95 Density Unstabilized Polyethylene resins



It is also apparent from this figure that ultramarine blue imparts little or no protection to the polymer since the performance of the compound containing ultramarine blue was little better than natural HDPE. The same general trend is found in stabilized, as well as unstabilized, systems.

Many green formulations are prepared by combining ultramarine blue and cadmium yellow. Since the UV protection provided by ultramarine blue in HDPE is poor, and only fair with cadmium yellow, it is not surprising that the combination is rather ineffective. Phthalocyanine green, however, imparts excellent UV resistance to polyethylene as do some of the chrome greens. Compounds containing these pigments last longer than 6,000 hours of Weather- Ometer exposure with no loss of tensile strength.

FIGURE 11

Effect of Titanium Dioxide and Zinc Oxide on UV Stabilization of 0.95 Density Polyethylene Resins Containing Hydroxybenzophenone Stabilizer

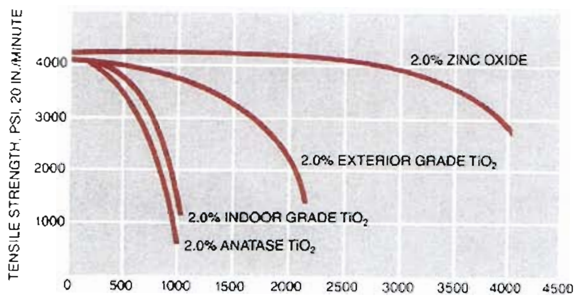
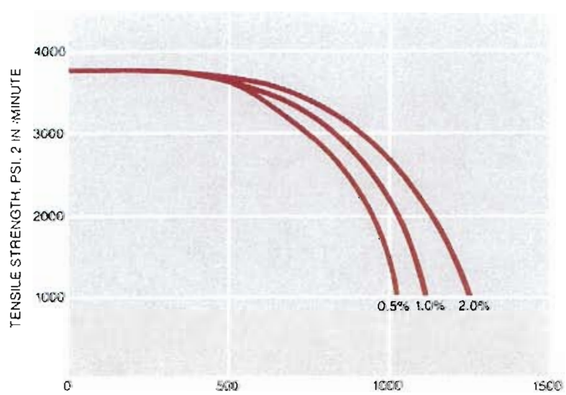


FIGURE 12

Effect of TiO2 Loading on UV Stabilization of 0.95 Density Unstabilized Polyethylene Resins

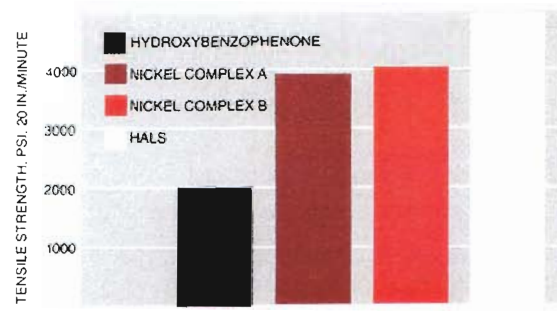


WHITE PIGMENTS

The weathering resistance of several types of white colorants is illustrated in Figure 11. Zinc oxide, an exterior grade rutile TiO_2, an indoor rutile TiO_2, as well as an anatase TiO_2 were compared. In all instances, 2% pigment was used in combination with 0.5% of a UV absorber. The anatase TiO_2 and indoor rutile TiO_2 were totally ineffective in protecting HDPE, and when compared to an unpigmented version, have poorer performance than natural stabilized resin. However, with exterior grade TiO_2 types, UV protection is somewhat improved.

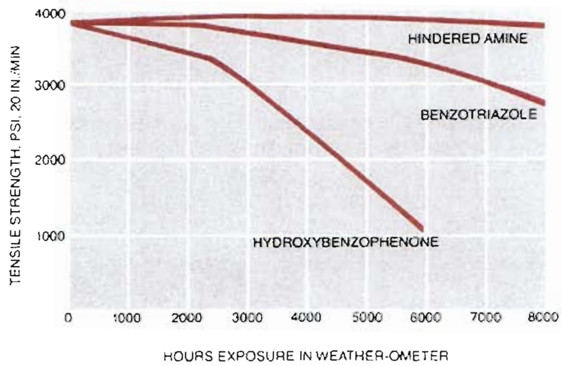
FIGURE 13

Effect of UV Stabilizers on 0.95 Density Polyethylene Resins Containing 2% Titanium Dioxide



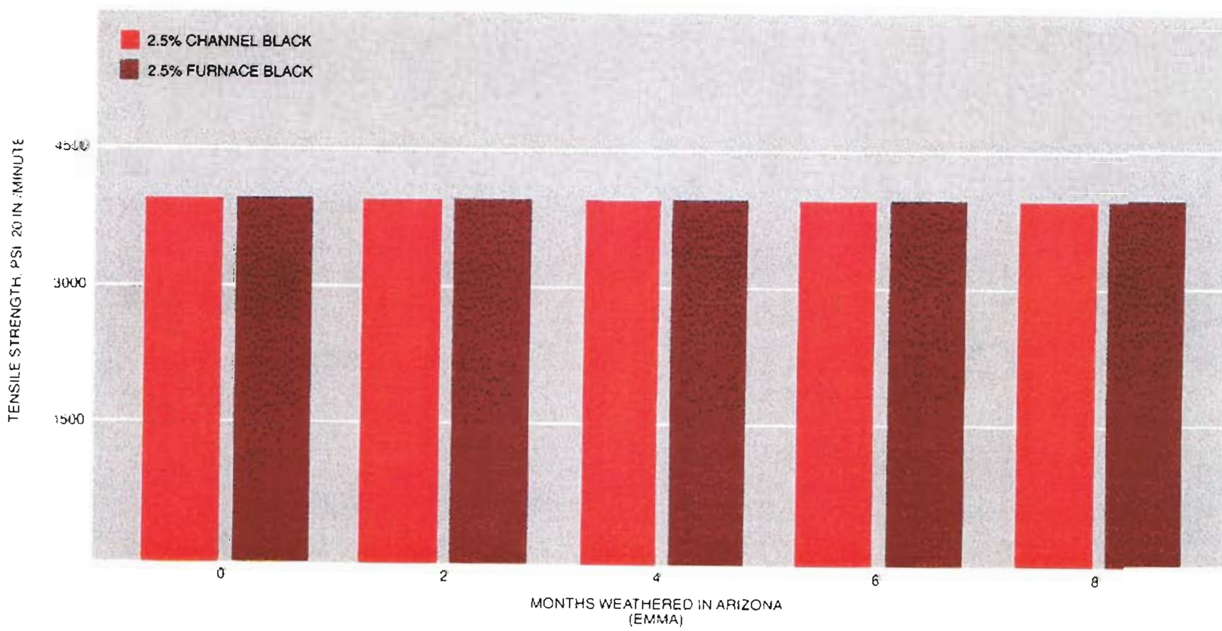
Zinc oxide, on the other hand, provides excellent UV protection to polyethylene. Tensile strength retention of the zinc oxide formulation is significantly better than one containing 2% TiO_2. For best weathering results, zinc oxide can be used, provided its hiding power is sufficient for the intended application. For high opacity film and thin-walled containers, the tint strength of zinc oxide is too low to provide sufficient opaqueness, and titanium dioxide is a better choice. Weathering performance of an exterior grade TiO_2, without UV absorber, and at three different pigment concentrations is shown in Figure 12. The formulation containing 2% TiO_2 has only 50% of the weathering resistance of the 2% TiO_2 with 0.5% hydroxybenzophenone.

FIGURE 13A
Effect of UV Stabilizers With 1% Titanium Dioxide



Such systems can be improved by the use of nickel and hindered amine light stabilizers. Figures 13 and 13A illustrate the effect of various types of UV stabilizers in systems containing TiO_2. Systems with nickel complex light and hindered amine stabilizers are not significantly affected after 2,000 hours of Weather-Ometer exposure, as compared to the formulation containing hydroxybenzophenone absorber. In addition, there appears to be less difference between the two nickel stabilizers than was demonstrated earlier. (Figure 4 showed the effect of these stabilizers in systems containing CP cadmium yellow.) It can be noted that more relative UV protection was obtained with hydroxybenzophenone and hindered amine light stabilizers in the TiO_2 system than with the cadmium yellow systems. This suggests that a different type of interaction may be occurring with TiO_2 than occurred with cadmium yellow.

FIGURE 14
Effect of Carbon Black Type on Weathering of Polyethylene Resins



EFFECT OF CARBON BLACK

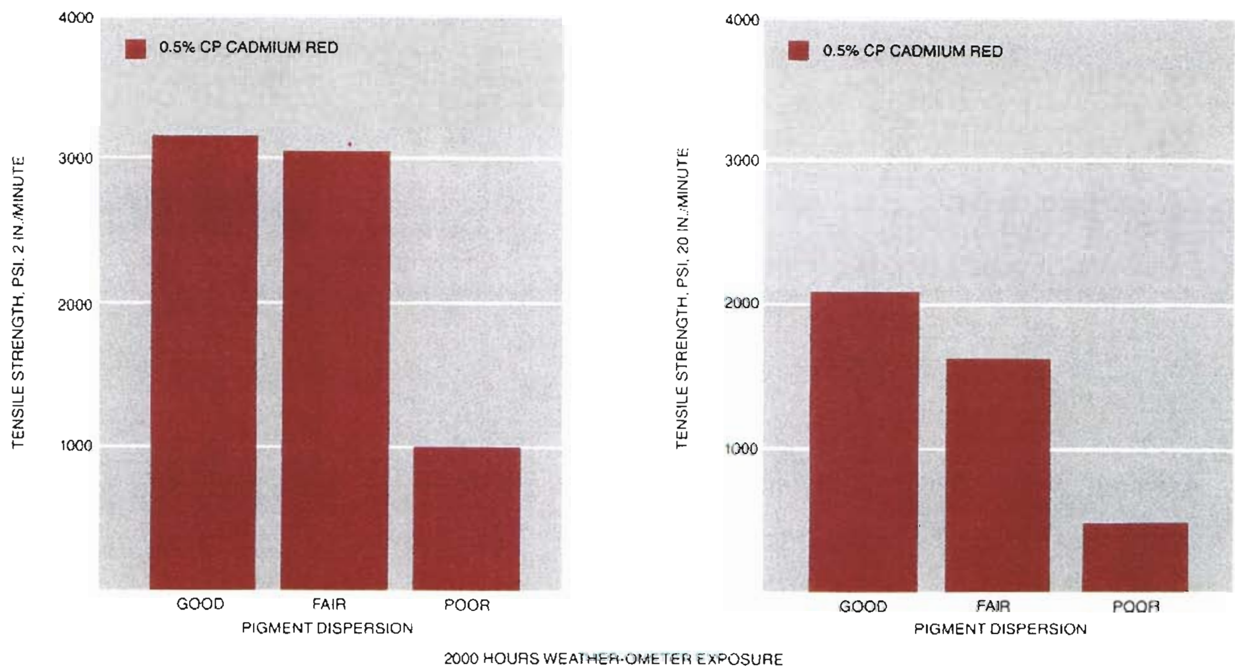
Another pigment deserving special attention is carbon black, particularly when its unique characteristics and volume used are considered. The protection that even relatively low levels of carbon black imparts to the polymer is so great that no other light stabilizers or UV absorbers are required. Several theories have been advanced to explain this phenomenon. Schonhorn and Luongo stated that the photo-oxidative stabilization of HDPE filled with carbon black is due not only to the light shield capability of carbon black, but also to its moderately low surface energy. Another possibility is, that since antioxidant properties of surface phenolic groups on carbon black have been well characterized, increased stability through interruption of chain propagation may be obtained. Regardless, compounds containing only 0.5% carbon black have been exposed for 10,000 hours in the Weather-Ometer with no loss in tensile strength.

Of all the carbon blacks on the market, channel black is thought to offer the most protection to the polymer. For this reason, two blends were prepared: one contained 2.5% channel black, the other 2.5% furnace black. Tensile specimens containing these formulations were exposed on EMMA in Arizona for eight months. Neither compound exhibited any change in tensile strength during this period (Figure 14). Similarly, samples containing 2.5% furnace black have been exposed in the Weather-Ometer for greater than 25,000 hours without any brittleness or loss in physical properties. Carbon blacks are in a class by themselves with respect to the UV protection they offer.

EFFECT OF PIGMENT DISPERSION

Pigment dispersion is important in the compounding of any colored resin, since inadequate dispersion can result in poor appearance, increased cost and poor outdoor weatherability. In order to illustrate the effect of dispersion on weathering, three blends containing 0.5% CP cadmium red were prepared. Each of the blends was compounded in order to achieve a good, fair and poor pigment dispersion.

FIGURE 15
Effect of Color Dispersion on the UV Stabilization of 0.95 Density Polyethylene Resins

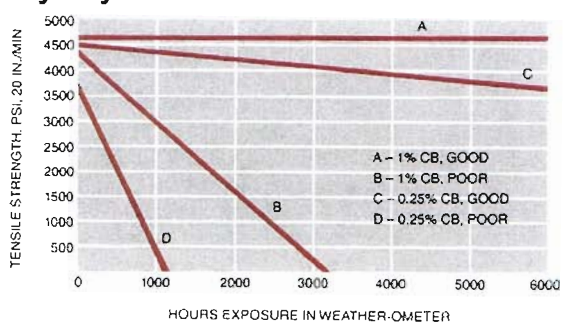


Tensile specimens from these compounds were aged in the Weather-Ometer for 2,000 hours (Figure 15). Tensile strength measured at 2 in./min. showed very little difference between good/fair pigment dispersion. However, measurements at 20 in./min. revealed that as pigment dispersion improved, there was a marked increase in tensile strength retention after UV exposure. As in the former case, the specimen with poor pigment dispersion was much less resistant to degradation than even the good or fair pigment system. These data clearly indicate that pigment dispersion is important to the UV resistance of a compound.

The degree of carbon black dispersion is also a determining factor in effectiveness of pigment for UV protection. Figure 16 shows good versus poor dispersion of black, and its effect on UV protection at two levels. Low levels of carbon black, properly dispersed, offer excellent UV protection. The usual condition is poor dispersion, normally compensated by using up to 2.5% black to give ultimate protection.

FIGURE 16

Effect of Carbon Black Dispersion on Weatherability of 0.96 Density Polyethylene Resins



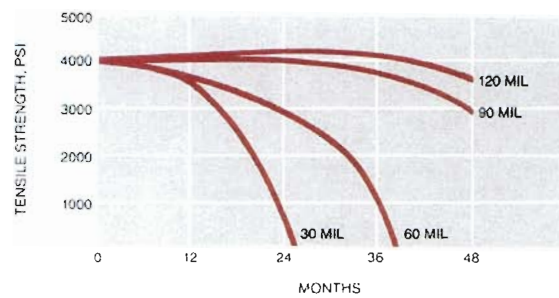
EFFECT OF PART THICKNESS

Part thickness also plays a significant role in outdoor life. Since degradation of a part occurs from the exterior to the interior, the thicker the part, the more time required to penetrate to a depth that affects its integrity. The data in Figure 17 depicts the effect of wall thickness on the UV resistance of test samples. A 120-mil thick sample has several times the life expectancy of a 30-mil sample in a yellow high density polyethylene tested outdoors in Arizona.

FIGURE 17

Effect of Part Thickness on Outdoor Weatherability of Yellow High Density Polyethylene

EXPOSED AT 45" SOUTH IN PHOENIX, ARIZONA



CONCLUSIONS

It has been demonstrated that various pigments have vastly different effects on high density polyethylene. They are important both in an aesthetic sense and as stabilizers. Some pigments such as carbon black, iron oxide, phthalocyanine blue, chrome green, and various red and orange pigments afford good and sometimes excellent protection to the resin, while pigments such as TiO_2, ultramarine blue, and cadmium yellow offer little protection. In some cases these pigments may even be detrimental to the resin. It is interesting to note that pigments of the same general type act quite differently with respect to the protection they afford the resin.

For pigments other than carbon black, data supports the hypothesis that (1) variations in absorption of light in ultraviolet/near ultraviolet wave lengths and (2) interaction between pigments and antioxidants and/or UV stabilizers are the major causes of variations in weatherability. Both good and bad side effects must be considered. For instance, carbon black and iron oxide are difficult to disperse, although they impart excellent UV resistance, while phthalocyanine blue and green pigments cause warpage of some parts molded from polyethylene.

Mercury-cadmium pigments tend to darken upon extended exposure to UV light. Further, many color formulations depend upon a white colorant with good hiding power to obtain the desired color. The only white colorant with strong tint strength is TiO_2, and although materials such as zinc oxide or barium sulfate impart excellent UV resistance, their hiding power is only about 30% of the TiO_2. This, of course, restricts the use of these materials in white or pastel formulations.

Data presented here illustrates the need to consider all phases of a compound when formulating for outdoor service. To successfully meet application requirements, the proper combination of antioxidants, UV absorbers or stabilizers, and pigments must be determined. Failure to consider all three groups of additives could result in production of compounds with inadequate stability. For this reason, the design of the compound is as important as either the part design or the end use application. All of these factors must be considered in developing a satisfactory part for outdoor applications.

If we may be of further assistance, please contact our Polyethylene Sales and Marketing team. Contact information is available at this web site http://www.cpchem.com/pe/index.asp, along with links to our polyethylene resins and MSDS sheets.

Last revised October 2002

Performance Pipe
Weatherability
Outdoor Storage Limits of Performance Pipe Gas Distribution Products

Weatherability
Outdoor Storage Limits of Performance Pipe Gas Distribution Pipe Products

Performance Pipe polyethylene gas distribution piping products are protected from UV effects and outdoor exposure to ensure pipe performance requirements are maintained during a reasonably handling time prior to installation. ASTM D2513 requires that all polyethylene gas distribution pipes produced to the standard must be able to withstand a minimum of 2 years outdoor storage without affecting the pipe's ability to meet the requirements of the standard. ASTM D2513 allows outdoor storage times in excess of 2 years if the pipes can still meet the requirements of ASTM D2513.[1]

Yellow Pipes

Yellow pipes, such as Driscopipe® 8100 and Driscoplex® 6500, are protected against outdoor exposure through additive formulations. Accelerated laboratory weathering tests were conducted on the yellow pipe formulations. The tests project that the yellow pipe materials are sufficiently protected to provide a service life of at least four years in outdoor exposure conditions. The accelerated tests measure changes in the tensile properties of the polyethylene materials after exposure to high levels of UV and humidity. Performance Pipe also conducted actual field pipe exposure tests to confirm the accelerated laboratory weathering test predictions. At periodic time intervals the field exposed pipe samples were tested for melt flow (ASTM D1238 condition 190/2.16), hoop stress/ring tensile (ASTM D1598/ASTM D2290), and ESCR (ASTM D1693, condition C). The test data confirm that there is no measurable change in pipe performance properties after four years of outdoor exposure. A summary of the test data is attached.

Black Pipes

For black pipes, the presence of a minimum of 2% carbon black finely dispersed in the polyethylene piping material provides long term protection from the potentially damaging affects of UV and outdoor exposure. 'Weathering studies have shown that pipe produced with a minimum 2.0% concentration of finely divided and evenly dispersed carbon black is protected from the harmful effects of UV radiation for indefinite periods of time.'[2],[3]

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1 ASTM D2513-07a Section A.1.5.7 *Outdoor Storage Stability*

2 Plastic Pipe Institute 'Handbook of Polyethylene Pipe' Chapter 8, *Above Ground Applications*

3 Plastic Pipe Institute TR18, "Weatherability of Plastic Pipes"

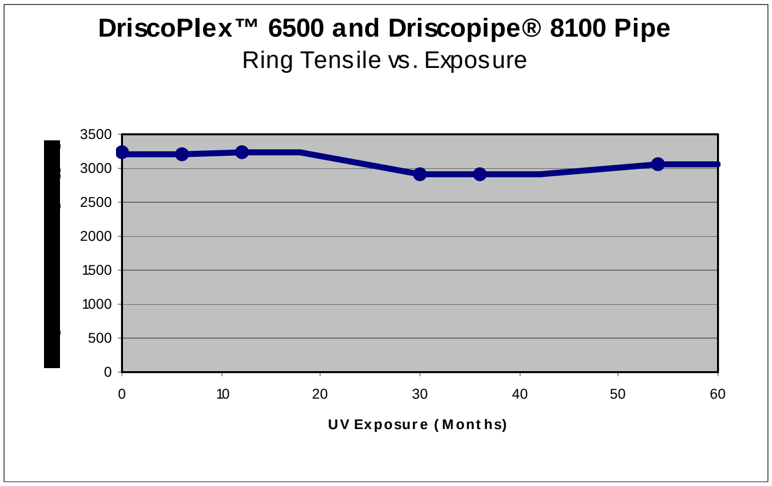
PERFORMANCE PIPE
A DIVISION OF CHEVRON PHILLIPS CHEMICAL COMPANY LP

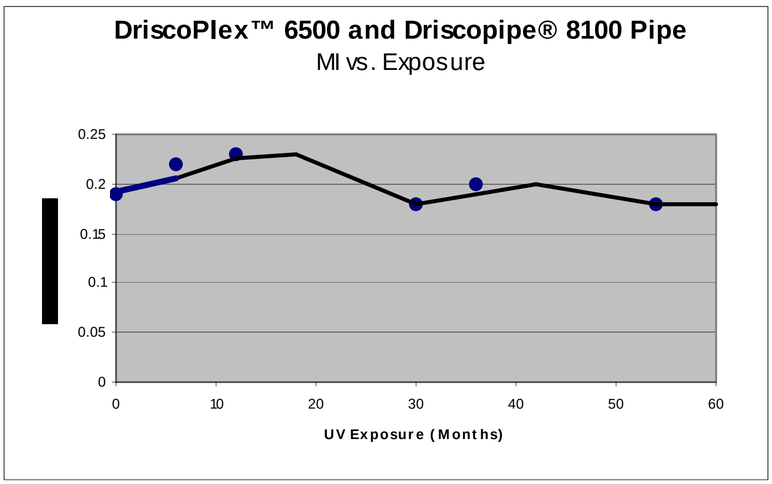
Where regulations allow, Performance Pipe black polyethylene pipes are routinely operated above ground and exposed to the elements for time periods in excess of ten years of continuous service with no change in performance. Pipes which have been exposed for long time periods have periodically been retested and have shown no significant change in the measured performance properties.

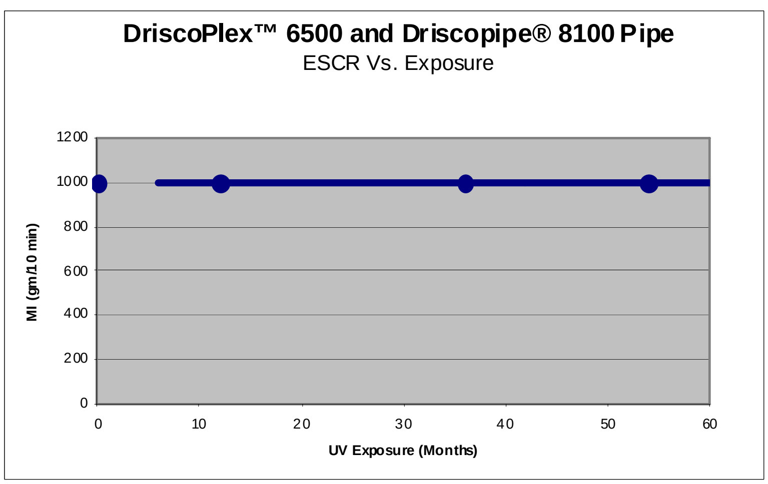
While there is no material property based need to limit the outdoor storage of Performance Pipe black HDPE pipes, based on good practice we recommend that gas distribution piping products be limited to 10 years outdoor storage prior to installing the product. This is not based on a concern for material degradation, but rather on best practices. Therefore, Performance Pipe provides the following specific outdoor storage recommendations for the Performance Pipe piping products.

- Yellowpipe, Driscoplex® 6500, and Driscopipe® 8100 pipes 4 years
- Driscopipe® 8000, 6800, and 8100, Yellowstripe®, Plexstripe II, Driscoplex® 6800, and 8300 pipes 10 years

Performance Pipe Black Pipe Products	
Requirements	***Affect after extended outdoor storage***
Quick Burst / Ring Tensile	No significant change
Sustained Pressure	No significant change
Squeeze Off Performance	No significant change
Thermal Stability	No significant change
ID Ductility	No significant change
Substantiation	No change as interpreted by no change in polymer morphology and measured by density and melt flow
Slow Crack Growth Resistance	No change as interpreted by no change in polymer morphology and measured by density and melt flow







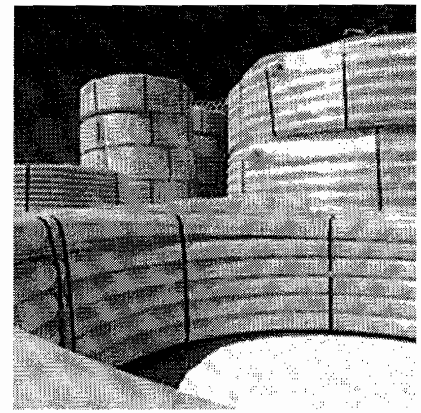
Technical Information -The information in this e-mail and its attachments is provided as general guidance on the use of Performance Pipe products. Performance Pipe does not design or engineer specific projects, and this recommendation does not replace the guidance of a professional engineer. Any technical advice or assistance furnished by Performance Pipe is given and accepted at your sole risk, and Performance Pipe has no liability whatsoever for the use of, or results obtained from, such assistance.

Polypipe Pipe
Gas Distribution Pipe

PolyPipe® Extruding Excellence

Gas Distribution

TOTAL PERFORMANCE, TOTAL SOLUTIONS



A reliable gas distribution system requires strength, integrity and uncompromising reliability. Not only from your pipe, but also from your pipe supplier.

These qualities make PolyPipe® the smart choice for gas distribution applications. As one of the largest manufacturers of medium and high - density polyethylene pipe, we understand the critical need for consistent, dependable products. Our MDPE and HDPE pipe are manufactured to the highest quality standards in the industry.

Our staff engineers and technical experts help assure you receive maximum performance and value - from evaluation and design, through job-site assistance and testing. In addition, our network of manufacturing facilities and distribution centers provide timely delivery. The result is a total system solution for your gas distribution project.

A PROVEN PIPING SYSTEM

Our medium density yellow GDY20, PE2406/2708 and our high density black, GDB30, GDB40 and GDB50 gas distribution products (with or without yellow stripes) are specially designed and produced for natural gas distribution system applications. This pipe offers outstanding environmental stress crack resistance, as well as high chemical and impact resistance.

PolyPipe® is lightweight and flexible for easy installation and heat fusible for fully restrained joints. It is manufactured to exceed all industry requirements including ASTM D2513 and Department of Transportation (DOT) CFR Title 49 Part 192.

Municipalities and contractors increasingly choose polyethylene pipe for gas systems use, due to its corrosion resistance, weatherability, strength and ease of handling. Polyethylene pipe provides long-term resistance to a variety of service conditions, including abrasion, temperature shifts, bending, internal pressure, direct burial, point loading and squeeze-off. Multiple tests confirm its consistent performance under these conditions.

PolyPipe® gas products are available in diameters from 1/2" to 1-1/4" CTS, 1/2" to 6" IPS coiled, and straight lengths from 1/2" through 24" IPS.

DESIGN PRESSURE RATING

The pressure rating of PolyPipe® is determined in accordance with the Plastics Pipe Institute (PPI) recommended hydrostatic design basis (HDB) for the material, the physical dimensions of the pipe, and the appropriate design and service factors.

Pressure design calculations are based on the following formula, which relates the stress on the pipe wall to the internal pressure.

Where S = For thermoplastic pipe, HDB, psi
(=1250 for GDY20, =1600 for GDB30, GDB40, GDB50)

P = Internal Pressure, psig

DR = Dimension Ratio (D/t)

D = Outside Diameter, inches

t = Minimum wall thickness,inches

DF = Design factor, 0.32 (Ref. DOT CFR 49 § 192.121)

F = Service factor (if needed)

Refer to the PolyPipe® **Design and Engineering Guide** for Polyethylene Piping for additional information.

THERMAL EXPANSION/CONTRACTION

Polyethylene, like other plastics, has a thermal expansion coefficient higher than metals. The coefficient of thermal expansion is 1.0×10^{-4} in/in/°F. A general rule is one-inch change in length per 100 feet of unrestrained pipe per 10°F change in temperature. This coefficient of expansion is for PE in an unrestrained mode.

When properly restrained at the end connections, PE is not prone to failure due to temperature changes for the following reasons:

- Since PE has a lower modulus of elasticity, the internal stress buildup is considerably less than the long-term strength of the material.
- The passive resistance of the soil prevents some movement when the pipe is direct buried.
- Plastics are viscoelastic; they are capable of relaxing or adjusting with time to stresses imposed by constant strain. However, this relaxation over time may not relieve all of the stresses imposed.

The crucial period for failure due to temperature effects is during installation, when temperature changes may be quite rapid and before heat fusion joints have attained a high percentage of their ultimate strength. Installation of plastic pipe under tension must be avoided to minimize the effects of contraction from thermal changes. Polyethylene should be allowed to cool to ambient temperature prior to final connection.

Bending Radius

An inherent advantage of PolyPipe® is its flexibility and resiliency. The minimum bending radius is based upon the Dimension Ratio (DR) of the pipe. This radius is determined by multiplying the outside diameter of the pipe by the radius factor for the corresponding DR.

When pipe is used in pressure applications, the longitudinal stress created by the sum of the bending radius, internal pressure and other stress loads on the pipe should not exceed the material's design stress rating. Severe but acceptable bends in polyethylene pipelines should be buried or properly restrained.

Refer to the PolyPipe® **Design and Engineering Guide** for Polyethylene Piping for additional information.

Outdoor Storage

The maximum unprotected above ground storage time for PolyPipe® gas products is dependent upon the type of polyethylene pipe.

For PolyPipe® GDY20 medium density yellow gas pipe, the recommended above ground storage should not exceed three years.

However, PolyPipe® black gas products (GDB30, GDB40 and GDB50) are suitable for above ground storage up to 50 years. Refer to DOT CFR Title 49, Part 192, § 192.321 (g) (1) and (3) for additional information.

JOINING

PolyPipe® can be joined by a variety of methods. The preferred method is heat fusion. This encompasses butt fusion, saddle fusion, socket fusion and electrofusion. This type of connection offers a completely leak-proof, fully restrained joint. Polyethylene can also be joined by use of mechanical fittings.

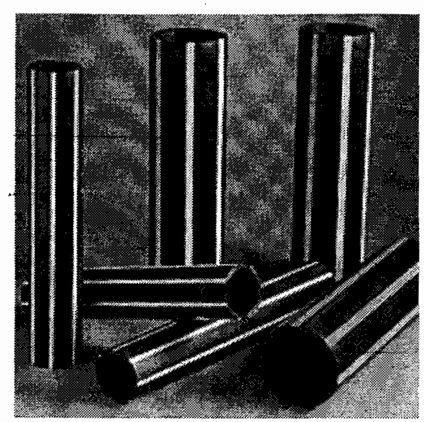
The integrity and versatility of the joining techniques used for polyethylene pipe allow the designer to take advantage of the performance benefits of polyethylene in a wide variety of applications.

For more information, consult PolyPipe® **Recommended Heat Fusion Joining Procedures**. Our procedures are in compliance with the joining requirements of DOT CFR Title 49 Part 192 § 192.283 for thermoplastic gas piping systems.

In addition, the recommended procedures for butt and saddle fusions are consistent with PPI **TR-33**, "Generic Butt Fusion Joining Procedure for Polyethylene Gas Pipe ", and **TR-41**, "Generic Saddle Fusion Joining Procedure for Polyethylene Gas Pipe."

POLYPIPE® FOR LPG SERVICE

The most common application for polyethylene gas pipe is distribution of natural gas. However, polyethylene pipe is also approved, per NFPA 58, "Liquefied Petroleum Gas Code ", for the transport of liquefied petroleum gases (LPG) provided the gas is in the vapor state.



The use of polyethylene pipe, manufactured in accordance with ASTM D2513, for the transport of vapor LPG is permitted and defined within DOT CFR Title 49 Part 192. DOT identifies ANSI/NFPA 58 as the installation standard for PE vapor LPG systems.

NFPA 58 imposes certain restrictions on the use of PE piping for vapor LPG distribution. They are as follows:

- The maximum operating pressure is limited to 30 psig.
- The size of PE is limited to 2 "NPS piping with a nominal OD of 2.375".

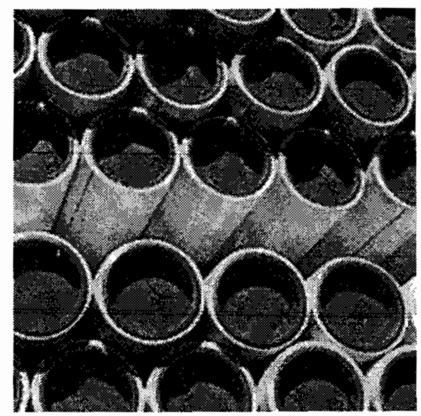
PPI TR-22, "Polyethylene Piping Distribution Systems for Components of Liquid Petroleum Gases", provides the following use recommendations for LPG service:

- PE gas piping and fittings should only be used in underground gas distribution systems where the operating pressure and temperature are such that condensation will not occur.
- The vapor LPG PE piping system shall be manufactured in accordance with ASTM D2513.
- The PE material shall have a hydrostatic design basis (HDB) category of at least 1,000 psi at 73°F as determined in accordance with ASTM D2837.

Refer to ANSI/NFPA 58 and PPI **TR-22** for further information on the use of PE for LPG service.

QUALITY ASSURANCE IN EVERY PRODUCT

At PolyPipe®, quality throughout the manufacturing process is an inherent value that assures the highest performance. Our manufacturing facilities start with only superior grade, polyethylene resins that have been specifically formulated for long-term integrity and performance in gas distribution systems.



Computer controlled extrusion techniques are utilized in the manufacture of our pipe to ensure quality. In addition, continuous wall monitoring during manufacture results in dimensional consistency.

PolyPipe®, gas products are produced in compliance with ASTM D2513. In addition to continuous dimension monitoring during manufacture, quick burst tests are routinely conducted to confirm short and long-term performance.

Long-term hydrostatic testing is also performed according to ASTM D1598, ASTM D2837 and Plastics Pipe Institute (PPI) **TR-3** to confirm that our products continually meet the established performance criteria.

PolyPipe® is continually striving to meet the demands of the market today. Our qualification as an

ISO 9001:2000 company has given us great confidence in our quality system to ensure quality products are manufactured on a consistent basis. It is the policy of PolyPipe® to achieve total quality system performance by understanding and meeting its customer requirements without error, on time, every time.

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Plastic Pipe Institute
"Handbook of Polyethylene Pipe" (1st edition, 2006)

Chapter 2
Inspections, Tests and Safety Considerations

Comprehensive guide to the use of smoothwall HDPE pipe and its applications. The handbook is available in PDF format at www.plasticpipe.org.

CHAPTER 2

Inspections, Tests and Safety Considerations

Scope

Once a polyethylene piping system has been selected and designed for an application, the design is implemented by securing the pipe, fittings and other necessary appurtenances, installing the system, and placing it in service. Piping installation involves setting various parts, people, and machines in motion to obtain, assemble, install, inspect and test the piping system. Whenever machinery, piping parts, and personnel are engaged in piping system construction, safety must be a primary consideration.

This chapter presents some of the inspections, tests and safety considerations related to installing polyethylene piping, placing an installed system into service, and operating a polyethylene piping system.

This chapter does not purport to address all of the product applications, inspections, tests, or construction practices that could be used, nor all of the safety practices necessary to protect persons and property. It is the responsibility of the users of this chapter, and the installers, inspectors and operators of piping systems to establish appropriate safety and health practices, and to determine the applicability of regulatory limitations before any use, installation, inspection, test or operation.

Introduction

Generally, piping system installation begins with obtaining the pipe, fittings, and other goods required for the system. Assembly and installation follow, then system testing and, finally, release for operation. Throughout the installation process, various inspections and tests are performed to ensure installed system quality, and that the system when completed is capable of functioning according to its design specifications. In the selection, design, and installation of polyethylene piping systems, professional engineering services and qualified installers should be used.

Handling and Storage

After the piping system has been designed and specified, the piping system components must be obtained. Typically, project management and purchasing personnel work closely together so that the necessary components are available when they are needed for the upcoming construction work.

Receiving Inspection

Few things are more frustrating and time consuming than not having what you need, when you need it. Before piping system installation begins, an important initial step is a receiving inspection of incoming products. Construction costs can be minimized, and schedules maintained, by checking incoming goods to be sure the parts received are the parts that were ordered, and that they arrived in good condition and are ready for installation.

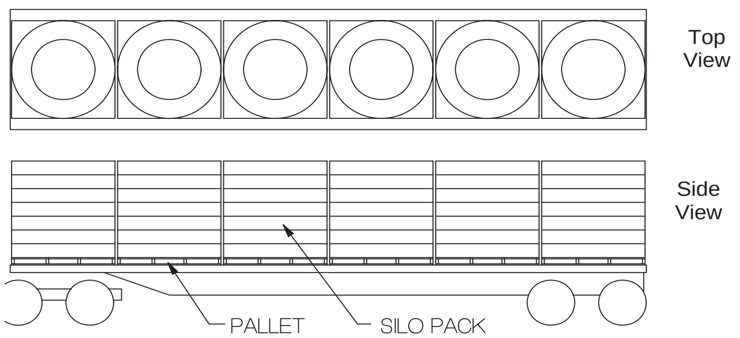

Figure 1 Typical Silo Bulk Pack Truckload

Polyethylene pipe, fittings, and fabrications are usually shipped by commercial carriers who are responsible for the products from the time they leave the manufacturing plant until they are accepted by the receiver. Pipe and fabricated fittings and structures are usually shipped on flatbed trailers. Smaller fittings may be shipped in enclosed vans, or on flatbed trailers depending upon size and packaging. Molded fittings are usually boxed, and shipped by commercial parcel services.

Product Packaging

Depending on size, polyethylene piping is produced in coils or in straight lengths. Coils are stacked together into silo packs. Straight lengths are bundled together in bulk packs or loaded on the trailer in strip loads. Standard straight lengths for conventionally extruded pipe are 40′ long; however, lengths up to 60′ long may be produced. Profile extruded pipes are typically produced in 20′ lengths. State transportation restrictions on length, height and width usually govern allowable load configurations. Higher freight costs will apply to loads that exceed length, height, or width restrictions. Although polyethylene pipe is lightweight, weight limitations may restrict load size for very heavy wall or longer length pipe.

Extruded profile pipe lengths are usually shipped on standard 40′ flatbed trailers. Pipes are commonly packaged in strip loads. Pipes 96″ ID (2438 mm ID) and 120″ ID (3048 mm ID) will exceed 8′ overall width, and are subject to wide load restrictions.

Figures 1 through 3 are general illustrations of truckload and packaging configurations. Actual truckloads and packaging may vary from the illustrations.

Small fittings are packaged in cartons which may be shipped individually by package carriers. Large orders may be palletized and shipped in enclosed vans. Large fittings and custom fabrications may be packed in large boxes on pallets, or secured to pallets.

Occasionally, when coiled pipe silos and boxed fittings are shipped together, fitting cartons are placed in the center of the silo packs. Tanks, manholes, and large fittings and custom fabrications are usually loaded directly onto flatbed trailers.

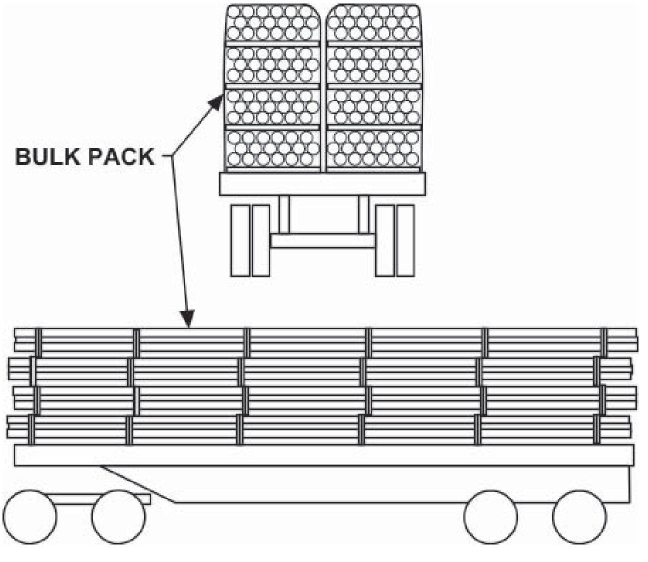

Figure 2 Typical Bulk Pack Truckload

Checking the Order

When a shipment is received, it should be checked to see that the correct products and quantities have been delivered. Several documents are used here. The **Purchase Order** or the **Order Acknowledgment** lists each item by its description, and the required quantity. The incoming load will be described in a **Packing List** which is attached to the load. The descriptions and quantities on the Packing List should match those on the Purchase Order or the Order Acknowledgment.

The carrier will present a Bill of Lading that generally describes the load as the number of packages the carrier received from the manufacturing plant. The Order Acknowledgment, Packing List, and Bill of Lading should all be in agreement. Any discrepancies must be reconciled between the shipper, the carrier, and the receiver. The receiver should have a procedure for reconciling any such discrepancies.

Load Inspection

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

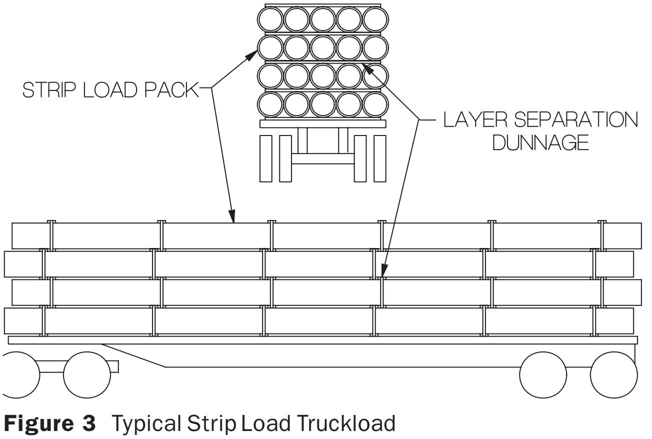

Figure 3 Typical Strip Load Truckload

This is the time to inspect for damage which may occur anytime products are handled. Obvious damage such as cuts, abrasions, scrapes, gouges, tears, and punctures should be carefully inspected.

Receiving Report and Reporting Damage

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.

Shipping problems such as damage, missing packages, document discrepancies, incorrect product, etc. should be reported to the product supplier immediately. Shipping claims must be filed as soon as possible as required by trade practice.

Unloading Instructions

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.

WARNING: Unloading and handling must be performed safely. Unsafe handling can result in damage to property or equipment, and be hazardous to persons in the area. Keep unnecessary persons away from the area during unloading.

WARNING: Only properly trained personnel should operate unloading equipment.

Unloading Site Requirements

The unloading site must be relatively flat and level. It must be large enough for the carrier's truck, the load handling equipment and its movement, and for temporary load storage. Silo packs and other palletized packages should be unloaded from the side with a forklift. Non-palletized pipe, fittings, fabrications, manholes, tanks, or other components should be unloaded from above with lifting equipment and wide web slings, or from the side with a forklift. The lifting slings/cables must be capable of safely carrying the weight of the product being unloaded. Damaged slings/cables must not be used.

Handling Equipment

Appropriate unloading and handling equipment of adequate capacity must be used to unload the truck. Safe handling and operating procedures must be observed.

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

Although polyethylene piping components are lightweight compared to similar components made of metal, concrete, clay, or other materials, larger components can be heavy. Lifting and handling equipment including cables and slings must have adequate rated capacity to lift and move components from the truck to temporary storage. Equipment such as a forklift, a crane, a side boom tractor, or an extension boom crane may be 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 4.) 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.

WARNING: 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 damage to the load or property, or hazards to persons.

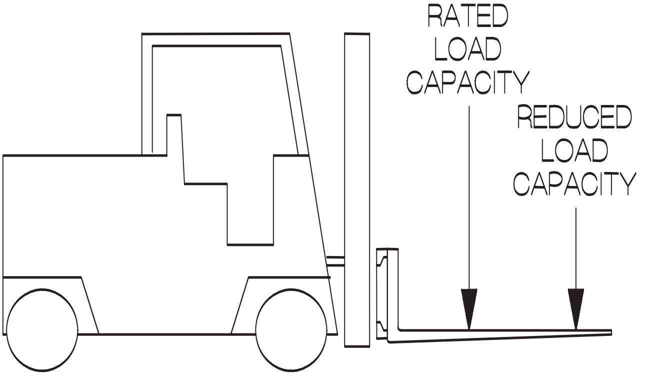

Figure 4 Forklift Load Capacity

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′.

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

Unloading Large Fabrications, Manholes and Tanks

Large fabrications, manholes and tanks should be unloaded using a wide web choker sling and lifting equipment such as an extension boom crane, crane or lifting boom. The choker sling is fitted around the manhole riser or near the top of the tank. Do not use stub outs, outlets, or fittings as lifting points, and avoid placing slings where they will bear against outlets or fittings. Larger diameter manholes and tanks are typically fitted with lifting lugs.

WARNING: All lifting lugs must be used. The weight of the manhole or tank is properly supported only when all lugs are used for lifting. Do not lift tanks or manholes containing liquids.

Pre-Installation Storage

The size and complexity of the project and the components will determine pre-installation storage requirements. For some projects, several storage or staging sites along the right-of-way may be appropriate, while a single storage location may be suitable for another job.

The site and its layout should provide protection against physical damage to components. General requirements are for the area to be of sufficient size to accommodate piping components, to allow room for handling equipment to get around them, and to have a relatively smooth, level surface free of stones, debris, or other material that could damage pipe or components, or interfere with handling. Pipe may be placed on 4-inch wide wooden dunnage, evenly spaced at intervals of 4 feet or less.

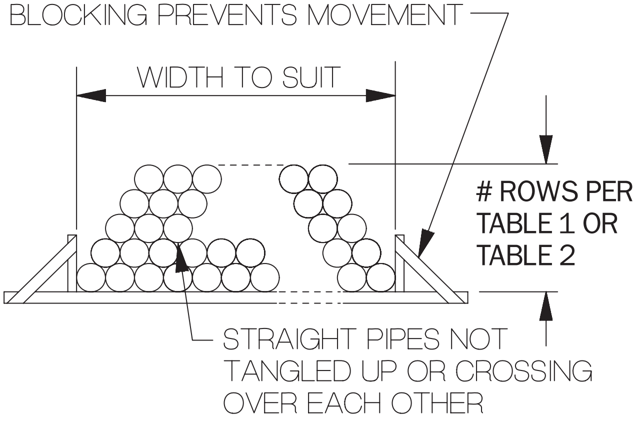

Figure 5 Loose Pipe Storage

TABLE 1

Suggested Jobsite Loose Storage Stacking Heights for Conventionally Extruded Pipe Lengths(1)

Pipe Size	Suggested Stacking Height* - Rows	
	DR Above 17	DR 17 & Below
4	15	12
5	12	10
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
30	2	2
32	2	2
36	2	1
42	1	1
48	1	1
54	1	1
63	1	1

* Stacking heights based on 6’ for level terrain and 4’ for less level terrain.

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.

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 5, Table 1, and Table 2.) The interior of stored pipe should be kept free of debris and other foreign matter.

TABLE 2

Suggested Jobsite Loose Storage Stacking Heights for Extruded Profile Pipe[2]

Pipe Size	Suggested Stacking Height* Rows
18	4
21	3
27	2
30	2
33	2
36	1
42	1
48	1
54	1
60	1
66	1
72	1
84	1
96	1
120	1

*Suggested stacking heights based on 6' for level terrain and 4' for less level terrain.

Exposure to UV and Weather

Polyethylene pipe products are protected against deterioration from exposure to ultraviolet light and weathering effects. Color and black products are compounded with antioxidants, thermal stabilizers, and UV stabilizers. Color products use sacrificial UV stabilizers that absorb UV energy and are eventually depleted. In general, non-black products should not remain in unprotected outdoor storage for more than 2 years; however, some manufacturers may allow longer unprotected outside storage. Black products contain at least 2% carbon black to protect the material from UV deterioration. Black products with and without stripes are generally suitable for unlimited outdoor storage and for service on the surface or above grade.[11, 12, 13, 14]

Cold Weather Handling

Temperatures near or below freezing will affect polyethylene pipe by reducing flexibility and increasing vulnerability to impact damage. Care should be taken not to drop pipe, or fabricated structures, and to keep handling equipment and other things from hitting pipe. 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.

Walking on pipe can be dangerous. Inclement weather can make pipe surfaces especially slippery.

WARNING: Keep safety first on the jobsite; do not walk on pipe.

General Considerations During Installation

Joining and 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.

Polyethylene piping products are connected using heat fusion, electrofusion, thermal welding, and mechanical methods such as gasketed bell-and-spigot joints, 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.

Connection design limitations and manufacturer's 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.

The tools and components required to construct and install joints in accordance with manufacturer's recommendations should always be used. However, field connections are controlled by, and are the responsibility of, the field installer.

Field Joining

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 may 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.

WARNING: Before using chemical cleaning solvents, the potential risks and hazards to persons should be known by the user, and appropriate safety precautions must be taken. Chemical solvents may be hazardous substances that may require special handling and personal protective equipment.

The manufacturer's instructions for use, and the material safety data sheet (MSDS) for the chemical should be consulted for information on risks to persons and for safe handling and use procedures. Some solvents may leave a residue on the pipe, or may be incompatible with the material. See PPI Technical Report TR-19, Thermoplastics Piping for the Transport of Chemicals for additional information on chemical compatibility of polyethylene materials.[4]

Field Fusion Joining

Heat fusion joining requires specialized equipment for socket, saddle, or butt fusion, or electrofusion. Heat fusion joining may be performed in any season. During inclement weather, a temporary shelter should be set up over the joining operation to shield heat fusion operations from rain, frozen precipitation and cold winds. It is strongly recommended that installers consult with the manufacturer's recommended joining procedures before installation begins.

WARNING: Most heat fusion equipment is not explosion-proof. The fusion equipment manufacturer's safety instructions must be observed at all times and especially when heat fusion is to be performed in a potentially volatile atmosphere.

WARNING: When installing large diameter polyethylene pipe in a butt fusion machine, do not bend the pipe against an open fusion machine collet or clamp. The pipe may suddenly slip out of the open clamp, and cause injury or damage.

Field Handling

Polyethylene pipe is tough, lightweight, and flexible. Installation does not usually require high capacity lifting equipment. See "Handling and Storage" for information on handling and lifting equipment.

WARNING: To prevent injury to persons or property, 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.

Pipe up to about 8" (219 mm) diameter and weighing roughly 6 lbs per foot (20 kg per m) or less can usually be handled or placed in the trench manually. Heavier, larger diameter pipe will require appropriate handling equipment to lift, move and lower the pipe. Pipe must not be dumped, dropped, pushed, or rolled into a trench.

WARNING: Appropriate safety precautions must be observed whenever persons are in or near a trench.

Coiled lengths and long strings of heat-fused polyethylene pipe may be cold bent in the field. Field bending usually involves sweeping or pulling the pipe string into the desired bend radius, then installing permanent restraint such as embedment around a buried pipe, to maintain the bend.

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

These paragraphs have attempted to convey the primary safety and handling considerations associated with joining and connecting polyethylene pipe. For a more thorough discussion on the joining methods used with polyethylene pipe, the reader is referred to the joining procedures chapter in this Handbook, and PPI's TR-33 Generic Fusion Procedures.

Inspection and Testing

Pre-Construction

Inspections and tests begin before construction. Jobsite conditions dictate how piping may be installed and what equipment is appropriate for construction. Soil test borings and test excavations may be useful to determine soil bearing stress and whether or not native soils are suitable as backfill materials.

In slipline rehabilitation applications, the deteriorated pipeline should be inspected by remote TV camera to locate structurally deteriorated areas, obstructions, offset and separated joints, undocumented bends, and service connections. In some cases, a test pull, drawing a short section of slipliner through the line, may be conducted to ensure that the line is free of obstructions.

The installer should carefully review contract specifications and plans. It is important that the specifications and plans fit the job. Different piping materials require different construction practices and procedures. These differences should be accurately reflected in the contract documents. Good plans and specifications help protect all parties from unnecessary claims and liabilities. Good documents also set minimum installation quality requirements, and the testing and inspection requirements that apply during the job.

All incoming materials should be inspected to be sure that sufficient quantities of the correct products for the job are at hand, and that they arrived in good condition, ready for installation.

During Construction

Tests and inspections performed during construction include butt fusion joint quality tests, soil compaction and density tests, pipe deflection tests, pressure tests, and other relevant inspections. Fusion joint qualification and inspection guidelines for butt, socket and saddle fusions should be obtained from the pipe or fitting manufacturer.

Butt Fusion Joint Quality

Visual inspection is the most common joint evaluation method for all sizes of conventionally extruded polyethylene pipe. Visual inspection criteria for butt fusion joints should be obtained from the pipe manufacturer. Computer controlled ultrasonic inspection equipment is available for 12″ IPS and smaller pipes with walls 1″ or less in thickness. Equipment for larger diameters and wall thickness is being developed. X-ray inspection is generally unreliable because x-ray is a poor indicator of fusion quality.

When butt fusion is between pipe and molded fittings, the fitting-side bead may exhibit shape irregularities which are caused by the fitting manufacturing process. A slightly irregular fitting-side bead may not indicate an improper joint, provided that the pipe-side bead is properly shaped, and the v-groove between the beads is correct. Contact the pipe or fitting manufacturer if assistance is required.

Fusion joining may be destructively tested to confirm joint integrity, operator procedure, and fusion machine set-up. A field-performed destructive test is a bent strap test.

The bent strap test specimen is prepared by making a trial butt fusion, usually the first fusion of the day, and allowing it to cool to ambient temperature. A test strap that is at least 6″ or 15 pipe wall thicknesses long on each side of the fusion, and about 1″ or 1-½ wall thicknesses wide, is cut out of the trial fusion pipe. (See Figure 6.) The strap is then bent so that the ends of the strap touch. Any disbondment at the fusion is unacceptable, and indicates poor fusion quality. If failure occurs, fusion procedures and/or machine set-up should be changed, and a new trial fusion and bent strap test specimen should be prepared and tested. Field fusion should not proceed until a test joint has passed the bent strap test.

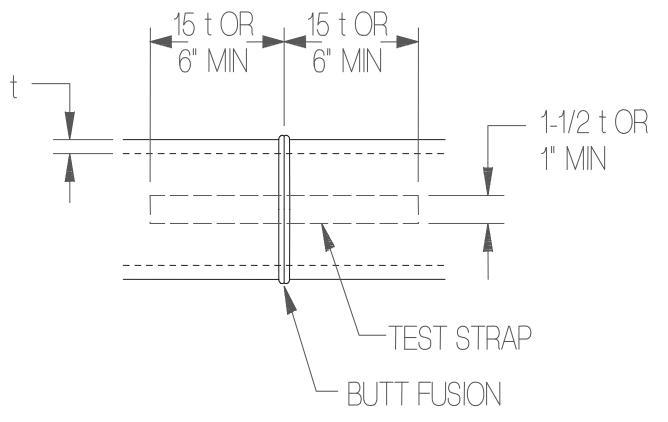

Figure 6 Bent Strap Test Specimen

WARNING: A test strap from thick wall pipe may require considerable effort to bend. Further, the test strap may spring back if the ends are inadvertently released while bending. Appropriate personnel safety precautions should be observed.

Soil Tests

During buried pipe installation, work should be checked throughout the construction period by an inspector who is thoroughly familiar with the jobsite, contract specifications, materials, and installation procedures. Inspections should reasonably ensure that significant factors such as trench depth, grade, pipe foundation (if required), quality and compaction of embedment backfill, and safety are in compliance with contract specifications and other requirements. To evaluate soil stability, density and compaction, appropriate ASTM tests may be required in the contract specifications.

Pipe Surface Damage

Surface damage may occur during construction handling and installation. Significant damage may impair the future performance of the pipeline. The following guidelines may be used to assess surface damage significance.

For polyethylene pressure pipelines, damage or butt fusion misalignment should not exceed 10% of the minimum wall thickness required for the pipeline's operating pressure.(5) Deep cuts, abrasions or grooves cannot be field repaired by hot gas or extrusion welding. Excessive damage may require removal and replacement of the damaged pipe section, or reinforcement with a full encirclement repair clamp. Severely misaligned butt fusions (>10% wall offset) should be cut out and redone.

If damage is not excessive, the shape of the damage may be a consideration. 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.

Deflection Tests

Buried flexible pipes rely on properly installed backfill to sustain earthloads and other loads. Proper installation requires using the backfill materials specified by the designer, and installing the pipe as specified by the designer.

Large diameter extruded profile pipes, and larger diameter, high DR conventionally extruded pipes are inherently flexible. Pipe deflection can be used to monitor the installation quality. Improperly embedded pipe can develop significant deflection in a short time, thus alerting the installer and the inspector to investigate the problem. Inspection should be performed as the job progresses, so errors in the installation procedure can be identified and corrected.

Figure 7 Determining Initial Deflection

Initial deflection checks of extruded profile pipe may be performed after embedment materials have been placed and compacted. The inside diameter of the pipe is measured after backfill materials have been placed to the pipe crown, and compacted. This is D1. Then final backfill materials are placed and compacted, and the pipe inside diameter is measured again at the exact location where the prior measurement was taken. This is D2. (See Figure 7.)

Percent initial deflection is calculated using the following:

$$\%Deflection = \left(\frac{D1 - D2}{D1}\right)100$$

Where D1 and D2 are as defined above and depicted in Figure 7.

Another method to measure deflection is to pull a pre-sized mandrel through the pipe. The mandrel should be sized so that if the pipe exceeds allowable deflection, the mandrel is blocked. (Calculations for mandrel sizing must include some allowance for fusion joint bead size and its reduction of the internal clearance.)

To properly size the mandrel, the allowable vertical diameter of the pipe must be established. It is necessary to account for pipe ID manufacturing tolerances and any ovality that may occur during shipping. Pipe base ID dimensions and tolerances should be obtained from the manufacturer. The maximum mandrel diameter is calculated as follows:

$$D_M = D - \left(\frac{Dy}{100}\right)$$

WHERE
DM = maximum mandrel diameter, in
D = base pipe ID, in

$$D = D_i - \sqrt{A^2 + B^2}$$

Di = nominal pipe ID, in
A = ID manufacturing tolerance, in
B = shipping ovality, in

$$B = 0.03\,D_i$$

y = allowable deflection, percent

Deflection tests of conventionally extruded pipe may be performed in the same manner. However, conventionally extruded pipe is manufactured to a controlled outside diameter, so the inside diameter is subject to the combined tolerances of the outside diameter and the wall thickness.

Post Installation

Leak Testing

The intent of leak testing is to find unacceptable faults in a piping system. If such faults exist, they may manifest themselves by leakage or rupture.

Leakage tests may be performed if required in the Contract Specifications. Testing may be conducted in various ways. Internal pressure testing involves filling the test section with a nonflammable liquid or gas, then pressurizing the medium. Hydrostatic pressure testing with water is the preferred and recommended method. Other test procedures may involve paired internal or end plugs to pressure test individual joints or sections, or an initial service test. Joints may be exposed to allow inspection for leakage.

Liquids such as water are preferred as the test medium because less energy is released if the test section fails. During a pressure test, energy (internal pressure) is applied to stress the test section. If the test medium is a compressible gas, then the gas is compressed and absorbs energy while applying stress to the pipeline. If a failure occurs, both the pipeline stress energy and the gas compression energy are suddenly released. However, with an incompressible liquid such as water as the test medium, the energy release is only the energy required to stress the pipeline.

This testing methodology may not apply to gas distribution polyethylene piping systems. The municipal gas utility should be contacted to obtain their protocol for pressure testing of gas distribution pipelines. Additional guidance for testing gas pipelines may also be found in ANSI/GPTC Z380, "Guide for Gas Transmission and Distribution Piping Systems.

WARNING: Pipe system pressure testing is performed to discover unacceptable faults in a piping system. Pressure testing may cause such faults to fail by leaking or rupturing. This may result in failure. Piping system rupture may result in sudden, forcible, uncontrolled movement of system piping or components, or parts of components.

WARNING: Pipe Restraint - The pipe system under test and any closures in the test section should be restrained against sudden uncontrolled movement from failure. Test equipment should be examined before pressure is applied to insure that it is tightly connected. All low pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.

WARNING: Personal Protection - Take suitable precautions to eliminate hazards to personnel near lines being tested. Keep personnel a safe distance away from the test section during testing.

Pressure Testing Precautions

The piping section under test and any closures in the test section should be restrained or otherwise restricted against sudden uncontrolled movement in the event of rupture. Expansion joints and expansion compensators should be temporarily restrained, isolated or removed during the pressure test.

Testing may be conducted on the system, or in sections. The limiting test section size is determined by test equipment capability. If the pressurizing equipment is too small, it may not be possible to complete the test within allowable testing time limits. If so, higher capacity test equipment, or a smaller test section may be necessary.

If possible, test medium and test section temperatures should be less than 100˚F (38˚C). At temperatures above 100˚F (38˚C), reduced test pressure is required. Before applying test pressure, time may be required for the test medium and the test section to temperature equalize. Contact the pipe manufacturer for technical assistance with elevated temperature pressure testing.

References

The following reference publications provide pressure testing information:

ASME B31.1 Power Piping, Section 137, "Pressure Tests." [6]

PPI TR-31 Underground Installation of Polyolefin Piping, Section 7, "System Testing."[1]

ASTM F 1417, Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air.[7]

Uni-Bell PVC Pipe Association Standard, Uni-b-6-90 Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe.

The piping manufacturer should be consulted before using pressure testing procedures other than those presented here. Other pressure testing procedures may or may not be applicable depending upon piping products and/or piping applications.

Test Pressure

Test pressure may be limited by valves, or other devices, or lower pressure rated components. Such components may not be able to withstand the required test pressure, and should be either removed from, or isolated from, the section being tested to avoid possible damage to, or failure of, these devices. Isolated equipment should be vented.

- For continuous pressure systems where test pressure limiting components or devices have been isolated, or removed, or are not present in the test section, the maximum allowable test pressure is 1.5 times the system design pressure at the lowest elevation in the section under test.
- If the test pressure limiting device or component cannot be removed or isolated, then the limiting section or system test pressure is the maximum allowable test pressure for that device or component.
- For non-pressure, low pressure or gravity flow systems, consult the piping manufacturer for the maximum allowable test pressure.

Test Duration

For any test pressure from 1.0 to 1.5 times the system design pressure, the total test time including initial pressurization, initial expansion, and time at test pressure, must not exceed eight (8) hours. If the pressure test is not completed due to leakage, equipment failure, etc., the test section should be de-pressurized, and allowed to "relax" for at least eight (8) hours before bringing the test section up to test pressure again.

Pre-Test Inspection

Test equipment and the pipeline should be examined before pressure is applied to ensure that connections are tight, necessary restraints are in-place and secure, and components that should be isolated or disconnected are isolated or disconnected. All low pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.

Hydrostatic Testing

Hydrostatic pressure testing is preferred and is strongly recommended. The preferred testing medium is clean water. The test section should be completely filled with the test medium, taking care to bleed off any trapped air. Venting at high points may be required to purge air pockets while the test section is filling. Venting may be provided by loosening flanges, or by using equipment vents. Re-tighten any loosened flanges before applying test pressure.

Monitored Make-up Water Test

The test procedure consists of initial expansion, and test phases. During the initial expansion phase, the test section is pressurized to the test pressure, and sufficient make-up water is added each hour for three (3) hours to return to test pressure.[1]

TABLE 3
Test Phase Make-up Amount

Nominal Pipe Size, in	Make-Up Water Allowance (U.S. Gallons per 100 ft of Pipe)		
	1 Hour Test	2 Hour Test	3 Hour Test
1-14	0.06	0.10	0.16
1-1/2	0.07	0.10	0.17
2	0.07	0.11	0.19
3	0.10	0.15	0.25
4	0.13	0.25	0.40
5	0.19	0.38	0.58
5-3/8	0.21	0.41	0.62
6	0.3	0.6	0.9
7-1/8	0.4	0.7	1.0
8	0.5	1.0	1.5
10	0.8	1.3	2.1
12	1.1	2.3	3.4
13-3/8	1.2	2.5	3.7
14	1.4	2.8	4.2
16	1.7	3.3	5.0
18	2.0	4.3	6.5
20	2.8	5.5	8.0
22	3.5	7.0	10.5
24	4.5	8.9	13.3
26	5.0	10.0	15.0
28	5.5	11.1	16.8
30	6.3	12.7	19.2
32	7.0	14.3	21.5
34	8.0	16.2	24.3
36	9.0	18.0	27.0
42	12.0	23.1	35.3
48	15.0	27.0	43.0
54	18.5	31.4	51.7
63	–	–	–

After the initial expansion phase, about four (4) hours after pressurization, the test phase begins. The test phase may be one (1), two (2), or three (3) hours, after which a measured amount of make-up water is added to return to test pressure. If the amount of make-up water added does not exceed Table 3 values, leakage is not indicated.

Non-Monitored Make-Up Water Test

The test procedure consists of initial expansion, and test phases. For the initial expansion phase, make-up water is added as required to maintain the test pressure for four (4) hours. For the test phase, the test pressure is reduced by 10 psi. If the pressure remains steady (within 5% of the target value) for an hour, no leakage is indicated.

Pneumatic Testing

WARNING: Compressed air or any pressurized gas used as a test medium may present severe hazards to personnel in the vicinity of lines being tested. Extra personnel protection precautions should be observed when a gas under pressure is used as the test medium.

WARNING: Explosive Failure - Piping system rupture during pneumatic pressure testing may result in the explosive, uncontrolled movement of system piping, or components, or parts of components. Keep personnel a safe distance away from the test section during testing.

Pneumatic testing should not be used unless the Owner and the responsible Project Engineer specify pneumatic testing or approve its use as an alternative to hydrostatic testing.

Pneumatic testing (testing with a gas under pressure) should not be considered unless one of the following conditions exists:

- when the piping system is so designed that it cannot be filled with a liquid; or
- where the piping system service cannot tolerate traces of liquid testing medium.

The testing medium should be non-flammable and non-toxic. The test pressure should not exceed the maximum allowable test pressure for any non-isolated component in the test section.

Leaks may be detected using mild soap solutions (strong detergent solutions should be avoided), or other non-deleterious leak detecting fluids applied to the joint. Bubbles indicate leakage. After leak testing, all soap solutions or leak detecting fluids should be rinsed off the system with clean water.

High Pressure Procedure

For continuous pressure rated pipe systems, the pressure in the test section should be gradually increased to not more than one-half of the test pressure, then increased in small increments until the required test pressure is reached. Test pressure should be maintained for ten (10) to sixty (60) minutes, then reduced to the design pressure rating, and maintained for such time as required to examine the system for leaks.

Low Pressure Procedure

For components rated for low pressure service, the specified rated test pressure should be maintained for ten (10) minutes to one (1) hour, but not more than one (1) hour. **Test pressure ratings must not be exceeded.**

Leakage inspections may be performed during this time. If the test pressure remains steady (within 5% of the target value) for the one (1) hour test time, no leakage is indicated.

Pressure testing of gravity-flow sewer lines should be conducted in accordance with ASTM F 1417, Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air.[7]

Initial Service Testing

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

Test Procedure

The piping system should be gradually brought up to normal operating pressure, and held at operating pressure for at least ten (10) minutes. During this time, joints and connections should be examined for visual evidence of leakage.

Non-Testable Systems

Some systems may not be suitable for pressure testing. These systems may contain non-isolatable components, or temporary closures may not be practical. Such systems should be carefully inspected during and after installation. Inspections such as visual examination of joint appearance, mechanical checks of bolt or joint tightness, and other relevant examinations should be performed.

Considerations for Post Start-Up and Operation

Disinfecting Water Mains

Applicable procedures for disinfecting new and repaired potable water mains are presented in standards such as ANSI/AWWA C651, *Disinfecting Water Mains.*[8] 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.

Warning/Caution: After disinfection, all strong concentrations of disinfection solution must be purged from the main pipeline, lateral pipelines, and even service lines. All strong solutions must be flushed with purified potable water prior to isolation or commissioning. Leave no disinfection solution in stagnant or deadend pipe runs.

Cleaning

Pipelines operating at low flow rates (around 2 ft/sec or less) may allow solids to settle in the 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.

WARNING: A pig may discharge from the pipeline with considerable velocity and force. The pig catcher is a basket or other device at the end of the line designed to receive the pig when it discharges from the pipeline. The pig catcher provides a means of safe pig discharge from the pipeline.

WARNING: Soft pigs must be used with polyethylene pipe. Scraping finger type or bucket type pigs may severely damage a polyethylene pipe and must not be used.

Commercial pigging services are available if line pigging is required.

Squeeze-Off

Squeeze-off (or pinch-off) is a means of controlling flow in smaller diameter polyethylene pipe and tubing by flattening the pipe between parallel bars. Flow control does not imply complete flow stoppage in all cases. For larger pipes, particularly at higher pressures, some seepage is likely. If the situation will not allow seepage, then it may be necessary to vent the pipe between two squeeze-offs.

Polyethylene gas pipe manufactured to ASTM D 2513 is suitable for squeeze-off; however, squeeze-off practices are not limited to gas applications. Squeeze-off is applicable to polyethylene PE3408 and PE2406 pressure pipe up to 24" IPS, and up to 100 psi internal pressure. Larger sizes and higher pressures may be possible, but suitable commercial equipment is not widely available, so there is limited experience with larger sizes or higher pressures.

WARNING: Squeeze-off is applicable ONLY to PE2406 and PE3408 polyethylene pipe and tubing. The pipe or tubing manufacturer should be consulted to determine if squeeze-off is applicable to his product, and for specific squeeze-off procedures.

Tools[9]

Squeeze-off tools should have:

- parallel bars that are shaped to avoid pipe damage,
- mechanical stops to prevent over-squeeze pipe damage,
- safety mechanisms to prevent accidental release, and
- a mechanism that controls the rate of closure, and the rate of release.

Typical bar shapes are single round bars, twin round bars, or flat bars with rounded edges. Other bar shapes may also be suitable as long as edge radius requirements are met. See Table 4.

Positive mechanical stops between the bars are essential to prevent over-squeeze and pipe damage. The stops limit bar closure to 70% of twice the maximum wall thickness.[9] For DR or SDR sized polyethylene pipe ONLY, (not tubing or schedule sized pipe), stop distance may be determined by:

$$g = 1.568\left(\frac{D}{DR}\right)$$

WHERE

g = stop gap, in

D = pipe outside diameter, in

DR = pipe dimension ratio

TABLE 4
Squeeze Tool Bar Radius

Pipe Diameter	Minimum Bar Radius
≤ 0.750	0.50
> 0.750 ≤ 2.375	0.63
> 2.375 ≤ 4.500	0.75
> 4.500 ≤ 8.625	1.00
> 8.625 ≤ 16.000	1.50

Consult the pipe manufacturer for stopgap dimensions for tubing sizes.

Typical squeeze-off tools use either a manual mechanical screw or hydraulic cylinders. In either case, a mechanism to prevent accidental bar separation is an essential safety feature of the tool.

Key Elements

Closing and opening rates are key elements to squeezing-off without damaging the pipe. It is necessary to close slowly and release slowly, with slow release being more important. The release rate for squeeze-off should be 0.50 inches/minute or less as specified in ASTM F1041(10) or ASTM F1563.(9) The pipe must be allowed sufficient time to adjust to the high compressive and tensile stresses applied to the pipe's inside wall during squeeze-off.

Research work performed under contract to the Gas Research Institute indicates that the greatest damage potential is during release, especially with heavier wall pipes. Flattening places high compressive stress on the inside wall at the outer edges of the squeeze. Then releasing and opening applies high tensile stress to the same area. The material must be given ample time to accommodate these stresses. Opening too fast may cause excessive strain, and may damage the inside wall.

Lower temperatures will reduce material flexibility and ductility, so in colder weather, closure and opening time must be slowed further.

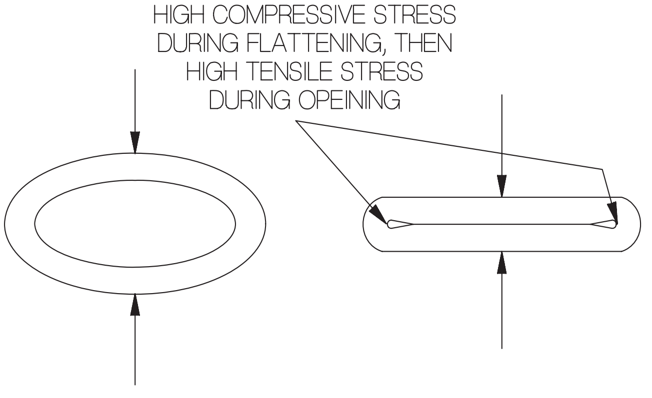

Figure 8 Squeeze-off Stresses

Testing of PE2406 and PE3408 polyethylene piping has shown that when proper procedures and tools are used, squeeze-off can be performed without compromising the expected service life of the system. However, pipe can be damaged during squeeze-off:

- if the manufacturer's recommended procedures are not followed, or
- if the squeeze is held closed too long, or
- from static electric discharge, or
- by altering or circumventing the closure stops, or
- by squeezing-off more than once in the same location.

WARNING: Pipe damaged during squeeze-off could leak or fail at the squeeze-off point. Pipe known or suspected to have been damaged during squeeze-off should be removed from the system, or should be reinforced at the squeeze-off point using a full encirclement clamp.

Procedure

From the installation of the squeeze-off tool to its removal, the total time should not exceed 8 hours. Excessive time may damage the pipe.

1. Select the correct size squeeze tool for the pipe being squeezed. Squeeze bar closure stops must be in place, and must be the correct size for the pipe's diameter and wall thickness or DR.

2. Fit the tool on the pipe so the pipe is centered in the tool, and the tool is square to the pipe. The squeeze-off tool must be at least 3 pipe diameters, or 12 inches, whichever is greater, away from any butt fusion, or any socket, saddle, or mechanical fitting.

WARNING: Static electricity control - When pipe conveying a compressed gas is being flattened, the gas flow velocity through the flattened area increases. High velocity, dry gas, especially with particles present in the flow, can generate a static electric charge on pipe surfaces which can discharge to ground. Before flattening the pipe, the tool should be grounded and procedures to control static charge build-up on pipe surfaces should be employed. Grounding and static control procedures should remain in place for the entire procedure.

3. Operate the bar closing mechanism and, at a controlled rate, flatten the pipe between the bars.

3.1 For 3" IPS and larger pipe, pause at least 1 minute when the pipe is flattened halfway and another minute when 3/4 closed. For all pipe sizes, pause 1 minute when the pipe inside walls make contact.

3.2 After pausing 1 minute when the pipe inside walls make contact, continue closing at about half the prior closing rate until the tool bars contact the closure stops.

3.3 If temperatures are near freezing or lower, closure rates should be halved and pauses should be doubled.

4. If necessary, engage the accidental release prevention mechanism.

5. Perform the necessary work downstream of the squeeze-off.

WARNING: Venting may be required for 100% shut-off. Squeeze-off may not stop all flow. If 100% shut-off is required, it may be necessary to install two squeeze-off tools at two points along the line, and vent between them. Any work performed must be downstream of the second squeeze-off. Do not remove or alter the closure stops, or place anything (rags, sticks, etc.) between the bars and the pipe.

6. When work is complete, disengage the accidental release mechanism (if required), and open the squeeze-off tool bars at a controlled rate no faster than the Step 3 closure rate. Opening must include a 1 minute pause at the wall contact point, and 1 minute pauses at 1/4 open (3/4 closed) and 1/2 open points for 3" IPS and larger pipes.

7. Open the bars, and remove the squeeze-off tool.

8. Identify the squeezed-off area by wrapping tape around the pipe, or installing a full encirclement clamp over the area.

WARNING: Do not squeeze off more than once in the same place. Doing so may damage the pipe.

Additional information on squeeze-off may be found in ASTM F 1041, *Standard Guide for Squeeze-off of Polyolefin Gas Pressure Pipe and Tubing.*[10]

Routine or Emergency?

Squeeze-off procedures may be used for routine, scheduled changes to piping systems, or as an emergency procedure to control gasses or liquids escaping from a damaged pipe. For scheduled piping changes, the above procedure should be followed, and if followed, the pipe's service life is not expected to be compromised.

However, an emergency situation may require quickly flattening the pipe and controlling flow because the escaping fluid may be an immediate hazard of greater concern than damaging the pipe.

WARNING: If an emergency situation requires rapid flattening, then the pipe or tubing will probably be damaged.

Repairs

Repair situations may arise if a polyethylene pipe has been damaged. Damage may occur during shipping and handling, during installation, or after installation. Damage may include scrapes or abrasions, breaks, punctures, kinks or emergency squeeze-off. Permanent repair usually involves removing and replacing the damaged pipe or fitting. In some cases, temporary repairs may restore sufficient serviceability and allow time to schedule permanent repairs in the near future.

Refer to TN-35, Repair of HDPE Pipelines, at www.plasticpipe.org for more information.

Damage Assessment

Damaged pipe or fittings should be inspected and evaluated. Pipe, fittings, fabrications or structures with excessive damage should not be installed. Damage that occurs after installation may require that the damaged pipe or component be removed and replaced.

WARNING: Scrapes or gouges in pressure pipe cannot be repaired by filling-in with extrusion or hot air welding. The damaged section should be removed and replaced.

WARNING: Improperly made fusion joints cannot be repaired.

Improper 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.

WARNING: Broken or damaged fittings cannot be repaired and, as such, should be removed and replaced.

WARNING: Kinked pipe must not be installed and cannot be repaired.

Kinked pipe must be removed and replaced.

WARNING: Pipe damaged during an emergency squeeze-off cannot be repaired.

Squeeze-off damaged pipe must be removed and replaced.

Permanent Repairs

For buried large diameter polyethylene pipe that has been poorly backfilled, excessive deflection may be correctable using point excavation to remove backfill, then reinstalling embedment materials in accordance with recommended procedures.

Where replacement is required, any joining method appropriate to the product and service requirements is generally acceptable. Butt and socket fusion joining procedures require that one of the components move longitudinally. However, constrained installations, such as buried pipes, may not allow such movement.

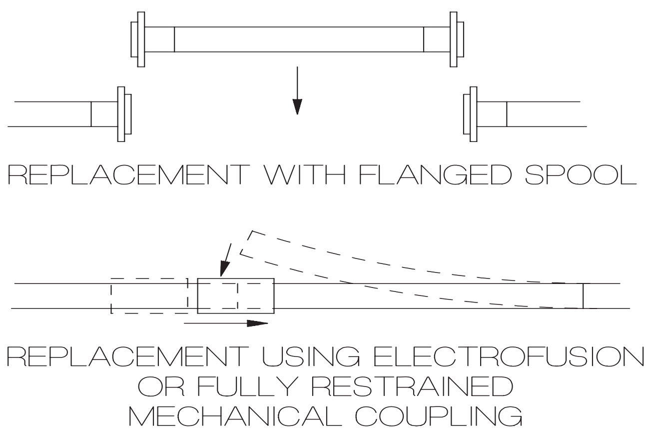

Figure 9 Constrained Pipe Repair

Permanent repair of constrained pipe typically employs techniques that do not require longitudinal movement of one or both pipe ends. Techniques include deflecting one pipe end to the side, using a mechanical or electrofusion coupling, or installing a flanged spool. See Figure 9. Typical methods for joining repair pipe sections include flanges, electrofusion couplings, and fully restrained mechanical couplings.

To repair using a flanged spool, cut out, remove and discard the damaged pipe section. Install flanges on the two pipe ends. Measure the distance between the flange sealing surfaces, and prepare a flanged pipe spool of the same length. Install the flanged spool.

Repair using an electrofusion coupling or a fully restrained mechanical coupling is limited to pipe sizes for which such couplings are available. Mechanical or electrofusion coupling repairs are made by deflecting one pipe end to the side for the coupling body to be slipped on. The pipe ends are then realigned, and the coupling joint fitted up. To allow lateral deflection, a length of about 10 times the pipe outside diameter is needed.

Temporary Repair

Until permanent repairs can be effected, temporary repairs may be needed to seal leaks or punctures, to restore pressure capacity, or to reinforce damaged areas. Temporary repair methods include, but are not limited to, mechanical repair couplings and welded patches.

Conclusion

A successful piping system installation is dependent on a number of factors. Obviously, a sound design and the specification and selection of the appropriate quality materials are paramount to the long-term performance of any engineered installation. The handling, inspection, testing, and safety considerations that surround the placement and use of these engineered products is of equal importance.

In this chapter, we have attempted to provide fundamental guidelines regarding the receipt, inspection, handling, storage, testing and repair of polyethylene piping products. While this chapter cannot address all of the product applications, test and inspection procedures, or construction practices, it does point out the need to exercise responsible care in planning out these aspects of any job site. It is the responsibility of the contractor, installer, site engineer or other users of these materials to establish appropriate safety and health practices specific to the job site and in accordance with the local prevailing codes that will result in a safe and effective installation.

References

1. Plastics Pipe Institute, *Handbook of Polyethylene Pipe*, chapter on Underground Installation of Polyethylene Pipe, Washington, DC.
2. Gilroy, H.M. (1985). Polyolefin Longevity for Telephone Service, Antec Proceedings.
3. Plastics Pipe Institute, *Handbook of Polyethylene Pipe*, chapter on Polyethylene Joining Procedures, Washington, DC.
4. Plastics Pipe Institute, TR-19, Thermoplastics Piping for the Transport of Chemicals, Washington, DC.
5. American Gas Association. (1994). *AGA Plastic Pipe Manual for Gas Service*, AGA.
6. American Society of Mechanical Engineers, B31.1, Section 137.
7. American Society for Testing and Materials. (1998). ASTM F1417, Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low Pressure Air, West Conshohocken, PA.
8. American Water Works Association. (1992). AWWA Standard for Disinfecting Water Mains, Denver, CO.
9. American Society for Testing and Materials. (1998). ASTM F1563, Standard Specification for Tools to Squeeze-off Polyethylene (PE) Gas Pipe or Tubing, West Conshohocken, PA.

10. American Society for Testing and Materials. (1998). ASTM F1041, Standard Guide for Squeeze-off of Polyethylene Gas Pressure Pipe or Tubing, West Conshohocken, PA.
11. American Society for Testing and Materials.(1998). ASTM D2104, Standard Specification for Polyethylene (PE) Plastic Pipe, Schedule 40, West Conshohocken, PA.
12. American Society for Testing and Materials. (1998). ASTM D2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter, West Conshohocken, PA.
13. American Society for Testing and Materials. (1998). ASTM D2447, Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter, West Conshohocken, PA.
14. American Society for Testing and Materials. (1998). ASTM D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter, West Conshohocken, PA.

Plastic Pipe Institute
Weatherability of Thermoplastic Piping Systems
TR-18/2005

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TR-18/2005

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WEATHERABILITY OF THERMOPLASTIC PIPING SYSTEMS

Foreword

This report was developed and published with the technical help and financial support of the members of the PPI (Plastics Pipe Institute). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

The purpose of this technical report is to provide information on the weather resistance of the basic plastic materials used in commercial plastic piping systems.

This report has been prepared by PPI as a service of the industry. The information in this report is offered in good faith and believed to be accurate at the time of its preparation, but is offered without any warranty, expressed or implied, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Consult the manufacturer for more detailed information about the particular weathering package used for its piping products. Any reference to or testing of a particular proprietary product should not be construed as an endorsement by PPI, which do not endorse the proprietary products or processes of any manufacturer. The information in this report is offered for consideration by industry members in fulfilling their own compliance responsibilities. PPI assumes no responsibility for compliance with applicable laws and regulations.

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The Plastics Pipe Institute
http://www.plasticpipe.org

October 2005

WEATHERABILITY OF THERMOPLASTIC PIPING SYSTEMS

1.0 INTRODUCTION

Thermoplastic polymers, like many other materials, are affected by weathering, which is a general term used to cover the entire range of outdoor environmental conditions. However, plastic piping made of thermoplastics that incorporate appropriate weathering protection have been used in various outdoor applications and have given many years of service. For those piping systems that are intended for continuous outdoor exposure, a material composition must be selected that has the necessary weather resistance for the specific conditions involved. Most thermoplastic piping has sufficient weather resistance to withstand normal exposure that occurs before installation. In some instances this time period can be as long as several years.

Thermoplastic polymers have definitive characteristics regarding weather deterioration: Some are inherently resistant while others are less resistant. The weatherability of all thermoplastics can be improved by the incorporation of select ingredients. The combination of the basic thermoplastic polymer with these select ingredients results in the finished material that is generally termed a thermoplastic compound.

This report covers the structure and inherent weather resistance of the basic thermoplastic polymers used in commercial thermoplastic piping and discusses the weather resistance of those thermoplastic compounds that are in established use. Much of the discussion focuses on the effects of ultraviolet radiation exposure, as this is generally the weathering factor with the greatest impact on the performance of thermoplastic piping.

2.0 FACTORS INFLUENCING WEATHERING

When making a determination for the suitability of a particular plastic material for either outside storage or long term above ground service, the environment surrounding the piping material must be considered. A brief description of the more important environmental parameters follows:

2.1 Sunlight

Sunlight contains a significant amount of ultraviolet radiation. The ultraviolet radiation that is absorbed by a thermoplastic material may result in actinic degradation (i.e., a radiation promoted chemical reaction) and the formation of heat. The energy may be sufficient to cause the breakdown of the unstabilized polymer and, after a period of time, changes in compounding ingredients. Thermoplastic materials that are to be exposed to ultraviolet radiation for long periods of time should be made from plastic compounds that are properly stabilized for such conditions.

2.2 Temperature

The daily range of temperature varies considerably both with season and location and can be quite large. Heat from solar radiation can raise the temperature of directly exposed materials as much as 60°F higher than ambient, depending on the pipe color. Such extremes of temperature over an extended period can cause physical damage to the polymer. Therefore, it is important that heat stabilizers be incorporated into the compounding ingredients in order to offset the deleterious effects of high temperature. In addition, it should be remembered that chemical reaction rates increase exponentially as the temperature increases.

2.3 Moisture

Rain and humidity are the two main contributors of moisture with humidity having the greater overall effect. In general, humidity contributes a moist continuum in constant contact with the material to produce hydrolysis, leaching, etc. Rain produces a washing and impacting action.

2.4 Wind

Wind acts as a carrier of impurities such as dust, gases and moisture that can contribute to weathering effects. Similarly, the absence of wind can allow the accumulation of air contaminants, as in smog areas, which could contribute significantly to the weathering of a material.

2.5 Gases

The nature and quantity of gases vary widely but, in industrial areas especially, gases are present which can result in chemical action on some materials.

2.6 Location

The geographical location is also a factor. Less effects are produced where there are less sunlight hours per year and where the radiation is less intense. For example, a specific period of exposure in Arizona is more detrimental than in New Hampshire due to the obvious extra hours of UV (ultraviolet) exposure and, less obviously, to the higher ambient temperatures encountered.

3.0 WEATHERING RESISTANCE OF BASIC THERMOPLASTIC POLYMERS

Some polymers are inherently quite resistant to weather, others less so, and some deteriorate quite rapidly. For the purpose of this discussion, only those polymers commonly used in piping applications are presented.

3.1 Polyethylene. Polypropylene. and Polyvinyl Chloride (Figure 1)

Polyethylene (PE), polypropylene (PP), and polyvinyl chloride (PVC) all have the same basic structure as shown in Figure 1. They all have a backbone of carbon-to-carbon bonds with various side components: hydrogen (H) for PE, a methyl (CH_3) group for PP, and chlorine (Cl) for PVC. With UV stabilization, these polymers give good long-term service in outdoor applications. The ability to withstand exposure to weathering conditions is dependent on the type of UV stabilization and the amount of UV exposure.

3.2 ABS (Acrylonitrile-Butadiene- Styrene) Terpolymers

Impact-modified styrenic polymers such as ABS (acrylonitrile-butadiene-styrene) terpolymers are very sensitive to oxidation, essentially because of the polybutadiene content. The carbon-carbon double bond (C=C), which is responsible for the elastomeric behavior of the rubber, is extremely sensitive to UV energy. This energy causes oxidation and crosslinking that modifies the materials rubbery behavior to one of a more brittle nature. Degradation from weathering starts at the surface and results in a rapid loss of mechanical properties such as ultimate elongation, toughness, and impact strength.

To avoid degradation, ABS is frequently protected by the inclusion of carbon black in the formulation. The addition of sufficient carbon black can make these polymers very weather resistant, as evidenced by the good field history of black ABS (acrylonitrile-butadiene-styrene) pipe. Carbon black is the most common UV stabilizer used for extended outdoor applications.

4.0 WEATHERING OF POLYETHYLENE (PE) PIPE

The basic polyethylene polymer has limited outdoor life. However, most polyethylene pipe manufactured today contains an ultraviolet stabilization package. For typical outdoor storage, ultraviolet stabilized non-black systems are satisfactory, but for prolonged outdoor use, polyethylene should be formulated with a minimum of 2 percent finely dispersed carbon black.

Incorporating carbon black in polyethylene compounds greatly increases their weather resistance (1,2). Carbon black acts as a UV absorbent and screens the polyethylene from damaging ultraviolet radiation. The aging resistance imparted by the carbon black depends upon its type, particle size, concentration, and degree of dispersion in the polyethylene (3).

ASTM material standard D 3350 requires a minimum concentration of 2 percent carbon black. It has been demonstrated that this amount of well-dispersed very fine particle carbon black is sufficient protection for continuous outdoor service.

5.0 WEATHERING OF POLYPROPYLENE (PP) PIPE

Pigmented (non-black) polypropylene (PP) pipe, like pigmented (non-black) polyethylene pipe, has a limited life when stored outdoors. The outdoor storage life of non-black polypropylene should be limited to a total of three months unless the pipe is covered or otherwise protected from sunlight (4).

Some PP piping is protected from ultraviolet radiation by the inclusion of carbon black in the compound. Polypropylene's weatherability, like polyethylene's, is greatly enhanced by the incorporation of carbon black. The degree of weatherability imparted by the carbon black depends upon its type and particle size, concentration and dispersion in the compound. A concentration of two percent generally results in the best resistance (5).

It should be noted that PP piping is available manufactured from both carbon black and non-carbon black UV stabilized compounds. Applications that are not subject to outdoor exposure, such as indoor plumbing applications, may successfully utilize non-black PP piping. Non-black PP pipe should not be installed above ground outdoors where it would be continuously exposed to ultraviolet light or sunlight.

6.0 WEATHERING OF POLYVINYL CHLORIDE (PVC) PIPE

Generally, standard PVC pipe grade materials covered under ASTM D 1784 (such as PVC 1120 - cell classification 12454) include sufficient UV screen, usually titanium dioxide (TiO_2), to be stored outdoors for at least one year. Special care must be given to ensure that PVC pipe used in outdoor applications has been formulated to be a highly weather resistant product. Otherwise, it may not deliver equally satisfactory performance outdoors.

PVC materials can be compounded with a suitable amount of TiO_2 to be a very highly weatherable product, as can be seen in siding, windows, and furniture. These PVC compounds use PVC resin, UV screens and other weather resistant ingredients.

7.0 WEATHERING OF ACRYLONITRILE-BUTADIENE-STYRENE (ABS)

ABS pipe usually contains carbon black to provide protection from sunlight. The effects of ultraviolet radiation are substantially reduced in pipe so protected and permit the use of ABS pipe in outdoor applications. The largest outdoor use is probably plumbing vent pipes of drain, waste and vent (DWV) systems that are fully exposed to all climatic conditions.

Prolonged exposure of such plumbing vents has not affected their performance. Close examination has shown that only a very thin surface layer of the pipe has been affected by sunlight, even after several years' exposure.

No adverse effects have been found from other weather conditions such as wet or cold, or from geographical location where the intensity of ultraviolet radiation varies. Non-black ABS compounds are not recommended for outdoor service.

8.0 EFFECTS OF WEATHERING

The effects of weathering can vary from a complete loss of tensile strength and reduction of ductility to slight surface degradation that does not detract from performance. Generally speaking, the first effect of weathering will be a slight discoloration of the pigment resulting in a chalky surface or whitening of the coloration.

Plastic compounds that have been adversely affected by weathering will exhibit a reduction in tensile strength and ductility. In all cases, surface degradation must be removed in order to allow the plastic compound to be hot plate welded (heat fused) or solvent bonded. The pipe and fitting manufacturer's recommended heat fusing or bonding procedures should be consulted.

9.0 DESIGN CONSIDERATIONS

The following statements on weathering characteristics of plastic piping compounds may be used for guidance on piping systems utilizing these materials. The weathering statements are appropriate for piping systems that have been designed to withstand the temperatures and other environmental conditions encountered in the specific application.

The service life of plastic pipe exposed simultaneously to weathering and external stresses may be greatly reduced by acceleration of chemical and physical changes (6,7). For example, unstressed control specimens of various polyethylene compounds required considerably longer time to show signs of degradation from natural ultraviolet light than did specimens exposed in the form of bent strips subjected to high stresses (8,9).

10.0 NATURAL WEATHERING

Most natural weathering studies are conducted in accordance with ASTM D 1435, "Standard Practice for Outdoor Weathering of Plastics" (10). The intensity of solar radiation, of course, varies widely with the geographical location and time of year. (One year's exposure in New Jersey, for example, does not give the same degree of aging as a year's exposure in Florida or Arizona). A month's exposure in July or August at any location is not the same as a month's exposure during December or January. Even at one location, the variation in solar radiation from year to year can be as great as the total radiation for a whole month. Therefore, even a year as a unit for timing exposure is variable and cannot be used for direct comparison of samples, unless they were exposed during the same period.

However, data and case histories from severe locations, where radiation is intense, enable users to properly design for applications at less severe locations. Change in tensile properties, color change, brittleness temperature and other significant properties are used as criteria.

11.0 ACCELERATED WEATHERING

A number of devices are used to simulate outdoor exposure. These employ mercury sunlamps, carbon arcs, xenon arcs or a combined fluorescent sunlamp-black light. ASTM Standard Practices D 4329 (11), D 1499 (12) and D 2565 (13) cover the latter three.

None of these tests can be absolutely correlated with outdoor exposure. The reasons for this lack of correlation are:

1. The extreme variations in outdoor environment.
2. The radiation spectrum does not exactly duplicate the solar spectrum.
3. Temperatures and temperature ranges differ from outdoor conditions.
4. Humidity difference.

However, in spite of this lack of correlation with outdoor exposure, accelerated testing is an extremely useful tool for comparing the relative aging resistance of materials and rapidly screening out materials that have a poor resistance. The same criteria of change in properties and appearance used to evaluate natural weathering are used for accelerated tests.

A very reliable index of weather resistance is provided by intensified natural sunlight testing stations. These test stations use an equatorial mount that follows the sun and also concentrates the sun's rays by a battery of mirrors. The sun's spectrum is used and the accompanying heat generated is controlled with air and water streams. Results are obtained in approximately one seventh of the time required in natural exposure. Reference numbers 14, 15, 16, 17 in Section 12.0 may be consulted for further information on this subject.

$$-\left[-CH_2 - CH_2 -\right]_n -$$

Polyethylene

$$-\left[-CH_2 - CH\left(CH_3\right)-\right]_n -$$

Polypropylene

$$-\left[-CH_2 - CH\left(CL\right)-\right]_n -$$

Polyvinyl chloride

$$-\left[-CH_2 - CH\left(C_6H_5\right)-\right]_n -$$

Polystyrene

FIGURE 1

12.0 REFERENCES

1. Gilroy, H. M., "Polyolefin Longevity for Telephone Service," Antech '85, pp. 258-260.

2. Whitney, Lynn, C., "Specifying Carbon Blacks for UV Light Protection," Plastics Engineering, (December 1988), pp. 29-33.

3. Wallder, V. T., Clarker, W. J., DeCoste, J. B., and J. B. Howard, "Weathering Studies on Polyethylene," Industrial and Engineering Chemistrv Vol 42, No. 11, pp. 2320-2325.

4. AWWA Standard C 902-88, "Polybutylene (PB) Pressure Pipe and Tubing, One-Half Inch Through Three Inch for Water," American Water Works Association, Denver, CO, 1988.

5. Plastics Piping Manual, Plastics Pipe Institute, Washington, DC, 1976.

6. Quackenbos, H. M. and Samuels, H., "Practical Problems for Predicting Weathering Performance," Modern Plastics Vol. 44, No. 8, (April 1967), p. 143.

7. Gary, V. E. and Cadoff, B. C., "Experimental Techniques for the Evaluation of the Effects of Weathering on Plastics," Modem Plastics, Vol. 44, No. 8 (April 1967), p. 219.

8. Kaufman, F. S., Jr., "Evaluating Weathering of High Density PE," Modern Plastics, Vol. 44, No. 8 (April 1967), p. 146.

9. Newland, G. C. and Tamblyn, J. W., "Weathering of Polyolefins Under Stress," Polvmer and Engineering Science (July 1965), pp. 148-151.

10. ASTM D 1435-94, "Standard Practice for Outdoor Weathering of Plastics," American Society for Testing and Materials, Philadelphia, PA, 1985.

11. ASTM D 4329-92, "Standard Practices for Operating Light and Water Apparatus (Fluorescent UV and Condensation Type) for Exposure of Plastics," American Society for Testing and Materials, Philadelphia, PA, 1984.

12. ASTM D 1499-92a, "Standard Practice for Operating Light and Water Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastics," American Society for Testing and Materials, Philadelphia, PA, 1984.

13. ASTM D 2565-92a, "Standard Practice for Operating Xenon ArcType Light Exposure Apparatus With and Without Water for Exposure of Plastics," American Society for Testing and Materials, Philadelphia, PA, 1988.

14. DeBlieu, I. K. and Zerlaut, G. A., "Weathering of Plastics and Plastics Piping; Real Time and Accelerated Outdoor Exposure Testing," American Gas Association Distribution/Transmission Conference, May 1984.

15. “Engineering Plastics”, Engineering Materials Handbook, Vol. 2, 1988, pp 575-580.

16. Modern Plastics Encyclopedia. Vol. 67, No. 11, p. 216, McGraw-Hill Publishing Co., New

17. Palermo, E. F., "New Outdoor Storage Requirements in ASTM D 2513," AGA Plastic Materials Committee Workshop, February 1987.

ASTM D 3350

Designation: D 3350 – 06

Standard Specification for Polyethylene Plastics Pipe and Fittings Materials[1]

This standard is issued under the fixed designation D 3350; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers the identification of polyethylene plastic pipe and fittings materials in accordance with a cell classification system. It is not the function of this specification to provide specific engineering data for design purposes, to specify manufacturing tolerances, or to determine suitability for use for a specific application.

1.2 Polyethylene plastic materials, being thermoplastic, are reprocessable and recyclable (Note 2). This specification allows for the use of those polyethylene materials, provided that all specific requirements of this specification are met.

NOTE 1—The notes in this specification are for information only and shall not be considered part of this specification.

NOTE 2—See Guide D 5033 for information and definitions related to recycled plastics.

1.3 The values stated in SI units are to be regarded as standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 3—There is no similar or equivalent ISO standard.

1.5 For information regarding molding and extrusion materials see Specification D 4976. For information regarding wire and cable materials see Specification D 1248.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 618 Practice for Conditioning Plastics for Testing
D 638 Test Method for Tensile Properties of Plastics
D 746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D 883 Terminology Relating to Plastics
D 1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
D 1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
D 1603 Test Method for Carbon Black Content in Olefin Plastics
D 1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics
D 1898 Practice for Sampling of Plastics[3]
D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
D 2839 Practice for Use of a Melt Index Strand for Determining Density of Polyethylene
D 3892 Practice for Packaging/Packing of Plastics
D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique
D 4703 Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets
D 4883 Test Method for Density of Polyethylene by the Ultrasound Technique
D 4976 Specification for Polyethylene Plastics Molding and Extrusion Materials
D 5033 Guide for Development of ASTM Standards Relating to Recycling and Use of Recycled Plastics
F 1473 Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins

2.2 *ISO Standard:*

[1] This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials.

Current edition approved Nov. 15, 2006. Published November 2006. Originally approved in 1974. Last previous edition approved in 2005 as D 3350 - 05.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Withdrawn.

***A Summary of Changes section appears at the end of this standard.**

ISO 12162 Thermoplastic Materials for Pipes and Fittings for Pressure Applications—Classification and Designation—Overall Service (Design) Coefficient

3. Terminology

3.1 *Definitions*—Terms as described in Terminology D 883 shall apply in this specification.

3.1.1 *polyethylene plastics*—as defined by this specification, plastics or resins prepared by the polymerization of no less than 85 % ethylene and no less than 95 % of total olefins with additional compounding ingredients.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *materials*—polyethylene (PE) resins with the added compounding ingredients.

3.2.2 *PE compounds*—has the same meaning as PE plastics materials, compounds, and plastics.

3.3 Historical usage and user group conventions have resulted in inconsistent terminology used to categorize and describe polyethylene resins and compounds. The following terminology is in use in ASTM specifications pertaining to polyethylene:

3.3.1 *Specification D 1248*:

3.3.1.1 Type (0, I, II, III, IV) = density ranges (same, respectively, as Class in Specification D 4976).

3.3.1.2 Class (A, B, C, D) = composition and use.

3.3.1.3 Category (1, 2, 3, 4, 5) = melt index ranges (same as Grade in Specification D 4976).

3.3.1.4 Grade (E, J, D, or W followed by one or two digits) = specific requirements from tables.

3.3.2 *Specification D 3350*:

3.3.2.1 Type (I, II, III) = density ranges (same as Types I, II, and III in Specification D 1248 and Classes 1, 2, and 3 in Specification D 4976).

3.3.2.2 Class = a line callout system consisting of "PE" followed by six cell numbers from Table 1 plus a letter (A, B, C, D, E) denoting color and UV stabilizer.

3.3.2.3 Grade = simplified line callout system using "PE" followed by density and slow crack growth cell numbers from Table 1.

3.3.3 *Specification D 4976*:

3.3.3.1 Group (1, 2) = branched or linear polyethylene.

3.3.3.2 Class (0, 1, 2, 3, 4) = density ranges (same, respectively, as Type in Specification D 1248).

3.3.3.3 Grade (1, 2, 3, 4, 5) = melt index ranges (same as Category in Specification D 1248).

4. Classification

4.1 Polyethylene plastic pipe and fittings compounds are classified in accordance with density, melt index, flexural modulus, tensile strength at yield, slow crack growth resistance, and hydrostatic strength classification in Table 1.

NOTE 4—It has been a long-standing practice to use the following terms in describing polyethylene plastics:

TABLE 1 Primary Properties—Cell Classification Limits

Property	Test Method	0	1	2	3	4	5	6	7	8
1. Density, g/cm^3	D 1505	Unspecified	0.925 or lower	>0.925-0.940	>0.940-0.947	>0.947-0.955	>0.955	. . .	Specify Value	
2. Melt index	D 1238	Unspecified	>1.0	1.0 to 0.4	<0.4 to 0.15	<0.15	^{A}		Specify Value	
3. Flexural modulus, MPa [psi]	D 790	Unspecified	<138 [<20 000]	138-<276 [20 000 to <40 000]	276-<552 [40 000 to 80 000]	552-<758 [80 000 to 110 000]	758-<1103 [110 000 to <160 000]	>1103 [>160 000]	Specify Value	
4. Tensile strength at yield, MPa [psi]	D 638	Unspecified	<15 [<2200]	15-<18 [2200-<2600]	18-<21 [2600-<3000]	21-<24 [3000-<3500]	24-<28 [3500-<4000]	>28 [>4000]	Specify Value	
5. Slow Crack Growth Resistance										
I. ESCR	D 1693	Unspecified								
a. Test condition (100% Igepal.)			A	B	C	C	. . .	. . .	. . .	Specify Value
b. Test duration, h			48	24	192	600				
c. Failure, max, %		Unspecified	50	50	20	20				
II. PENT (hours)	F 1473									
Molded plaque, 80°C, 2.4 MPa		Unspecified	. . .	. . .	. . .	10	30	100	500	Specify Value
Notch depth, F 1473, Table 1		Unspecified								
6. Hydrostatic Strength Classification										
I. Hydrostatic design basis, MPa [psi], (23°C)	D 2837	NPR^B	5.52 [800]	6.89 [1000]	8.62 [1250]	11.03 [1600]	. . .	. . .		
II. Minimum required strength, MPa [psi], (20°C)	ISO 12162	. . .	. . .	. . .	. . .	. . .	8 [1160]	10 [1450]		

^{A} Refer to 10.1.4.1.

^{B} NPR = Not Pressure Rated.

Type I (0.910 to 0.925) = Low Density
Type II (0.926 to 0.940) = Medium Density
Type III (0.941 to 0.965) = High Density

NOTE 5—The manner in which materials are identified in the cell classification is illustrated for Class PE233424B as follows (refer also to Table 1 and 6.2):

Class	2	3	3	4	2	4	B
Density (0.926–0.940 g/cm^3)	2						
Melt index (<0.4–0.15)		3					
Flexural modulus (276–<758 MPa (40 000–<110 000 psi))			3				
Tensile strength at yield (21–<24 MPa (3000–<3500 psi))				4			
Slow Crack Growth Resistance I. ESCR D 1693 Condition B, 24 h, 50 % max failure II. PENT F 1473 Average 1 h failure					2		
Hydrostatic design basis at 23°C (11.03 MPa (1600 psi))						4	
Color and UV stabilizer (colored)							B

4.2 Materials used in polyethylene plastic pipe and fittings shall use a cell-type format for the identification, close characterization, and specification of material properties. The information from the format is to be used alone or in combination.

NOTE 6—This type format, however, is subject to possible misapplication since unobtainable property combinations can be selected if the user is not familiar with commercially available materials. The manufacturer should be consulted. Additionally, the appropriate ASTM standard specification should be reviewed to assure materials utilized will meet all the material and piping requirements as specified in the standard.

4.3 *Grade*—A code for polyethylene pipe and fittings materials that consists of the two letter abbreviation for polyethylene (PE) followed by two numbers that designate the density cell (Property 1) and the slow crack growth resistance cell (Property 5), as defined by either Test Method F 1473 or Test Method D 1693, of the thermoplastic, as specified in Table 1. For the requirements of Property 5 (slow crack growth resistance), consult the materials section of the appropriate ASTM standard specification for the end-use application.

NOTE 7—Grade designations were adapted from Specification D 1248 - 84 prior to the removal of pipe material from D 1248 - 84. Former Specification D 1248 - 84 grades for PE pipe materials were P14, P23, P24, P33, and P34. Equivalent Specification D 3350 grade designations for these materials are PE11, PE20, PE23, PE30, and PE33, respectively.

5. Materials and Manufacture

5.1 The molding and extrusion material shall be polyethylene plastic in the form of powder, granules, or pellets.

5.2 The molding and extrusion materials shall be as uniform in composition and size and as free of contamination as is achieved by good manufacturing practice. If necessary, the level of contamination may be agreed upon between the manufacturer and the purchaser.

5.3 When specified, the color and translucence of molded or extruded pieces formed, under the conditions specified by the manufacturer of the materials, shall be comparable within commercial match tolerances to the color and translucence of standard samples supplied in advance by the manufacturer of the material.

6. Physical Properties

6.1 *Cell Classification*—Test values for specimens of the PE material prepared as specified in Section 9 and tested in accordance with Section 10 shall conform to the requirements given in Table 1. A typical property value for a PE material is to be the average value from testing numerous lots or batches and determines the cell number. When, due to manufacturing tolerances and testing bias, individual lot or batch values fall into the adjoining cell, the individual value shall not be considered acceptable unless the user, or both the user and the producer, determine that the individual lot or batch is suitable for its intended purpose.

6.2 *Color and Ultraviolet (UV) Stabilizer*—The color and UV stabilization shall be indicated at the end of the cell classification by means of a letter designation in accordance with the following code:

Code Letter	Color and UV Stabilizer
A	Natural
B	Colored
C	Black with 2 % minimum carbon black
D	Natural with UV stabilizer
E	Colored with UV stabilizer

6.3 *Thermal Stability*—The PE material shall contain sufficient antioxidant so that the minimum induction temperature shall be 220°C when tested in accordance with 10.1.9.

6.4 *Brittleness Temperature*—The brittleness temperature shall not be warmer than −60°C when tested in accordance with Test Method D 746.

6.5 *Density*—The density used to classify the material shall be the density of the PE base resin (uncolored PE) determined in accordance with 10.1.3. When the average density of any lot or shipment falls within ±0.002 g/cm^3 of the nominal value, it shall be considered as conforming to the nominal value and to all classifications based on the nominal value.

6.5.1 For black compounds, containing carbon black, determine the density, Dp, and calculate the resin density, Dr, as follows:

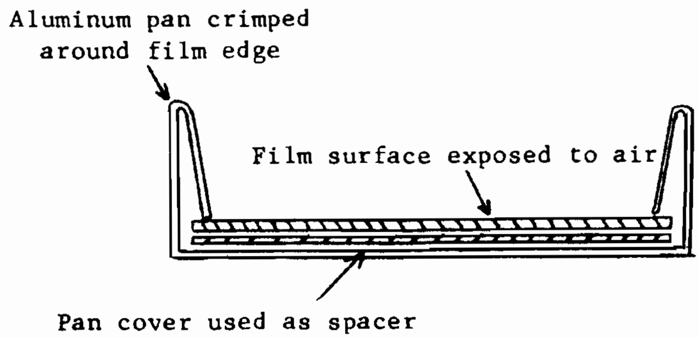
$$Dr = Dp - 0.0044C$$

where:
C = weight percent of carbon black.

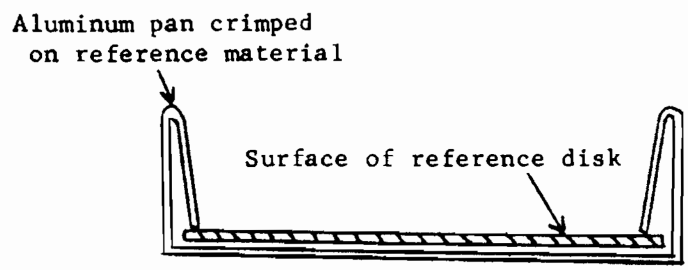
6.5.2 For colored compounds, the nominal density of the base resin shall be provided by the manufacturer, on request.

6.6 *Tensile Strength at Yield*—The tensile strength at yield used to classify the material shall be the tensile strength at yield of the PE resin determined in accordance with 10.1.6. When the average tensile strength at yield of any lot or shipment falls within ±3.45 MPa [±500 psi] of the nominal value, it shall be considered as conforming to the nominal value and to all classifications based on the nominal value.

6.7 *Elongation at Break*—As tested in accordance with 10.1.6, all pressure rated materials shall have a minimum extension at break of 500 % as determined by grip separation.



(*a*) Specimen in pan.



(*b*) *Reference*—Temperature standard shall be placed under reference disk in reference pan or alternatively under pan cover (spacer).

FIG. 1 Mounting Film Specimen in Cup

7. Sampling

7.1 A batch or lot shall be considered as a unit of manufacture and shall consist of one production run or as a blend of two or more production runs of material.

7.2 Unless otherwise agreed upon between the manufacturer and the purchaser, the material shall be sampled in accordance with the procedure described in Sections 9 through 12 of Practice D 1898. Adequate statistical sampling prior to packaging shall be considered an acceptable alternative.

NOTE 8—A sample taken from finished product may not necessarily represent the original batch or lot.

8. Number of Tests

8.1 The requirements identified by the material designation and otherwise specified in the purchase order shall be verified by tests made in accordance with 11.1. For routine inspection, only those tests necessary to identify the material to the satisfaction of the purchaser shall be required. One sample shall be sufficient for testing each batch or lot provided that the average values for all of the tests made on that batch or lot comply with the specified requirements.

9. Specimen Preparation

9.1 Unless otherwise specified in Section 10, the test specimens shall be molded in accordance with Procedure C of Annex A1 of Practice D 4703.

9.2 When pipe or fitting test specimens are required, they shall be extruded or molded in accordance with the specifications of the material manufacturer.

10. Test Methods

10.1 The properties enumerated in this specification shall be determined in accordance with the following test methods:

10.1.1 *Conditioning*—Unless otherwise specified in the test methods or in this specification, for those tests where conditioning is required, condition the molded test specimens in accordance with Procedure A of Practice D 618.

10.1.2 *Test Conditions*—Unless otherwise specified in the test methods or in this specification, conduct tests at the standard laboratory temperature of 23 ± 2°C [73.4 ± 3.6°F].

10.1.3 *Density*—Test Method D 1505 or alternative methods referenced in 2.1 (see D 792, D 2839, and D 4883) providing equivalent accuracy. Make duplicate determinations using two separate portions of the same molding or from two moldings. The molded specimen thickness portions shall be 1.9 ± 0.2 mm [0.075 ± 0.008 in.]. Calculate the average value.

10.1.4 *Melt Index*—Test Method D 1238, using Condition 190/2.16. Make duplicate determinations on the material in the form of powder, granules, or pellets, and calculate the average; no conditioning is required.

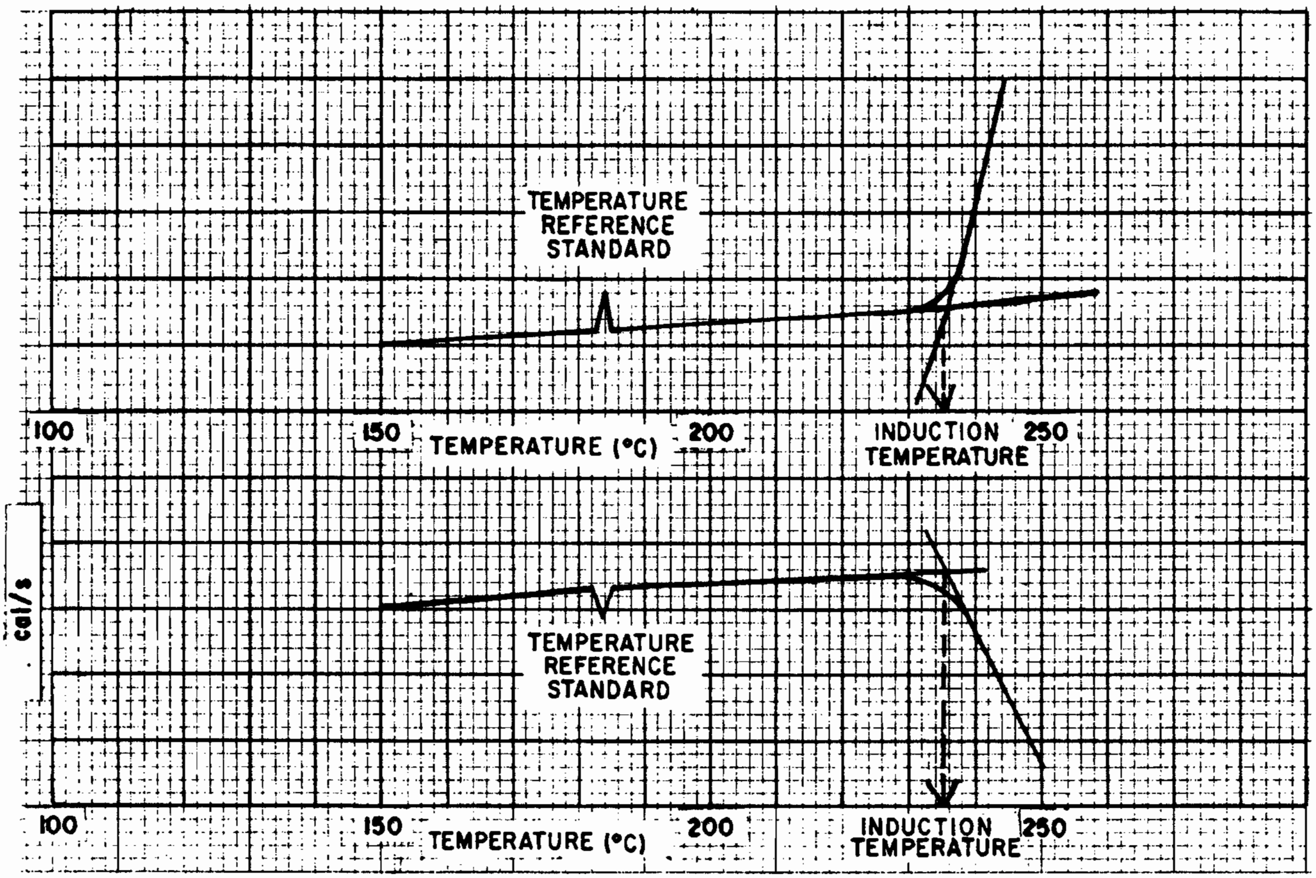


FIG. 2 Typical DSC Plots

10.1.4.1 Classify materials having a melt index less than 0.15 (Cell 4) as Cell 5 only if they have a flow rate not greater than 4.0 g/10 min when tested in accordance with Test Method D 1238, Condition 190/21.6.

NOTE 9—Flow rate is the general term used for all results obtained with Test Method D 1238. Although the flow rate of polyethylene plastics may be measured under any of the conditions listed for it under 7.2 of Test Method D 1238, only measurements made at Condition 190/2.16 may be identified as "Melt Index."

10.1.5 *Flexural Modulus*—Test Methods D 790, using Method 1, Procedure B, and a 50-mm [2-in.] test span. Test five specimens, each 3.2 by 12.7 mm [⅛ by ½ in.] flatwise at a crosshead speed of 12.7 mm/min [0.5 in./min] and the average value of the secant modulus calculated at 2 % strain in the outer fibers.

10.1.5.1 The deflection of the test specimen corresponding to 2 % strain (0.02 mm/mm or in./in.) is calculated as follows:

$$D = rL^2/6d$$

where:
D = deflection of the center of the beam test specimen at 2 % strain, in.,
r = strain in the outer fibers = 0.02 mm/mm [0.02 in./in.],
L = test span = 50 mm [2 in.], and
d = specimen depth = 3.2 mm [⅛ in.].

10.1.5.2 The stress corresponding to 2 % strain is calculated as follows:

$$S = 3\ PL/2\ bd^2$$

where:
S = stress in the outer fiber at 2 % strain,
P = load corresponding to 2 % strain, N [lbf],
L = test span = 50 mm [2 in.],
d = specimen depth = 3.2 mm [⅛ in.], and
b = specimen width = 12.7 mm [½ in.].

The secant modulus at 2 % strain is the ratio of stress to strain or $S/0.02$.

10.1.6 *Tensile Strength at Yield*—The tensile strength at yield shall be determined in accordance with Test Method D 638 except that rate of grip separation shall be 500 mm/min [20 in./min for materials in the density range from 0.910 to 0.925 g/cm^3] and 50 mm/min [2 in./min for all others]. Specimens shall conform to the dimensions given for Type IV in Test Method D 638 with a thickness of 1.9 ± 0.2 mm [0.075 ± 0.008 in.]. Specimen shall be either die cut or machined.

10.1.7 *Slow Crack Growth Resistance*—One method shall be used to classify this material property.

10.1.7.1 *Slow Crack Growth Resistance*—The material's resistance shall meet the minimum requirement shown for the appropriate cell classification when tested in accordance with Test Method D 1693.

10.1.7.2 *Slow Crack Growth Resistance*—The average failure time from two test specimens shall meet the minimum requirement shown for the appropriate cell classification when tested in accordance with Test Method F 1473. Test at least four specimens in case of a dispute.

10.1.8 *Hydrostatic Strength Classification*—One method shall be used to classify this material property.

10.1.8.1 *Hydrostatic Design Basis*—Determine the hydrostatic design basis in accordance with Test Method D 2837, on pipe extruded from three different lots of material. Subject specimens from one lot for at least 10 000 h. Terminate the tests on the two additional lots after 2000 h. The results from each of the three lots shall be within the same or next higher cell limits.

NOTE 10—For pressure application at elevated temperatures, the hydrostatic design basis should be determined at that temperature in accordance with Test Method D 2837. The 100 000-h intercept should be categorized in accordance with Table 1 of Test Method D 2837.

10.1.8.2 *Minimum Required Strength*—Determine the minimum required strength in accordance with ISO 12162.

10.1.9 *Thermal Stability*—Test specimens taken from pipe or fittings made from the virgin material with a differential scanning calorimeter (DSC).[4] The directions of the instrument manufacturer regarding calibration and operation shall be followed except when in conflict with other parts of this section.

NOTE 11—This test requires accurate temperature and atmosphere control on the DSC specimen compartment. The DSC manufacturers offer choices in cell configuration and temperature control parameters that may affect this required control. For example, in some power compensation DSCs, use of the two-hole platinum specimen holder lids with a special "flow-through" swing-away block cover is required. Therefore, the user may wish to consult equipment-specific literature and with the equipment manufacturer to optimize the operation of individual DSCs for this test.

10.1.9.1 *Specimens*—Press small pieces of the pipe into films 0.127 ± 0.013 mm [0.0050 ± 0.0005 in.] thick. Cut at least three disks 6.35 ± 0.13 mm [0.250 ± 0.005 in.] in diameter from the film.

10.1.9.2 *Procedure*—Place the disk of film in a small aluminum cup used in the DSC in a stretched condition, as shown in Fig. 1(*a*). Place a small piece of indium (melting point 156.6°C) or anisic acid (melting point 183.0°C) for a temperature reference standard contained in a similar cup (see Fig. 1(*b*)) in the reference position. Use an oxidized copper reference disk for black, filled, or dark brown test specimens and an aluminum disk for natural or light pigmented polymers. Place the specimen and reference standard cups in the instrument which is preset at approximately 150°C. The bottoms of the cups shall be pressed and rubbed securely against the flat surface so as to ensure that thermal contact is made. Allow 5 min for the cups to reach thermal equilibrium. Begin the programmed heating at approximately 150°C at a heating rate of 10.0°C/min in static air. Test at least three film specimens from each sample and use the average value for the induction temperature.

NOTE 12—Since the indium standard may change with use, it should not be used more than 30 times without confirming that no significant change in melting point has occurred. This check can be made by comparison with a fresh piece of indium.

10.1.9.3 *Results*—The temperature change (ΔT) or heat absorption rate (J/s) in the specimen plotted against temperature shall produce a line with a clear rise in slope. The induction temperature (degradation onset) is the intersection of the extended base line and a line tangent to the leading slope of the exothermic decomposition peak (see Fig. 2).

10.1.10 *Carbon Black Content*—Test Method D 1603 or Test Method D 4218 shall be used. Make duplicate determinations from a sample of the material in the form of powder, granules, or pellets.

11. Inspection

11.1 Inspection of the material shall be made as agreed upon between the purchaser and the manufacturer as part of the purchase contract.

12. Retest and Rejection

12.1 If any failure occurs, and when specified by the manufacturer, the material shall be retested to establish conformity in accordance with the agreement between the purchaser and the manufacturer.

13. Packaging and Marking

13.1 *Packaging*—The material shall be packaged in standard commercial containers, so constructed as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery, unless otherwise specified in the contract or order.

13.2 *Marking*—Unless otherwise agreed upon between the seller and the purchaser, shipping containers shall be marked with the name of the material, identification in accordance with this specification, the lot or batch number and quantity contained therein, as defined by the contract or order under which shipment is made, and the name of the manufacturer.

13.3 All packing, packaging, and marking provisions of Practice D 3892 shall apply to this specification.

[4] Instruments are available from TA Instruments, Perkin-Elmer, and others.

14. Keywords

14.1 cell classification system; pipe and fittings material; polyethylene; recycled

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue, D 3350 - 05, that may impact the use of this standard. (November 15, 2006)

(*1*) Added D 2839, D 4218, and D 4883 to 2.1.

(*2*) Revised 10.1.3 and 10.1.10.

Committee D20 has identified the location of selected changes to this standard since the last issue, D 3350 - 04, that may impact the use of this standard. (September 15, 2005)

(*1*) Modified PENT cell classes in Table 1.

(*2*) Removed sentence from 4.3. Thermoplastic material designation codes such as PE 2406 or PE 3408 are more commonly used in pipe application standards than grade designations. As represented in Specification D 3350-04, a PE 2406 or PE 3408 material may have a slow crack growth cell of 4 or 6. Modification of the PENT cells will result in a thermoplastic material designation code upgrade as represented by the slow crack growth properties of the material. For example, a traditional PE 3408 material with >100 hours PENT will be designated as PE 3608 and a traditional PE 3408 material with >500 hours PENT will be designated as PE 3708.

Performance Pipe

PE Pipe Data Sheet

For more information and technical assistance contact:

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Plano, TX 75026-9006
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Yellowstripe® 8300
PE4710-PE100 / (PE3408)
Pipe Data Sheet

Typical Material Physical Properties of Yellowstripe® 8300 PE4710-PE100 / (3408)

High Density Polyethylene Materials

Property	Unit	Test Procedure	Typical Value
Material Designation	---	PPI TR-4	PE4710[1] PE100
Cell Classification	---	ASTM D3350	445574C 445576C
Pipe Properties			
Density	gms / cm^3	ASTM D1505	0.961 (black)
Melt Index (HLMI) Condition 190 / 21.6	gms / 10 minutes	ASTM D1238	7.5
Hydrostatic Design Basis 73°F (23°C)	psi	ASTM D2837	1600
Hydrostatic Design Basis 140°F (60°C)	psi	ASTM D2837	1000
Minimum Required Strength (MRS) @ 20°C (68°F)	Mpa (psi)	ISO 9080	>10 (>1450)
Rapid Crack Propagation Critical Pressure (Pc), 0°C (32°F)[2]	Bar (psi)	ISO 13477	>12bar (>174 psi)
Pipe Test Category	---	ASTM D2513	CEC
Material Properties			
Flexural Modulus @ 2% strain	psi	ASTM D790	>150,000
Tensile Strength at Yield	psi	ASTM D638 (Type IV)	>3500
Elongation at Break 2 in / min., Type IV bar	%	ASTM D638	>800
Hardness	Shore D	ASTM D2240	65
PENT	hrs	ASTM F1473	>1000
Thermal Properties			
Vicat Softening Temperature	°F	ASTM D1525	255
Brittleness Temperature	°F	ASTM D746	-180
Thermal Expansion	in / in / °F	ASTM D696	1.0×10^{-4}

Another quality product from Chevron Phillips Chemical Company LP, The Woodlands, Texas

For more information and technical
assistance contact:

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800.527.0662

1. Meets new requirements for PE 4710 materials and use of increased design factors. 49CFR Part 192 references older versions of the PPI document that do not yet recognize the new requirments and carry the PE3408 designation.
2. Determination made using Small-Scale Steady state. Pc calculated in accordance with ISO 13477.

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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 product can vary from these typical values. Performance Pipe has made every reasonable effort to ensure the accuracy of this data sheet, but this data sheet may not provide all necessary information, particularly with respect to special or unusual applications. The data sheet may be changed from time to time without notice. Contact Performance Pipe to determine if you have the most recent edition.

PHMSA
Office of Pipeline Safety
Web Page
Guidance Manual for Operators of Small Natural Gas Systems

MATERIALS AND EQUIPMENT QUALIFIED FOR USE IN NATURAL GAS SYSTEMS

The pipeline safety regulations list many different materials that are qualified for gas service. The materials and specifications listed in this manual are those most commonly used in natural gas distribution systems. Not all qualified materials or specifications are included in this section. The operator of a small natural gas system is referred to 49 CFR Part 192 for further information.

It is important for an operator to know the material make-up and operating pressure of an existing gas pipeline system. The operator must develop, or have a consultant develop, a list of qualified materials for construction and repair of the system. Installation procedures must be included for each type of material used in the system. This can be accomplished by including or referencing manufacturers' "gas product installation manuals" in the operations and maintenance plan.

When purchasing material for use in a natural gas pipeline system, it is important to check the marking of the material. The marking on the material will help identify whether the material is qualified for gas service. Of course, a natural gas pipeline system consists of both pipe and fittings. Therefore, an operator must select materials that are compatible with each other. This chapter will cover the most common specifications and standards used by manufacturers for pipes, valves, flanges, regulators, and other equipment commonly used in natural gas distribution systems.

PIPE

Steel and plastic pipe specifications applicable to operators of small natural gas systems are included in this manual. Pipe specifications are listed below. Be sure to check Appendix A of 49 CFR Part 192 for the current specifications and standards.

API 5L - Steel pipe

ASTM A53 - Steel pipe

ASTM D2513 - Thermoplastic pipe and tubing

Operators are cautioned that the actual maximum allowable operating pressure (MAOP) of a new or replacement pipe in a natural gas system is determined by a pressure test performed on the pipeline system by the operator before it is put in service. It is also recommended that threaded pipe not be installed underground.

When purchasing PE plastic pipe, the pipe must be marked ASTM D2513. Plastic pipe with this marking is the only PE pipe suitable for gas service.

Plastic pipe and tubing should be protected at all times from damage by crushing, piercing, or extended exposure to direct sunlight. As a rule of thumb, never store plastic pipe outdoors for more than six months. It should be placed inside or covered to protect it from exposure to direct sunlight. It is a good idea to obtain the manufacturer's recommendation on how long the pipe can be exposed to sunlight before it loses physical strength (see 49 CFR §192.321 for more information).

In recent years, the vast majority of natural gas companies and operators of natural gas system have been installing ASTM D2513, PE pipe. Some of the reasons PE pipe is being installed are flexibility, good joining characteristics, durability, ease of installation, and cost. The PE type designations most often used are PE 2406, and PE 3408 (see FIGURE VI-14).

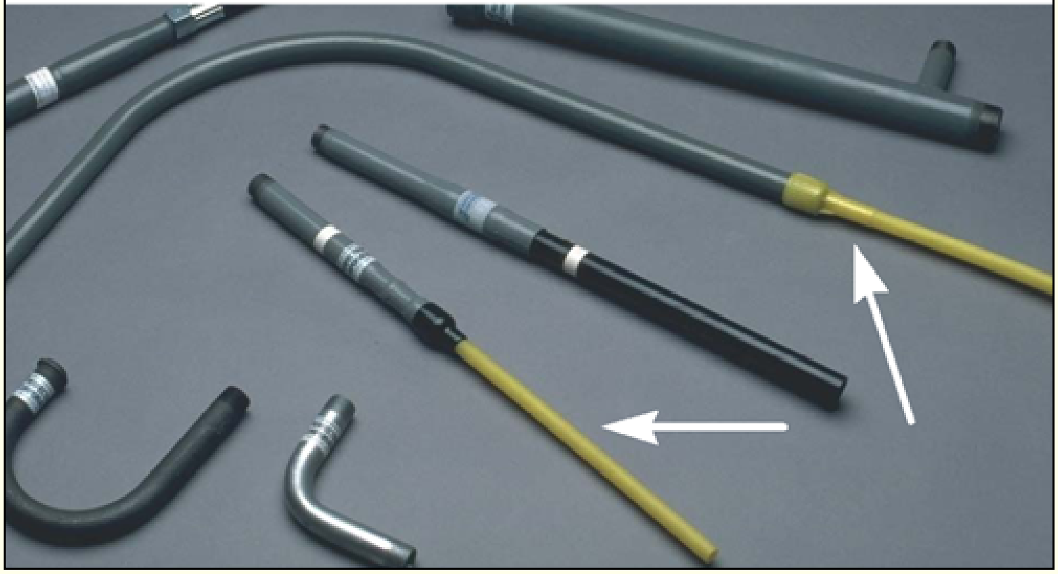
FIGURE VI-14

Below is a picture of 4-inch SDR 11 PE pipe manufactured according to ASTM D2513. When using plastic pipe in the underground piping system, make sure it has ASTM D2513 stamped on it.

An anodeless riser is a transition fitting that permits plastic service lines to be brought above ground in compliance with 49 CFR §192.375. The regulations require plastic services to be installed below ground level, except that it may terminate above ground, outside of buildings, if the plastic pipe is protected from deterioration and damage and it is not used to support external loads. Anodeless risers are readily available from various manufacturers and suppliers and are either fully fabricated from the manufacturer, or are field-fabricated by the installer, as is the case with service head adapter risers. Typically, the external protective casing is pre-bent, epoxy coated or galvanized, schedule 40 steel pipe. The plastic gas piping (inside the casing) must extend to an aboveground point for the riser to qualify as anodeless. Otherwise, the riser casing becomes a buried steel pipe gas carrier and is required to comply with Subpart I of 49 CFR Part 192. In most cases there is a grade level or “do not bury” label to indicate the bury depth to the installer. The outlet typically is provided with tapered pipe threads, or in the case of commercial or industrial risers, a bolted flange for attachment to the meter valve. The PE piping inlet, designated as the “pigtail,” is provided ready for connection to the service line. This service connection is accomplished either by heat fusion or, if so specified, with a mechanical coupling already attached to the pigtail for additional installation convenience.

FIGURE VI-15

Examples of anodeless service risers. There are many different manufacturers of anodeless risers. The primary advantage of an anodeless riser is that it does not have to be cathodically protected because the outside steel casing is not the gas carrier. The plastic inside the steel casing is the gas carrier. When purchasing anodeless risers, make sure that they meet all DOT requirements. When installing steel risers connected to plastic pipe by a transition fitting, make sure that the steel riser is coated and cathodically protected.



Most PE pipe manufacturers subscribe to the "Standard Dimension Ratio" (SDR) method of rating pressure piping. The SDR is the ratio of pipe diameter to wall thickness. An SDR 11 means the outside diameter (O.D.) of the pipe is eleven times the thickness of the wall.

For high SDR ratios the pipe wall is thin in comparison to the pipe O.D. For low SDR ratios the wall is thick in comparison to the pipe O.D. Given two pipes of the same O.D., the pipe with the thicker wall will be stronger than the one with the thinner wall. High SDR pipe has a low-pressure rating; low SDR pipe has a high-pressure rating. The operator should check the manufacturer's specific pressure rating for each specific pipe. Do not use pipe with SDR values greater than 11.

PE pipe must be joined by either the heat fusion method (butt, socket, or electrofusion) or by a mechanical coupling. Each joining procedure and each person making joints must be qualified.

For information about local suppliers of plastic gas pipe, contact the local gas utility.

VALVES

A valve may not be used under operating conditions that exceed the applicable pressure-temperature rating. The valve will be stamped with the maximum working pressure rating (psig). Never operate valves at pressures that exceed their rating. The maximum working ratings are applicable at temperatures from -20°F to 100°F. Metal valves will often be stamped with the symbols "WOG." This means that they are suitable for service for water, oil, or gas. Sometimes just the letter "G" (for gas) appears. The valves must be rated for at least 100 psig.

The manufacturer's name or trademark must be included on a valve. Operators must maintain manufacturers' manuals, which include installation, operation, and maintenance procedures, for each type valve in the gas system. These manuals and procedures should be incorporated or referenced in the operations and maintenance plan.

Plastic valves purchased for gas service must comply with the appropriate industry standard. The valves must be compatible with the plastic pipe used in the natural gas system. It is important that operators buy plastic valves only from suppliers who are knowledgeable about gas piping. Supplier information can be obtained from trade journals, local gas associations (state or regional), or local gas utilities (see enclosed handout).

FLANGES AND FLANGE ACCESSORIES

Each flange or flange accessory must meet the minimum requirements found in 49 CFR §192.147. Operators must verify that metal flanges purchased for their system meet these requirements. This can be done by checking the markings on the flange. The markings are similar to those on the valves.

REGULATORS AND OVERPRESSURE PROTECTION EQUIPMENT

There are many different manufacturers and models of gas regulators and overpressure equipment (relief valves) for use in gas pipeline systems.

Regulators and overpressure protection equipment must be sized to ensure that overpressure or low-pressure conditions do not occur in the gas system. Manufacturers of gas regulators and relief valves have manuals that contain formulas and charts for each of their models or types of equipment. These formulas and charts are necessary to properly size regulators and relief valves. A qualified person must install the equipment. Operators who do not have a technical background should rely on a consultant or the equipment manufacturer representative to size the equipment. Check with the state for additional local requirements. See the enclosed handout for further information.

It is important to obtain the manufacturer's operation and maintenance instructions for each type of regulator and relief valve used in the gas pipeline system. The instructions must be incorporated into the operations and maintenance plan. CHAPTER II is a primer on basic concepts on pressure regulation, regulators, and relief devices.

OTHER EQUIPMENT

A natural gas operator may need additional equipment to operate a natural gas system. This additional equipment may include:

- pipe-to-soil meters;
- pipe locators;
- gas leak detection equipment;
- industry publications.

An illustration of a pipe-to-soil meter is in CHAPTER III. Additional information on gas leak detection equipment and pipe locators is found in CHAPTER IV. The local gas utility or gas association is a good source of assistance.

WELDING REQUIREMENTS

How can an operator determine whether pipeline welding is performed as required?

1. Welding must be performed in accordance with written welding procedures qualified to produce acceptable welds. For typical pipeline welding, standard API 1104 is most often relied on. The welding procedures should include:
    1. Records of the complete results of the procedural qualification test
        1. Procedural specification
            1. Identifying the process
            2. Identifying the materials
            3. Identifying the wall thickness groups
            4. Identifying the pipe diameter groups
            5. Showing a joint design sketch
            6. Designating filler metal and number of beads
            7. Designating electrical characteristics
            8. Designating flame characteristics
            9. Designating positions or roll welding
            10. Designating direction of welding
            11. Designating maximum time lapse between passes
            12. Designating type of line-up clamp and removal criteria
            13. Designating type of cleaning tool used
            14. Specifying preheat and post heat practices
            15. Designating composition of gas and range of flow rate
            16. Designating type and size of shielding flux
            17. Designating range of speed of travel for each pass
    2. Essential variables Most changes in b. require requalification of the welding procedure. (Refer to API 1104, paragraph 2.4.)
        1. Welding and testing of test joint
            1. Preparation of specimen
                1. Destructive tests - butt welds
                    1. Tensile strength test
                    2. Nick break test
                    3. Root and face bend test
                    4. Side bend test
            2. Destructive test - fillet welds: Break in weld as specified
1. Welders who are qualified for the welding procedure to be used must perform welding.
        1. The welder shall be qualified under one of the applicable requirements specified.
                1. Transmission pipelines
                    1. API 1104, Section 3; or
                    2. ASME Boiler and Pressure Vessel Code, Section IX
                1. Distribution pipeline
                    1. API 1104, Section 3;
                    2. ASME Boiler and Pressure Vessel Code, Section IX; or
                    3. 49 CFR Part 192, Appendix C, Section I (not acceptable for service line to main connection welding).
                1. Service line to main connections
                    1. API 1104, Section 3;
                    2. ASME Boiler and Pressure Vessel Code, Section IX; or
                    3. 49 CFR Part 192, Appendix C, Sections I and II.
        1. Welder qualification under API 1104, Section 3.
            1. Perform qualification test as specified in the written welding procedure in the presence of the company's representative.
                1. Essential variables (certain changes require re-qualification).

1. For single qualification refer to API 1104, paragraph 3.11; or
2. For multiple qualification refer to API 1104, paragraph 3.21.

1. Welding and testing of test joint
    1. Preparation of specimen(s)
    2. Visual examination
    3. Destructive test - butt welds Determine if all or part of these tests is required: 1 Tensile strength test *(optional)* 2 Nick break test 3 Root and face bend test 4 Side bend test
    4. Destructive tests - fillet welds: Break in weld as specified.
    5. Visual inspection

NOTE: Nondestructive radiographic inspection of butt welds only can be done in lieu of (3)(c) above. This is the operator's option. The standards of acceptability for radiographic inspection are specified in API 1104, paragraph 6.0.

(4) Keep the following records:

(a)
Detailed test results for each welder.

(b)
List of qualified welders and the procedures(s) for which they are qualified.

c.
Welder qualification under 49 CFR Part 192, Appendix C, Section I

(1)
Perform qualification test on pipe 12 inches or less in diameter

(2)
Use position welding

(3)
Preparation must conform to written welding procedure

(4)
Destructive test. - root bend test

(5)
Visually inspect

(6)
Keep the following records:

(a)
Detailed test results for each welder

(b)
List of qualified welders under this procedure

d.
Welder qualification under of 49 CFR Part 192, Appendix C, Sections I and II

(1)

Perform c. above

(2)

Weld service line connection fitting to a pipe typical of the main using similar position as one would in actual production welding

(3)

Destructive test - break, or attempt to break, the fitting off the run pipe

(4)

Keep the following records:

(a)

Detailed test results for each welder

(b)

List of qualified welders under this procedure

e.

Remain qualified under API 1104, Section 3 or ASME Boiler and Pressure Vessel Code, Section IX, if:

(1) Within the preceding six months, welder has welded with the particular welding process (either test or production welding is acceptable), and welder has made a weld and had it tested satisfactorily either destructively or nondestructively. (Refer to 2b(3) for required procedure.)

f.

Remain qualified under either 49 CFR Part 192, Appendix C, Section I or II, if:

(1) Within the preceding 7½ months but at least twice each year, welder has had one production weld cut out, tested, and found acceptable in accordance with the initial qualification test; or,

NOTE: Welders who work only on service lines 2 inches or smaller in diameter may be tested in each 6-month period under 49 CFR Part 192, Section III, Appendix C in lieu of f(1) above, but at the same intervals.

(2) Within the preceding 15 months, but at least once each year, welder has requalified under 49 CFR Part 192 Appendix C

3. Production welding

a.

Use a welder qualified in a qualified welding procedure.

b.

The following items should be part of the written welding procedure:

(1)

Weather protection - 49 CFR §192.231

(2)

Preparation - 49 CFR §192.235

(3)

Visual Inspection - 49 CFR §192.241

(4)
Nondestructive Testing (under specified conditions) - 49 CFR §192.243. Must meet standards of acceptability in API 1104, Section 6.

c.
Miter joint restrictions The use of miter joints is restricted as follows:

(1)
If MAOP produces a hoop stress of 30 percent or more SMYS, the joint cannot deflect the pipe more than 3 degrees.

(2)
If MAOP produces a hoop stress of more than 10 percent SMYS but less than 30 percent, the joint cannot deflect the pipe more than 12.5 degrees and must have at least one pipe diameter separation from another miter joint.

(3)
If MAOP produces a hoop stress of 10 percent of SMYS or less, the joint cannot deflect the pipe more than 90 degrees.

d.
Repair or removal of defect requirements is as follows:

(1)
Remove or repair all welds that fail to pass the nondestructive test requirements (standards of acceptability in API 1104, Section 6).

(2)
Remove all welds that contain cracks that are more than 8 percent of the weld length.

(3)
Repairs must have the defect removed down to clean metal and the segment to be repaired must be preheated if conditions exist which would adversely affect the quality of the weld repair. Inspect the repaired weld.

(4)
Repair of a crack, or any defect in a previously repaired area, must be in accordance with written weld repair procedures that have been qualified under this guidance manual.