Specification for Polyethylene Line Pipe (PE)

API SPECIFICATION 15LE
FOURTH EDITION, JANUARY 2008

EFFECTIVE DATE: JULY 2008

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Upstream Segment

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This standard shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution.

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Specification for Polyethylene Line Pipe (PE)

1 Scope

1.1 Purpose

The purpose of this specification is to provide standards for polyethylene (PE) line pipe suitable for use in conveying oil, gas and non-potable water in underground, above ground and reliner applications for the oil and gas producing industries.

The standard does not propose to address all of the safety concerns associated with the design, installation or use of products suggested herein. It is the responsibility of the user of the standard to utilize appropriate health and safety considerations.

All pipe produced under this standard must utilize pressure rated materials, but may be used in pressurized, non-pressure and negative pressure applications.

The technical content of this document provides requirements and guidelines for performance, design, materials inspection, dimensions and tolerances, marking, handling, storing and shipping.

1.2 Applications

1.2.1 Equipment

This specification covers polyethylene line pipe utilized for the production and transportation of oil, gas and non-potable water. The piping is intended for use in new construction, insertion renewal, line extension and repair, of both above ground and buried pipe applications. Specific equipment covered by this specification is listed as follows:

1) polyethylene line pipe;

2) polyethylene fittings.

1.2.2 Service Conditions

The standard service conditions for the API Spec15LE Standard Pressure Rating are as follows:

1) HDB is established to 50 years;

2) service temperature is between –30 °F and 140 °F;

3) the fluid environment is oil, gas and non-potable water;

4) axial loads shall include end loads due to pressure only.

Service conditions other than the standard API Spec 15LE conditions are discussed in Section 5—Design.

1.3 Unit Conversion

A decimal/inch system is the standard for the dimensions shown in this specification. Nominal sizes will continue to be shown as fractions. For the purposes of this specification, the fractions and their decimal equivalents are equal and interchangeable. For SI metric unit equivalents in millimeters (mm), multiply by 25.4 and round to 1 decimal place. Basic metric conversions are described in Annex A.

2 References

2.1 General

This specification includes by reference, either in total or in part, the most current issue of the following standards:

ANSI B16.5[1], *Pipe Flanges and Flanged Fittings*

ASTM D638[2], *Standard Test Method for Tensile Properties of Plastics*

ASTM D792, *Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement*

ASTM D1238, *Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer*

ASTM D1505, *Standard Test Method for Density of Plastics by the Density-Gradient Technique*

ASTM D1598, *Standard Test Method for Time-to Failure of Plastic Pipe Under Constant Internal Pressure*

ASTM D1599, *Standard Test Method for Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings*

ASTM D1600, *Standard Terminology for Abbreviated Terms Relating to Plastics*

ASTM D1603, *Standard Test Method for Carbon Black Content in Olefin Plastics*

ASTM D2122, *Standard Test Method for Determining Dimensions of the Thermoplastic Pipe and Fittings*

ASTM D2290, *Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic by Split Disk Method*

ASTM D2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings*

ASTM D2683, *Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter—Controlled Polyethylene Pipe and Tubing*

ASTM D2765, *Standard Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics*

ASTM D2774, *Standard Practice for Underground Installation of Thermoplastic Pressure Piping*

ASTM D2837, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials*

ASTM D3035, *Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter*

ASTM D3261, *Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing*

ASTM D3350, *Standard Specification for Polyethylene Plastic Pipe and Fitting Materials*

ASTM D4218, *Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique*

[1]American National Standards Institute, 25 West 43rd Street, 4th floor, New York, New York 10036, www.ansi.org.
[2]ASTM International, 100 Bar Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

ASTM F412, *Standard Terminology Relating to Plastic Piping Systems*

ASTM F714, *Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter*

ASTM F1055, *Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing*

ASTM F1473, *Standard Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins*

ASTM F2206, *Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE) Plastic Pipe, Fittings, Sheet Stock, Plate Stock or Block Stock*

ASTM F2620, *Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings*

PPI TN-7[3], *Nature of Hydrostatic Stress Rupture Curves*

PPI TN-11, *Suggested Temperature Limits for the Operation and Installation of Thermoplastic Piping in Non-Pressure Applications*

PPI TN-13, *General Guidelines for Butt, Saddle and Socket Fusion of Unlike Polyethylene Pipes and Fittings*

PPI TR-3, *Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Pipe Materials or Pipe*

PPI TR-4, *Listing of Hydrostatic Design Basis (HDB), Strength Design Basis (SDB), Pressure Design Basis (PDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe*

PPI TR-9, *Recommended Design Factors for Pressure Applications of Thermoplastic Pressure Pipe Materials*

PPI TR-33, *Butt Fusion Joining of Polyethylene Gas Pipe*

PPI TR-41, *Generic Saddle Fusion Joining Procedure for Polyethylene Gas Piping*

U.S. DOT Title 49, *CFR* Part 192[4], *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards*

2.2 Requirements

Requirements of other standards included by reference in this specification are essential to the safety and interchangeability of the equipment produced.

2.3 Equivalent Standards

Standards referenced in this specification may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standard. Manufacturers who use other standards in lieu of standards referenced herein are responsible for documenting the equivalency of the standards. Where a standard is revised, the latest edition may be used on issue and shall become mandatory 6 months from the date of the revision.

[3]Plastics Pipe Institute, 105 Decker Court, Suite 825, Irving Texas 75062, www.plasticpipe.org.
[4]U.S. Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590, www.dot.gov.

3 Glossary (Definitions, Abbreviations)

3.1 Definitions

3.1.1
acceptance criteria
Defined limits placed on characteristics of materials, products, or services.

3.1.2
adapters
Appurtenances that allow connecting components with different joining systems.

3.1.3
butt fusion
The fusing of polyethylene materials per a qualified procedure that entails squaring and aligning the pipe, heating the pipe ends to a specified temperature, pressurizing the two aligned ends together and allowing the resultant joint to cool.

3.1.4
cell classification
Applies to the use of ASTM D3350 in specifying the polyethylene material parameters. Polyethylene pipe and fitting materials are classified using Density, Melt Index, Flexural Modulus, and Tensile Strength at Yield, Slow Crack Growth Resistance, the Hydrostatic Design Basis (HDB) and an Ultraviolet (UV) stabilizer.

3.1.5
component
Any pressure line pipe, pipe connection, fitting, flange, adapter, reducer, or end of outlet connection covered by this specification.

3.1.6
Design Service Factor (DSF)
A safety factor applied to the Hydrostatic Design Basis (HDB) to calculate the hydrostatic design stress.

3.1.7
eccentricity
The wall thickness variability as measured and calculated in accordance with ASTM D2122 Test Method in any diametrical cross section of the pipe shall be within 12 %. Wall thickness eccentricity range shall be measured in accordance with ASTM D2513, Section 6.5.1.3.

3.1.8
fittings
Tees, 90s, 45s and fittings manufactured by butt fusion welding of shape modified or mitered components prepared from molded fittings, sheet stock or block.

3.1.9
flanges
Face flanges with bolt hole circle per ANSI B16.5. Flanges and flange adapter as used in this specification, incorporates use of polyethylene flange adapter and metallic backup ring utilizing ANSI B16.5 bolt hole pattern.

3.1.10
Fluid Service Factor (FSF)
Factor applied to the Hydrostatic Design Stress (HDS) to account for the impact of the transported fluid on pipe performance.

3.1.11
Hydrostatic Design Basis (HDB)
The categorized Long-term Hydrostatic Strength (LTHS) in the circumferential or hoop direction for a given set of end use conditions, as established by ASTM D2837, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials*.

3.1.12
Hydrostatic Design Stress (HDS)
The maximum allowable working hoop stress in the pipe wall when the pipe is subjected to long term hydrostatic pressure. The HDS at 73.4 °F is determined by reducing the HDB at 73.4 °F by a Design Service Factor (DSF), a multiplier of less than 1.0.

3.1.13
lot number
Assignment of a unique code to each lot of manufactured pipe or fittings under the same conditions of production. Lot numbers are used to maintain production identification and traceability.

3.1.14
ovality
The maximum measured diameter, minus the minimum measured diameter, divided by the average measured diameter, times 100, expressed as a percentage:

$$\text{Ovality (\%)} = \frac{(\text{max. measured diameter} - \text{min. measured diameter})}{(\text{average measured diameter})} \times 100$$

3.1.15
Pipe Material Designation Code
A set of letters and numbers used to identify stress-rated thermoplastic compounds. The code consists of two or three letters which describe the type of material i.e. PE, PVC, PB, PEX, etc., per ASTM D1600. This is followed by four numbers to describe material and physical properties in accordance with ASTM D3350 and PPI TR-4. Two of the numbers describe material properties according to the ASTM standard and two refer to pipe properties of HDS in water at 73 °F as listed in PPI TR-4. Where the Hydrostatic Design Stress is less than 1000 psi, a zero is used for the third number.

i.e. PE4708 where PE = Polyethylene

4 = Density (according to ASTM D3350)

7 = Slow Crack Growth Resistance (according to ASTM D3350)

08 = Hydrostatic Design Stress of 800 psi at 73 °F in water

3.1.16
reducers
Component fittings that allow two pipes of different diameters to be connected.

3.1.17
shall
In this document the word "shall" is used to indicate requirements, which are mandatory.

3.1.18
Short Term Hydrostatic Pressure (STHP)
The short term hydraulic failure pressure of pipe or fittings when subjected to the failure conditions of ASTM D1599, where the pressure is increased at a prescribed rate, under specific test conditions.

3.1.19
socket fusion
A joining process of polyethylene pipe and socket type polyethylene fittings manufactured per ASTM D2683. The preparation, heating, and fusion welding the pipe and fitting components shall be defined in a qualified procedure.

3.1.20
Standard Dimension Ratio (SDR) or Dimension Ratio (DR)
Interchangeably used terms equal to the ratio of a pipe's outside diameter to its wall thickness.

3.1.21
Standard Pressure Rating (PR)
The established maximum pressure that a fluid in the pipe can exert continuously with a high degree of certainty that failure in the pipe will not occur.

3.1.22
Temperature Service Factor (TSF)
Factor applied to the HDS to compensate for the circumstance where elevated temperature HDB data is not available.

3.1.23
visual examination
Examination of parts and equipment for visible defects in material and workmanship.

3.1.24
working pressure
The maximum anticipated, sustained operating pressure applied to the pipe in actual service.

3.2 Abbreviations

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society of Testing and Materials
DSF	Design Service Factor
DR	Dimension Ratio
HDB	Hydrostatic Design Basis
HDS	Hydrostatic Design Stress
LTHS	Long-term Hydrostatic Strength
PPI	Plastics Pipe Institute, Inc.

4 Purchasing Guidelines

4.1 General

Table 1 provides recommended guidelines for inquiry and purchase of API Spec 15LE pipe or fittings.

Table 1—Purchasing General Guidelines

Pipe	
Specification	API 15LE
Material	HDPE
Pipe Material Designation Code	e.g. PE3608
Cell Classification	e.g. 345464C
Outside Diameter	Nominal OD (Project Specific)
Standard Dimension Ratio (DR)	Required (Project Specific)
Order Length	Available in Coils or Straight Lengths (Project Specific)
Fittings	
Molded Fittings (DR)	(Project Specific)
Fabricated Fittings Must Meet Pressure Rating of Pipe	(Project Specific)
Service	
Fluid Service	(Project Specific)
Internal Pressure	(Project Specific)
Design Temperature	(Project Specific)
Above Ground/Below Ground Application	(Project Specific)

An important consideration for purchasing quality materials for application in oil and gas gathering is the selection of a quality vendor. Vendors should have an understanding of the necessary quality control testing and the capability to perform the testing required by standards.

Vendors should be able to provide records showing that a detailed QA/QC program is in place that utilizes the testing required by API Spec 15LE.

Appropriate records of in-plant inspection and testing and quality control/quality assurance testing should be available to demonstrate that the manufacturer's piping products meet the requirements of this specification.

Vendors should have the ability to provide sound technical support for its products in field applications.

5 Design

5.1 Design

5.1.1 Hydrostatic Design Basis (HDB)

The HDB shall be established by the manufacturer in accordance with PPI TR-3 using ASTM D2837 methodology. Polyethylene materials meeting the requirements of this specification shall have their HDBs listed in PPI TR-4.

PPI TN-7 and PPI TR-9 illustrate some of the differences between the HDB approach taken here and the Minimum Required Strength (MRS) approach taken by ISO polyethylene standards. PPI TR-4 lists comparative data for many PE compounds.

5.1.2 Hydrostatic Design Stress (HDS)

HDS is the maximum allowable hoop stress in the pipe wall when the pipe is subjected to long-term hydrostatic pressure. The HDS shall be determined by reducing the HDB by the DSF. This multiplier takes into account certain material performance requirements (according to PPI TR-3) and degrees of safety involved in thermoplastic piping manufacture and installation, and shall be either 0.5 or 0.63 depending on the material grade, as defined in PPI TR-4. Under conditions such as severe pressure cycling, higher temperature and aggressive chemical environments, a more conservative DSF may be chosen.

PE pipe materials meeting the requirements of this specification are PE2708, PE3608, PE3708, PE3710, PE4708 and PE4710.

Materials designated as PE2708 meeting this specification have an HDB of 1,250 psi (8.3 MPa) for water at 73 °F(23 °C). After applying a 0.63DSF, the HDS at 73 °F (23 °C) will be 800 psi (5.5 MPa).

Materials designated as PE3608, PE3708, and PE4708 meeting the requirements of this specification have an HDB of 1,600 psi (11.0 MPa) for water at 73 °F (23 °C). After applying a 0.5 DSF, the HDS at 73 °F (23 °C) will be 800 psi (5.5 MPa).

Materials designated as PE3710 and PE4710 meeting the requirements of this specification have an HDB of 1,600 psi (11.0 MPa) for water at 73 °F (23 °C). After applying a 0.63 DSF, the HDS at 73 °F (23 °C) will be 1000 psi (6.9 MPa).

5.1.3 Fluid Service Factor (FSF)

The FSF in Table 2 is a number equal to or less than 1.0 and is used to account for possible chemical effects of the transported medium on the long-term performance of the piping, hazardous nature of the application and may reflect governmental regulations.

Table 2—Fluid Service Factors (FSF)

Environment	Factor
Produced water, seawater, brine, process water and other oilfield water based fluids excluding oilfield water containing > 2 % liquid hydrocarbons[1]	1.0
Dry gas gathering (no associated hydrocarbon liquids)[2]	1.0
Dry gas gathering that is subject to Canadian Federal Regulations[3]	1.0
Multiphase fluids, wet natural gas and liquid hydrocarbons	0.5

[1]Water containing significant quantities of liquid hydrocarbons (> 2%) shall be treated as hydrocarbon liquids in this instance.
[2]Gas gathering in this standard refers to gas from a well or production source in a low population density area that is not subject to Department of Transportation, Office of Pipeline Safety, Title 49 *CFR* Part 192.
[3]CSA Z662 Clause 13.3.

5.1.4 Temperature Service Factor (TSF)

For materials using HDS values calculated at 73.4 °F to calculate MAOP and propose operation at a higher temperature, the TSFs in Table 3 should be applied to the HDS calculated with 73.4 °F data.

Table 3—Temperature Service Factors

Service Temperature °F (°C)	≤ 80 (27)	≤ 90 (32)	≤ 100 (38)	≤ 110 (43)	≤ 120 (49)	≤ 130 (54)	≤ 140 (60)
Temperature Factor	1.00	0.90	0.78	0.75	0.63	0.60	0.50

A TSF is not required for materials with an HDB established at or above the service temperature when used to calculate the MAOP at that temperature. When calculating a HDB between 73.4 °F and the elevated temperature at which the manufacturer has an established HDB, the HDB at any intermediate temperature may be calculated by linear interpolation.

PE pipe should not typically be used at temperature above those listed in Table 3, the manufacturer should be consulted in such circumstances.

5.1.5 Standard Pressure Rating

The Standard Pressure Rating of a pipe is the design capacity to resist working pressure at the anticipated operating temperature with sufficient capacity to withstand anticipated positive pressure surges above working pressure. Standard Pressure Rating is calculated using the formula below:

$$P = \left[\frac{2 \times HDS}{\frac{D_o}{t} - 1} \right] \times FSF \times TSF \qquad \text{or} \qquad P = \frac{2 \times HDS}{SDR - 1} \times FSF \times TSF$$

where

P is the Standard Pressure Rating (psi);

HDS is the Hydrostatic Design Stress (psi) at 73.4° in water;

D_o is the outside diameter (in.);

t is the minimum pipe wall thickness (in.);

SDR is the Standard Dimension Ratio;

FSF is the Fluid Service Factor;

TSF is the Temperature Service Factor, if required by 5.1.4.

Table 4—Standard Pressure Ratings

Standard Pressure Ratings at 73 °F in psi					
DR	**PE2708**	**PE3608**	**PE3710**	**PE4708**	**PE4710**
5.0	—	400	504	400	504
6.0	—	320	403	320	403
7.0	—	267	336	267	336
7.3	250	254	320	254	320
9	197	200	252	200	252
11	158	160	202	160	202
13.5	126	128	162	128	162
17	98	100	126	100	126
21	79	80	101	80	101
26	63	64	81	64	81
32.5	50	51	64	51	64
NOTE Pressure ratings above calculated formula of 5.1.5 with FSF and TSF of 1.0.					

5.1.6 External Collapse Rating

Guidelines on the collapse rating of polyethylene pipe are laid out in Annex B.

5.1.7 Cross-linked Polyethylene

The use of cross-linked polyethylene is not yet controlled within this standard. It is the intention to address this at a future point in time, as the industry gains more experience with this type of material. In order to prepare the industry for this standardization, Annex C has been included in this revision of API Spec 15LE, for information.

5.2 Dimensions and Tolerances

5.2.1 Size

Pipe furnished to this specification shall comply with the dimensions and tolerances given in Table 5 as specified on the purchase order.

In applications where special conditions or requirements dictate diameters, wall thicknesses or dimensions other than those listed in this table, if the pipe is manufactured from PE compounds meeting the requirements of this specification and the strength and design basis is the same, meeting all the requirements of this specification it shall be acceptable.

For diameters not shown in the table, the tolerance shall be the same percentage as that used in the table for the next smaller listed size.

5.2.2 Toe-in

The outside diameter when measured at the cut end of the pipe length shall not be more than 1.5 % smaller than the outside diameter specified in Table 5, when measured at any point within 1.5 pipe diameters or 11.8 in. (300 mm), whichever is less, to the cut end of the pipe length. Measurements shall be made using ASTM D2122 Test Method.

5.2.3 Eccentricity

The wall thickness variability as measured and calculated in accordance with ASTM D2122 Test Method in any diametrical cross section of the pipe should not exceed 12 %.

5.2.4 Length

Pipe shall be furnished in cut lengths or coils as specified on the purchase order. Two pieces fused together to make a length are not acceptable. Measurements shall be made using ASTM D2122 Test Method.

5.2.5 Fittings

Fittings furnished for use with this specification shall meet requirements of specification ASTM D3261 for butt-fused fittings, ASTM F1055 for electrofusion fittings, ASTM F2206 for fabricated fittings and ASTM D2683 for socket fused fittings.

Fabricated, molded or machined fittings shall meet the dimensional requirements of Table 5 and the testing requirements of the applicable standard.

5.2.6 Ovality

The ovality of the pipe shall not exceed 5 % when measured in accordance with 6.5.3 of ASTM D2513. Other factors such as installation, compaction, static soil loading, exposure to high ambient temperature and vehicular loads may increase ovality.

6 Process of Manufacture

6.1 Process of Manufacture

Pipe furnished to this specification shall be produced by extrusion. Fittings shall be produced by one of the following processes: injection molding, forming, transfer molding, extrusion, machining, or fabrication.

Table 5—Dimension and Tolerances Based on Outside Diameters

Outside Diameter			Wall Thickness		
Nominal Size (in.)	in.	mm	DR	in.	mm
1/2	0.840 ± 0.004	21.34 ± 0.10	11 9 7	0.076 + 0.009 0.093 + 0.011 0.120 + 0.014	1.93 + 0.22 2.36 + 0.28 3.05 + 0.36
3/4	1.050 ± 0.004	26.67 ± 0.10	11 9 7	0.095 + 0.011 0.117 + 0.014 0.150 + 0.018	2.41 + 0.28 2.97 + 0.36 3.81 + 0.46
1	1.315 ± 0.005	33.40 ± 0.13	17 13.5 11 9 7.3 7 6 5	0.077 + 0.009 0.097 + 0.012 0.119 + 0.014 0.146 + 0.018 0.180 + 0.022 0.188 + 0.023 0.219 + 0.026 0.210 + 0.025	1.96 + 0.22 2.46 + 0.30 3.02 + 0.36 3.97 + 0.46 4.57 + 0.56 4.78 + 0.58 5.56 + 0.66 5.33 + 0.64
1 1/4 in.	1.660 ± 0.005	42.16 ± 0.13	21 17 13.5 11 9 7.3 7 6 5	0.079 + 0.009 0.098 + 0.012 0.123 + 0.015 0.151 + 0.018 0.184 + 0.022 0.227 + 0.027 0.237 + 0.028 0.277 +0.033 0.332 + 0.040	2.01 + 0.24 2.49 + 0.30 3.12 + 0.38 3.84 + 0.46 4.67 + 0.56 5.77 + 0.69 6.02 + 0.72 7.03 + 0.84 8.43 + 1.01
1 1/2 in.	1.900 ± 0.006	48.26 ± 0.15	21 17 13.5 11 9 7.3 7 6 5	0.09 + 0.011 0.112 + 0.013 0.141 + 0.017 0.173 + 0.021 0.211 + 0.025 0.260 + 0.031 0.270 + 0.033 0.317 + 0.038 0.380 + 0.045	2.27 + 0.27 2.84 + 0.34 3.58 + 0.43 4.39 + 0.53 5.36 + 0.64 6.60 + 0.79 6.88 + 0.84 8.05 + 0.96 9.62 + 1.15
2 in.	2.375 ± 0.006	60.33 ± 0.15	21 17 13.5 11 9 7.3 7 6 5	0.113 + 0.013 0.140 + 0.017 0.176 + 0.021 0.216 + 0.026 0.264 + 0.032 0.325 + 0.039 0.339 + 0.041 0.395 + 0.048 0.475 + 0.057	2.97 + 0.35 3.56 + 0.43 4.47 + 0.51 5.49 + 0.66 6.70 + 0.81 8.25 + 0.99 8.62 + 1.04 10.03 + 1.21 12.07 + 1.45
2 1/2 in.	2.875 ± 0.007	73.0 ± 0.18	21 17 13.5 11 9 7.3 7 6 5	0.137 + 0.016 0.169 + 0.020 0.213 + 0.026 0.261 + 0.031 0.319 + 0.038 0.394 + 0.047 0.411 + 0.049 0.479 + 0.575 0.575 + 0.069	3.48 + 0.406 4.29 + 0.508 5.41 + 0.660 6.63 + 0.787 8.10 + 0.972 10.00 + 1.200 10.44 + 1.250 12.17 + 1.460 14.61 + 1.753

Table 5—Dimension and Tolerances Based on Outside Diameters (Continued)

Outside Diameter			Wall Thickness		
Nominal Size (in.)	in.	mm	DR	in.	mm
3 in.	3.500 ± 0.008	88.90 ± 0.20	21	0.167 + 0.020	4.24 + 0.51
			17	0.206 + 0.025	5.23 + 0.64
			13.5	0.259 + 0.031	6.58 + 0.79
			11	0.318 + 0.038	8.08 + 0.97
			9	0.389 + 0.047	9.88 + 1.19
			7.3	0.479 + 0.058	12.17 + 1.47
			7	0.500 + 0.060	12.70 + 1.52
			6.0	0.583 + 0.070	14.81 + 1.78
			5	0.700 + 0.084	17.78 + 2.13
4 in.	4.500 ± 0.009	114.30 ± 0.23	21	0.214 + 0.026	5.44 + 0.66
			17	0.265 + 0.032	6.73 + 0.81
			13.5	0.333 + 0.040	8.46 + 1.02
			11	0.409 + 0.049	10.39 + 1.24
			9	0.500 + 0.060	12.70 + 1.52
			7.3	0.616 + 0.074	15.65 + 1.88
			7	0.643 + 0.077	16.33 + 1.96
			6	0.750 + 0.090	19.05 + 2.29
			5	0.900 + 0.108	22.86 + 2.74
5 in.	5.563 ± 0.010	141.30 ± 0.25	21	0.265 + 0.032	6.73 + 0.81
			17	0.328 + 0.039	8.33 + 0.99
			13.5	0.413 + 0.050	10.49 + 1.26
			11	0.506 + 0.061	12.85 + 1.54
			9	0.618 + 0.075	15.65 + 1.88
			7.3	0.762 + 0.091	19.35 + 2.32
			7	0.795 + 0.095	20.19 + 2.42
			6	0.927 + 0.111	23.55 + 2.83
			5	1.112 + 0.133	28.26 + 3.39
6 in.	6.625 ± 0.011	168.28 ± 0.28	32.5	0.204 + 0.024	5.18 + 0.61
			26	0.255 + 0.031	6.48 + 0.79
			21	0.315 + 0.038	8.00 + 0.97
			17	0.390 + 0.047	9.91 + 1.19
			13.5	0.491 + 0.059	12.47 + 1.50
			11	0.602 + 0.072	15.29 + 1.83
			9	0.736 + 0.088	18.69 + 2.24
			7.3	0.908 + 0.109	23.06 + 2.77
			7	0.946 + 0.114	24.03 + 2.90
			6	1.104 + 0.133	28.04 + 3.36
			5	1.325 + 0.159	33.66 + 4.04
8 in.	8.625 ± 0.015	219.08 ± 0.38	32.5	0.265 + 0.032	6.73 + 0.81
			26	0.332 + 0.040	8.43 + 1.02
			21	0.411 + 0.049	10.44 + 1.24
			17	0.507 + 0.061	12.88 + 1.55
			13.5	0.639 + 0.077	16.23 + 1.96
			11	0.784 + 0.094	19.91 + 2.39
			9	0.958 + 0.115	24.33 + 2.92
			7.3	1.182 + 0.142	30.02 + 3.61
			7	1.232 + 0.148	31.29 + 3.76
			6	1.438 + 0.173	36.53 + 4.38
			5	1.725 + 0.207	43.82 + 5.26

Table 5—Dimension and Tolerances Based on Outside Diameters (Continued)

Outside Diameter			Wall Thickness		
Nominal Size (in.)	in.	mm	DR	in.	mm
10 in.	10.750 ± 0.015	273.05 ± 0.38	32.5	0.331 + 0.040	8.41+ 1.02
			26	0.413 + 0.050	10.49 + 1.27
			21	0.512 + 0.061	13.00 + 1.55
			17	0.632 + 0.076	16.05 + 1.93
			13.5	0.796 + 0.096	20.22 + 2.44
			11	0.977 + 0.117	24.82 + 2.97
			9	1.194 + 0.143	30.33 + 3.63
			7.3	1.473 + 0.177	37.41 + 4.50
			7	1.536 + 0.184	39.01 + 4.68
			6	1.792 + 0.215	45.51 + 5.46
			5	2.150 + 0.258	54.61 + 6.55
12 in.	12.750 ± 0.017	323.85 ± 0.43	32.5	0.392 + 0.047	9.96 + 1.19
			26	0.490 + 0.059	12.45 + 1.50
			21	0.607 + 0.073	15.42 + 1.85
			17	0.750 + 0.090	19.05 + 2.29
			13.5	0.944 + 0.113	23.98 + 2.87
			11	1.159 + 0.139	29.44 + 3.53
			9	1.417 + 0.170	35.99 + 4.32
			7.3	1.747 + 0.210	44.37 + 5.33
			7	1.821 + 0.219	46.25 + 5.56
			6	2.125 + 0.255	53.98 + 6.48
			5	2.550 + 0.306	64.77 + 7.77
14 in.	14.000 ± 0.063	355.60 ± 1.60	32.5	0.431 + 0.052	10.95 + 1.32
			26	0.538 + 0.065	13.67 + 1.65
			21	0.667 + 0.080	16.94 + 2.03
			17	0.824 + 0.099	20.93 + 2.51
			13.5	1.037 + 0.124	26.34 + 3.16
			11	1.273 + 0.153	32.33 + 3.89
			9	1.556 + 0.187	39.52 + 4.75
			7	2.000 + 0.240	50.80 + 6.10
			6	2.333 + 0.280	59.18 + 7.10
			5	2.800 + 0.336	71.12 + 8.53
16 in.	16.000 ± 0.072	406.40 ± 1.83	32.5	0.492 + 0.059	12.50 + 1.50
			26	0.615 + 0.074	15.62 + 1.88
			21	0.762 + 0.091	19.35 + 2.31
			17	0.941 + 0.113	23.90 + 2.87
			13.5	1.185 + 0.142	30.10 + 3.61
			11	1.455 + 0.175	36.96 + 4.45
			9	1.778 + 0.213	45.16 + 5.41
			7	2.286 + 0.274	58.06 + 6.96
			6	2.667 + 0.320	67.74 + 8.13
			5	3.200 + 0.384	81.28 + 9.75
18 in.	18.000 ± 0.081	457.20 ± 2.05	32.5	0.554 + 0.066	14.07 + 1.68
			26	0.692 + 0.083	17.58 + 2.11
			21	0.857 + 0.103	21.77 + 2.62
			17	1.059 + 0.127	26.90 + 3.23
			13.5	1.333 + 0.160	33.85 + 4.06
			11	1.636 + 0.196	41.55 + 4.98
			9	2.000 + 0.240	50.80 + 6.10
			7	2.571 + 0.309	65.30 + 7.85
			6	3.000 + 0.360	76.20 + 9.14
			5	3.600 + 0.432	91.50 + 10.98

Table 5—Dimension and Tolerances Based on Outside Diameters (Continued)

Outside Diameter			Wall Thickness		
Nominal Size (in.)	in.	mm	DR	in.	mm
20 in.	20.000 ± 0.090	508.00 ± 2.29	32.5 26 21 17 13.5 11 9 7	0.615 + 0.074 0.769 + 0.092 0.952 + 0.114 1.176 + 0.141 1.482 + 0.178 1.818 + 0.218 2.222 + 0.267 2.857 + 0.343	15.62 + 1.88 20.22 + 2.34 24.18 + 2.90 29.87 + 3.58 37.64 + 4.52 46.18 + 5.54 56.44 + 6.78 72.57 + 8.71
22 in.	22.000 ± 0.099	558.80 ± 2.51	32.5 26 21 17 13.5 11 9 7	0.677 + 0.081 0.846 + 0.102 1.048 + 0.126 1.294 + 0.155 1.630 + 0.196 2.000 + 0.240 2.444 + 0.293 3.143 + 0.377	17.20 + 2.06 21.49 + 2.59 26.62 + 3.20 32.87 + 3.94 41.40 + 4.97 50.80 + 6.10 62.08 + 7.44 79.83 + 9.58
24 in.	24.000 ± 0.108	609.60 ± 2.74	32.5 26 21 17 13.5 11 9 7	0.738 + 0.089 0.923 + 0.111 1.143 + 0.137 1.412 + 0.169 1.778 + 0.213 2.182 + 0.262 2.667 + 0.320 3.429 + 0.411	18.75 + 2.25 23.44 + 2.82 29.03 + 3.48 35.86 + 4.29 45.16 + 5.420 55.42 + 6.65 67.74 + 8.13 87.10 + 10.44
26 in.	26.000 ± 0.117	660.40 ± 2.97	32.5 21 17 13.5 1 9	0.800 1.238 1.529 1.925 2.364 2.889	20.32 31.45 38.84 48.90 60.05 73.38
28 in.	28.000 ± 0.126	711.20 ± 3.20	32.5 21 17 13.5 11 9	0.862 1.333 1.647 2.074 2.545 3.111	21.89 33.86 41.83 52.68 64.64 79.02
30 in.	30.000 ± 0.135	762.00 ± 3.43	32.5 21 17 13.5 11 9	0.923 1.428 1.764 2.222 2.727 3.333	23.44 36.27 44.81 56.44 69.27 84.66
32 in.	32.000 ± 0.144	812.80 ± 3.66	32.5 21 17 13.5 11	0.985 1.524 1.882 2.370 2.909	25.02 38.71 47.80 60.20 73.89
34 in.	34.000 ± 0.153	863.60 ± 3.89	32.5 21 17 13.5 11	1.046 1.619 2.000 2.520 3.091	26.57 41.12 50.80 64.01 78.51

Table 5—Dimension and Tolerances Based on Outside Diameters (Continued)

Outside Diameter			Wall Thickness		
Nominal Size (in.)	in.	mm	DR	in.	mm
36 in.	36.000 ± 0.162	914.40 ± 4.11	32.5 21 17 13.5 11	1.108 1.714 2.112 2.667 3.273	28.14 43.54 53.65 67.74 83.13
42 in.	42.000 ± 0.189	1066.80 ± 4.80	32.5 21 17 13.5	1.292 2.000 2.470 3.111	32.82 50.80 62.74 79.02
48 in.	48.000 ± 0.216	1219.20 ± 5.49	32.5 26 21 17 13.5	1.477 1.846 2.286 2.824 3.556	37.52 46.89 58.06 71.73 90.31
54 in.	54.000 ± 0.243	1371.60 ± 6.17	32.5 26 21 17	1.662 2.077 2.571 3.176	42.22 52.75 65.31 80.68

NOTES

1) Pipe dimensions and schedules listed are most commonly used by the oil and gas industries. Additional sizes and schedules are available. The complete list of sizes and schedules are listed in the following ASTM standards:
ASTM D2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings*.
ASTM D3035, *Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.*
ASTM F714, *Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter*.

2) The Dimension Ratio (DR) is the specified diameter divided by the minimum wall thickness.

6.2 Materials

Polyethylene materials approved for use in the manufacture of pipe and fittings under this specification shall be classified in accordance with ASTM D3350. Cell classifications values for materials meeting the requirements of this specification are included in Table 6.

Resins and compounds meeting the material requirements and cell classifications of this standard shall have HDB and HDS ratings listed in PPI TR-4. An HDB listing at 140 °F in PPI TR-4 is required.

6.3 Rework Material

Clean rework materials of the same grade and commercial designation, generated from the manufacturer's own pipe and fitting production may be used by the same manufacturer as long as the pipe and fittings produced meet all of the requirements of this specification.

6.4 Fittings

Fittings furnished for use with this specification shall meet requirements of specification ASTM D3261 for butt-fused fittings, ASTM F1055 for electrofusion fittings, ASTM D2683 for socket fused fittings and this API specification for dimensional requirements. Material and resins shall meet the Cell Classifications listed in Table 6.

Table 6—Cell Classifications According to ASTM D3350

Material Designation Code	PE2708	PE3608	PE3708	PE3710	PE4708	PE4710
Physical Property						
Density	2	3	3	3	4	4
Melt Index	3	4	4	4	4	4
Flexural Modulus	4	≥ 4	≥ 4	≥ 4	≥ 4	≥ 5
Tensile Strength	3	≥ 4	≥ 4	≥ 4	≥ 4	≥ 4
Slow Crack Growth Resistance (PENT)	7	6	7	7	7	7
Hydrostatic Strength Classification	3	4	4	4	4	4
Color and Ultraviolet (UV) Stabilizer[1]	C or E	C or E	C or E	C or E	C or E	C or E

[1]Color and UV stabilizers shall meet either Class C or Class E as defined in ASTM D3350. Class C compounds shall contain a minimum 2 % to 3.5 % carbon black. Class E compounds shall contain an antioxidant compound adequate for outdoor storage unprotected in sunlight for a minimum of 24 months.

6.5 Finish and Workmanship

6.5.1 Pipe Ends

Pipe ends shall be plain and squared.

6.5.2 Finish

The interior and exterior of the pipe shall be uniform in finish without voids, cracks, crazing, foreign inclusions or deep scratches.

6.5.3 Workmanship

Cut pipe ends shall be clean without ledges, shaving tails, burrs or cracks.

The interior of the pipe shall be blown or washed clean of cuttings and shavings.

7 Quality Program

The adoption of an external quality management system by a manufacturer is not a necessity to meet the requirements of this standard. It is, however, desirable for manufacturers to conform their quality program to meet an internationally recognized quality management system.

7.1 Quality Manual

The manufacturer shall maintain a quality manual that adequately describes the quality program. The quality program shall confirm that sufficient quality records are maintained to demonstrate conformance to requirements and verify effective product manufacturing to the requirements of this standard and to any related mentioned standards. Quality records shall remain legible, readily identifiable and retrievable for a period of not less than 10 years or as specified by an external quality system.

7.2 Quality Control Tests

7.2.1 Conditioning

Test specimens shall be conditioned at 73.4 ± 3.6 °F (23 ± 2 °C) prior to testing for a minimum of 1 hour in water or 4 hours in air at 73.4 ± 3.6 °F (23 ± 2 °C).

7.2.2 Quality Control Testing

Samples for quality control testing shall be conditioned in accordance with 7.2.1 or in accordance with ASTM D2122. This applies to test methods covering the determination of diameter, wall thickness, and length dimensions of pipe and fittings.

Polyethylene pipe materials may undergo dimensional change near cut ends due to internal residual stresses. When this condition is noted, care shall be taken to make measurements at a location that is not affected by the toe-in effect.

7.2.3 Pipe Requirements and Frequency

7.2.3.1 Physical Properties

a) Elevated Temperature Sustained Pressure tests shall be conducted for each material designation code listed in Table 6 used at the facility. The test shall be conducted per ASTM D1598.

b) Elevated temperature testing of product materials and extrusion technique qualification shall be performed when a polyethylene pipe material designation is first used in a manufacturing facility to manufacture pipe or tubing and in two separate trials during the year, such that the tests generally represent a first half or a second half of the annual production at the facility.

c) The test sample shall consist of three specimens of a generally representative pipe or tubing size produced at the manufacturer's facility using a material designation code from Table 6. Select one Table 6 material to test at one Table 7 condition for all three specimens using water as the testing medium per ASTM D1598.

d) Passing results are (1) non-failure for all three specimens at a time equal to or greater than the "minimum average time before failure," or (2) not more than one ductile specimen failure and the average time before failure for all three specimens shall be greater than the specified "minimum average time before failure" for the selected Table 7 condition. For Table 7, Condition 1 through 5: If more than one ductile failure occurs before the "minimum average time before failure," it is permissible to conduct one retest at a Table 7 condition of lower stress and longer "minimum average time before failure" for the material designation code. For Table 7, Condition 6, no retest is possible. Brittle failure of any specimen in the test sample when tested at Table 7, Condition 1 through 6 constitutes failure to meet this requirement.

e) Except as provided in items a, b, c and d above, if the results of any test(s) do not meet the requirements of this specification, the test(s) may be conducted again in accordance with an agreement between the purchaser and the seller. There shall be no agreement to lower the minimum requirement of the specification by such means as omitting tests that are a part of the specification, substituting or modifying a test method, or by changing the specification limits. In retesting, the product requirements of this specification shall be met, and the test methods designated in the specification shall be followed. If, upon retest, failure occurs, the quantity of the product represented by the test(s) does not meet the requirements of this specification.

7.2.3.2 Test Description and Frequency for Pipe

The following tests shall be conducted per the prescribed frequencies indicated in Table 8.

Table 7—Elevated Temperature Sustained Pressure Test Requirements

		PE2708, PE3608, PE3708, PE4608, PE4708		PE3710, PE4710	
Condition	Test Temperature	Test Pressure Hoop Stress	Minimum Average Time Before	Test Pressure Hoop Stress	Minimum Average Time Before
	°F (°C)	psi (kPa)	Failure (Hours)	Psi (kPa)	Failure (Hours)
1	176 °F (80 °C)	670 (4620)	170	750 (5170)	200
2	176 °F (80 °C)	650 (4480)	340	730 (5035)	400
3	176 °F (80 °C)	630 (4345)	510	705 (4860)	600
4	176 °F (80 °C)	610 (4210)	680	685 (4725)	800
5	176 °F (80 °C)	590 (4070)	850	660 (4550)	1000
6	176 °F (80 °C)	580 (4000)	1000	640 (4415)	1200

Table 8—Test Description and Frequency for Pipe

Test Description	Frequency	Minimum Requirements
Outside Diameter (per ASTM D2122)	Once/hour or once/coil, whichever is less frequent.	Must meet dimensions specified in Table 6.
Wall Thickness (per ASTM D2122)	Once/hour or once/coil, whichever is less frequent.	Must meet dimensions specified in Table 6.
Short term Burst Pressure (per ASTM D1599) (for sizes 12 in. and less)	Once every 8 hours or once/coil, whichever is less frequent.	Failures must be ductile and must occur between 60 and 70 seconds.
Apparent Ring Tensile Strength (per ASTM D2290) (may be substituted for the Short Term Burst Pressure Test for pipe sizes larger than 4 in.)	Once every 8 hours or once/coil, whichever is less frequent.	Minimum apparent tensile strength must be 2900 psi when tested per Procedure B (0.5 in./min, specimens $^{1}/_{2}$ in. wide with $^{1}/_{4}$ in. reduced area section).
Density (per ASTM D1505)	Once per extrusion run.	Must meet requirements for ASTM D3350.
Melt Index (per ASTM D1238)	Once per extrusion run.	Must meet requirements for ASTM D3350.
Out-of-Roundness (per ASTM D2122)	Once/hour or once/coil, whichever is less frequent.	Pipe must not exceed OOR requirements per ASTM D2513-93 when measured using a re-rounding device, if necessary.
Carbon Content	At start up and once every 24 hours.	Ash range is 2.0 % to 3.50 %
Ovality (per ASTM D2513)	Once per run.	Not to exceed 5 %. Does not apply pipe greater than 3 in. IPS.

7.2.4 Fittings Requirements and Frequency

7.2.4.1 Fittings

The following tests shall be conducted per the prescribed frequencies as outlined in Table 9.

7.2.5 Retest and Rejection

Failure of two of the six specimens tested constitutes failure in the test. Failure of one of the six specimens tested is cause for retest of six additional specimens. Failure of one of six specimens tested in retest constitutes failure in the test.

Table 9—Fittings Requirements and Frequency

Test Description	Frequency	Minimum Requirements
Socket Fittings		
Socket Entrance Dia. (ASTM D2122)	Once per hour or 1 per 10 fittings, whichever is less frequent. Fittings must meet all applicable dimensions of ASTM D2683.	
Socket Bottom Dia. (ASTM D2122)		
OOR for Socket Entrance and Bottom Diameters		
Inner Diameter (ASTM D2122)		
Wall thickness (Socket fitting) (ASTM D2122)	Once per cavity at the beginning of each production setup.	Must be 125 % of the minimum wall thickness of pipe to which it is designed to be joined.
Knit-line integrity: Either, or a) Crush Test (ASTM D2513) b) Ring Tensile (ASTM D2290) c) Short term Burst (ASTM D1599)	Once at start-up and at the beginning of each change in production.	Fitting must exhibit no separation of knit line.
Butt Fittings—Molded		
Outside Diameter (ASTM D2122)	Once per hour or 1 per 10 molded pieces, whichever is less frequent.	Fittings must meet all applicable dimensions of ASTM D3261and ASTM D2683.
Wall Thickness (butt fitting) (ASTM D2122)		
Knit-line Integrity: Either, or a) Crush Test (ASTM D2513) b) Ring Tensile (ASTM D2290) c) Short term Burst (ASTM D1599)	Once at start-up and at the beginning of each change in production.	Fitting must exhibit no separation of knit line.
Butt Fittings—Fabricated		
Outside Diameter (ASTM D2122)	Once per hour or 1 per 10 pieces, whichever is less frequent.	Fitting must meet all applicable dimensions of Table 6 of this specification.
Wall Thickness (butt fitting) (ASTM D2122)		
Visual Inspection of Fusion Beads	Every fitting.	As described in manufacturers QA/QC procedure (API Spec Q1 or ISO 9001:2000).
Misalignment	Visual per fitting.	Must fall within O.D Tolerance of pipe.
All Fittings		
Short Term Burst (ASTM D1599) @ 73 °F	1st and every 50th fitting of each size.	60 s to 70 s
PE2708		2520 psi
PE3608, PE3708, PE4708 and PE4710		2900 psi

When the pipe or fittings fail to meet the specification requirements of any test, additional tests shall be made on the products produced, back to the previous acceptable results. The pipe or fittings produced in the interim that do not pass the requirements shall be rejected.

7.2.6 Failure

Pipe failure is identified as failure to meet the applicable requirements listed in Tables 7 – 9.

7.3 Inspection and Rejection

7.3.1 Purchaser Inspection

Receiving Inspection:

1) Visually inspect all incoming product to verify that the paperwork accurately identifies the load being delivered.

2) The descriptions and items on the packing list should describe the items being ordered.

3) The Bill of Lading generally describes the order as the number of packages received from the manufacturer.

4) The packing list, the order acknowledgement list and the Bill of Lading should all be in agreement before the shipment is accepted.

Receiving Report:

1) The Bill of Lading should not be signed until it is acknowledged that the order was received in good condition.

2) Any damage, missing packages, etc. should be noted on the Bill of Lading at the time.

3) Shipping problems in delivery such as damaged pipe or fittings, missing parts or packages, document discrepancies, incorrect product, etc. should be noted on the Bill of Lading and the manufacturer should be notified immediately. Discrepancies should be noted and documented to the appropriate vendor.

4) If they are not in agreement, provisions should be made for discrepancies.

7.3.2 Injurious Defects

Injurious defects are those that adversely affect the service life of the pipe such as foreign inclusions, kinks, visible cracks, or contamination with foreign materials and any other defects and imperfections reducing the wall thickness below minimum tolerance listed in Table 5.

8 Equipment Marking

8.1 General

Pipe manufactured in conformance with this specification shall be marked by the manufacturer as specified.

8.1.1 Pressure rating markings are prohibited.

8.1.2 The required print line markings on pipe shall be legible, visible and permanent. The permanency of the marking shall be such that it can only be removed by physically removing part of the pipes wall thickness. The marking shall not reduce the pipes wall thickness to less than the minimum value required for the pipe or tubing. It should not have an effect on the long term strength of the pipe and it should not provide channels for leakage when elastomeric gasket compression fittings are used to make joints.

8.1.3 The print string on each length of pipe or fitting shall include in any sequence:

1) manufacturer's name, Product's name or trademarks;

2) Spec 15LE;

3) additional standards optional[5] (e.g. ASTM D2513);

4) size;

5) Dimension Ratio (SDR);

6) Material Designation Code (PE2708, PE3608, PE3708, PE3710, PE4708, PE4710);

7) color and UV stabilizer (C or E);

8) date of manufacture (e.g. 16 Mar 06);

9) manufacturer's lot number;

10) additional markings, except pressure ratings, as agreed upon between manufacturer and purchaser, are not prohibited.

9 Handling, Storage and Installation

9.1 Storage

Polyethylene pipe products are protected against deterioration from exposure to ultraviolet light and weathering effects. Color and black products are typically 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 are generally suitable for unlimited outdoor storage and for service on the surface, above grade or buried. In the case of striped products, the manufacturer should be consulted for storage lifetime recommendations in excess of 2 years.

The size and complexity of any particular project will determine the pre-installation storage requirements. For some projects, several storage or staging areas along the right-of-way may be appropriate, while a single location may be suitable for another job. The site and its layout should provide protection against physical damage to pipe, fittings and any pipeline components. General requirements are for the area to be of sufficient size to accommodate piping materials, 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-in. wide wooden dunnage, evenly spaced at intervals of 4 ft or less.

Coiled pipe is best stored as received in silo packs. Individual coils may be removed from the silo pack without disturbing the stability of the package. Coils may be stored either on edge or stacked flat one on top of the other, but in either case, they should not be allowed to come into contact with hot water or steam pipes and should be kept away from hot surfaces.

Pipe received in bulk packs or strip loads should be stored in the same package. If the storage area is flat and level, bulk packs or strip load packs may be stacked evenly upon each other to an overall height of about 6 ft, for less flat or less level terrain the maximum stacking height should be limited to about 4 ft.

9.2 Handling

Polyethylene piping materials are lightweight compared to similar piping materials made of steel but larger pieces and components can be heavy. Lifting and handling equipment must have adequate rated capacity to lift and move components from the truck to onsite or temporary storage. Equipment such as a forklift, a crane, a side boom tractor, or an extension boom crane is used for unloading.

[5]API Spec 15LE is a stand alone specification and is the primary manufacturing standard. If a manufacturer decides to dual mark a product it is permitted as long as the manufacturer meets the requirements of API Spec 15LE and the additional standard.

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. 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. Care should be taken not to damage the load with the forks.

9.3 Installation

Discussion of installation requirements is contained in informative Annex E.

Annex A
(informative)

Conversions

U.S. Customary units are in all cases preferential and shall be the standard in this specification.

LENGTH	**1** inch (in.)	= **25.4** millimeters (mm) exactly
PRESSURE	**1** pound per square inch (psi)	= **0.06894757** Bar NOTE **1** Bar = **100** kilopascals (kPa)
STRENGTH **OR** STRESS	**1** pound per square inch (psi)	= **0.006894757** Megapascals (MPa)
MASS	**1** pound (lb)	= **0.4535924** kilograms (kg)
TEMPERATURE	To convert degree Fahrenheit (°F) to degrees Celsius (°C):	ºC = **5/9** (ºF – **32**)
IMPACT ENERGY	**1** foot-pound (ft-lb)	= **1.3558181** Joules (J)
TORQUE	**1** foot pound (ft-lb)	= **1.3558181** Newtonmeters (Nm)

Annex B
(informative)

External Pressure Rating (Collapse Pressure)

In certain applications, polyethylene pipe may be subjected to a "negative pressure" that could cause the collapse of the pipe. A "negative pressure" situation exists where the external loading on the pipe is greater than the internal pressure in the pipe, which can result in pipe collapse if the external hydraulic pressure exceeds the flattening resistance of the pipe. Flattening resistance should be considered for gravity flow lines, vacuum lines, submerged lines and any line where the internal pressure is less than the static external hydraulic load. Flattening resistance is usually not a consideration where the end of the line is open to an external water environment. Open ended lines are pressure balanced and the static head in a full pipe crossing a water body will usually be the same or higher that the water height above the pipeline.

A few examples of where negative pressure situations may occur are as follows.

1) Above or below ground gravity flow lines.

2) A vacuum line—a water suction line submerged 23 ft in a lake (equivalent to 10 psi external loading) and is operating under a partial vacuum of 5 psi. The net negative pressure is 15 psi.

3) A water line going over a hill. The velocity of the water flow down the hill can exceed the velocity of the water coming up the hill and cause a "negative pressure" to occur.

Excessive external pressure or nor net internal vacuum pressure can cause pipe flattening or collapse. The maximum external load is determined not by material strength but by the pipe's stiffness. The pipe will flatten if the bending moment due to the load exceeds the resisting moment due to the elastic stresses in the pipe. The critical external pressure above which round pipe will flatten or collapse can be estimated by using Love's Equation:

$$P_{cr} = \frac{2E}{1-\mu^2}\left\langle\frac{1}{DR-1}\right\rangle^3$$

where

P_{CR} is the critical flattening pressure, lb/in.^{2};

E is the elastic modulus, lb/in.^{2};

μ is Poisson's ratio;

(0.45 for polyethylene under long-term stress);

(0.35 for polyethylene under short-term stress);

DR is the pipe Dimension Ratio.

An appropriate safety factor should be applied when using this equation for design. If short-term modulus is used in the calculation, a safety factor of 3 would be typical. If a long-term value of modulus is available, this may be reduced to 1.5.

For above ground lines, increased temperatures will decrease the pipe's collapse resistance and in buried lines, pipe deflection will reduce flattening resistance.

Annex C
(informative)

Cross-linked Polyethylene

This annex discusses how cross-linked polyethylene fits into the general methodology used with polyethylene in this document. This information is informative, rather than normative.

Polyethylene line pipe may be crosslinked by a number of industry-proven means to increase temperature resistance. These include:

1) peroxide crosslinking (PEX-a);

2) moisture-cured vinylsilane (PEX-b);

3) beta-irradiation (PEX-c).

Polyethylene line pipe that has been crosslinked by one of these means should conform to this specification and meet the following additional requirements.

C.3.1 Definitions

C.3.1.1
crosslinking
The process by which the adjacent polymer chains of a polyethylene plastic are joined to produce a insoluble, unmeltable, three dimension polymer network.

C.3.2 Abbreviations

PEX	Cross-linked Polyethylene
XLPE	Cross-linked Polyethylene

C.5.1.4 Temperature Service Factors

DSFs, such as those shown in Table 1, shall be determined by hydrostatic regression testing. The test fluid environment shall be maintained on the inside of the pipe with fluid, air or water outside. As a minimum, the data set shall cover the E-2 requirements set forth by PPI TR-3.

C.5.1.5 Hydrostatic Strength

Materials designated as PEX0006 meeting this specification have a HDS of 1250 psi (8.6 MPa) for water at 73 °F (23 °C). After applying a 0.5 design service factor, the design stress rating at 73 °F (23 °C) will be 630 psi (4.3 MPa). Materials designated as PEX0008 meeting this specification have a HDS of 1600 psi (11.0 MPa) for water at 73 °F (23 °C). After applying a 0.5 design service factor, the design stress rating at 73 °F (23 °C) will be 800 psi (5.5 MPa). Due to the improved resistance to stress cracking upon crosslinking, validation of the HDS by the Rate Process Method is not required for PEX compounds.

Additional long-term stress rupture testing shall be performed up the materials maximum operational temperatures, not to exceed 210 °F, and evaluated in accordance with the requirements of Method ASTM D2837 with the 100,000 hour intercept not less than 600 psi.

C.6.2 Material

Crosslinked polyethylene line pipe shall be listed in the PPI TR-4.

C.6.3 Rework Material

Due to crosslinking of the material during extrusion, no rework material is permitted for PEX-a and PEX-b materials. Clean PEX-c rework materials are permitted only as defined by 6.3.

C.6.4 Fittings

Plastic fusion fittings for use with this pipe must be fabricated from a PEX material made from the same crosslinking process and with the same Type and Class designation. All fittings, plastic or metallic, must be demonstrated by the pipe manufacturer to meet or exceed the thermal and mechanical properties of the pipe.

C.6.6 Special Processes

Crosslinking of the PEX-b materials may be facilitated by the use of increased temperatures and/or humidity using steam or hot water immersion.

C.7.4.3.2 Test Description and Frequency

In addition to the requirements in 7.4.3.2, the following tests shall be conducted per the prescribed frequencies.

1) *Property*: Gel Content. Method: ASTM D2765.

2) *Frequency*: Once every hour or once every coil, whichever is less frequent.

When tested in accordance with ASTM D2765, the degree of crosslinking for PEX pipe material shall be within the range from 65 % to 89 %, inclusive. Depending on the process used, the following minimum percentage crosslinking values shall be achieved: 70 % for PEX-a, 65 % for PEX-b or 65 % for PEX-c.

Annex D
(informative)

API Monogram

D.1 Introduction

The API Monogram Program allows an API Licensee to apply the API Monogram to products. The use of the Monogram on products constitutes a representation and warranty by the Licensee to purchasers of the products that, on the date indicated, the products were produced in accordance with a verified quality management system and in accordance with an API product specification. The API Monogram Program delivers significant value to the international oil and gas industry by linking the verification of an organization's quality management system with the demonstrated ability to meet specific product specification requirements.

When used in conjunction with the requirements of the API License Agreement, API Specification Q1, including this Annex, defines the requirements for those organizations who wish to voluntarily obtain an API License to provide API monogrammed products in accordance with an API product specification.

API Monogram Program Licenses are issued only after an on-site audit has verified that the Licensee conforms to the requirements described in API Spec Q1 in total.

For information on becoming an API Monogram Licensee, please contact API, Certification Programs, 1220 L Street, N. W., Washington, D.C. 20005 or call 202-682-8000 or by email at quality@api.org.

D.2 API Monogram Marking Requirements

These marking requirements apply only to those API licensees wishing to mark their products with the API Monogram. Each length of pipe or fitting shall be marked with the following:

1) Spec 15LE;

2) API license number;

3) additional standards optional[6] (e.g. ASTM D2513);

4) size;

5) Dimension Ratio (SDR);

6) Material Designation Code (e.g. PE2708, PE3608, PE3708, PE3710, PE4708, PE4710);

7) color and UV stabilizer (C or E);

8) date of manufacture (e.g. 16 Mar 06);

9) manufacturer's lot number;

10) additional markings, except pressure ratings, as agreed upon between manufacturer and purchaser, are not prohibited.

[6] API Spec 15LE is a stand alone specification and is the primary manufacturing standard. If a manufacturer decides to dual mark a product it is permitted as long as the manufacturer meets the requirements of API Spec 15LE and the additional standard.

Annex E
(informative)

Installation

E.1 Support Spacing

Above grade applications frequently require non-continuous support for polyethylene pipe. These type applications usually involve piping in pipe racks, trestles, on sleepers, or suspended from overhead structures. Where applicable the structures should provide proper pipeline support, accommodate thermal expansion and contraction and provide structural support spacing that limits the vertical deflection and movement between supports.

Supports for polyethylene pipe should cradle at least the bottom 120° of the pipe, and be at least $^1/_2$ pipe diameter wide. Edges should be rounded or rolled to prevent cutting into the pipe. Commercial pipe supports such as U-bolts, narrow strap-type hangers, and roller type supports are unsuitable unless modified for width and cradling. The weight of the pipe and its contents must be distributed over a broad surface. Narrow support surfaces can produce high concentrated stress (point loading), and can possibly lead to pipeline failure.

Pipes supported in an overhead rack require design consideration for both support spacing and thermal length change. Support beams are spaced according to vertical deflection limits, and the rack width accommodates the total thermal expansion offset plus the diameter of the pipe. Pipe supports should be allowed to move along support beams, or otherwise accommodate horizontal movement as the pipe deflects laterally with changing temperature.

When not supported continuously in horizontal runs, hangers and brackets should be used at approximately the spacing given in Table E.1.

E.2 Joining

Polyethylene (PE) pipe can be joined to other PE pipe or fittings or to pipe or appurtenances of other materials by selecting one or more of the following joining systems: 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. The procedures provided below reference and incorporate information from the following documents.

1) ASTM F2620, *Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings*

2) PPI TR-33, *Generic Butt Fusion Joining Procedure for Polyethylene Gas Pipe* (2003)

3) PPI TR-41, *Generic Saddle Fusion Joining Procedure for Polyethylene Gas Piping* (2002)

4) PPI, *Handbook of Polyethylene Pipe*, Chapter 9, "Polyethylene Joining Procedures"

5) ASTM D2683, *Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter—Controlled Polyethylene Pipe and Tubing*

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

Table E.1—Support Spacing

IPS size	OD, in.	Support Spacing[1], ft						
		DR 7.3	DR 9	DR 11	DR 13.5	DR 17	DR 21	DR 26
2	2.375	5.3	5.1	4.9				
3	3.5	6.4	6.2	6	5.8	5.5	5.3	
4	4.5	7.3	7	6.8	6.5	6.3	6	5.7
5	5.563	8.1	7.8	7.6	7.3	7	6.7	6.4
6	6.625	8.8	8.5	8.3	7.9	7.6	7.3	6.9
8	8.625	10.1	9.7	9.4	9.1	8.7	8.3	7.9
10	10.75	11.2	10.9	10.5	10.1	9.7	9.2	8.8
12	12.75	12.2	11.9	11.5	11	10.5	10.1	9.6
14	14	12.8	12.4	12	11.5	11	10.6	10.1
16	16	13.7	13.3	12.8	12.3	11.8	11.3	10.8
18	18	14.5	14.1	13.6	13.1	12.5	12	11.4
20	20	15.3	14.8	14.3	13.8	13.2	12.6	12
22	22	16.1	15.6	15	14.5	13.8	13.2	12.8
24	24	16.8	16.3	15.7	15.1	14.4	13.8	13.2
26	26	17.5	16.9	16.3	15.7	15	14.4	13.7
28	28		17.6	17	16.3	15.6	14.9	14.2
30	30		18.2	17.6	16.9	16.1	15.4	14.7
32	32		18.8	18.1	17.5	16.7	15.9	15.2
34	34			18.7	18	17.2	16.4	15.7
36	36			19.2	18.5	17.7	16.9	16.2
42	42				20	19.1	18.3	17.4
48	48				21.4	20.4	19.5	18.6
54	54					21.7	20.7	19.8

[1]Support spacing for pipe at 73 °F (23 °C) filled with 73 °F (23 °C) water. Spacing will vary for different temperature and for different fluids in the pipe.

Heat fusion joining to liquid hydrocarbon permeated pipes may result in a low strength joint. Hydrocarbon permeated lines requiring repair should not be repaired using heat fusion joining or electrofusion joining methods. Mechanical fittings should be used to join or repair hydrocarbon permeated lines.

E.2.1 Heat Fusion

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

There are three types of heat fusion joints currently used in the industry; Butt, Saddle, and Socket Fusion. Additionally, there are two methods for producing the socket and saddle heat fusion joints. One method, used for all three types of joints, uses special heating tools for heating the parts to be joined. The other method, "Electrofusion," is used only for socket and saddle-type joints. Heat is generated by inducing electric current into a conductor that is a part of the electrofusion fitting.

The principle of heat fusion is to heat two surfaces to a designated temperature, then fuse them together by application of a sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion. When fused according to the pipe and/or fitting manufacturers' procedures, the joint area becomes as strong as or stronger than the pipe itself in both tensile and pressure properties. As soon as the joint cools to near ambient temperature, it is ready for handling.

Polyethylene pipe and fittings used for oil and gas applications are exposed to internal or external chemicals such as hydrocarbons, which may permeate polyethylene. Liquid hydrocarbon permeated polyethylene pipes should not be joined using heat fusion. Permeating chemicals may vaporize during heating, contaminate the bonding area and cause a low quality bond.

The following sections provide general procedural guidelines for each of these heat fusion methods.

E.2.1.1 Butt Fusion

The most widely used method for joining individual lengths of polyethylene pipe is by heat fusion of the pipe butt ends. This technique called butt fusion, excludes the need for specially modified pipe ends or couplings and produces a permanent, economical and flow-efficient connection. In the field butt fusions may be easily performed by trained operators using specially developed butt fusion machines.

There are basically six steps involved in making a butt fusion joint:

1) securely fasten the components to be joined;

2) face the pipe ends;

3) align the pipe profile;

4) melt the pipe interfaces;

5) join the two profiles together; and

6) hold under pressure and allow to cool.

E.2.1.2 Socket Fusion

Socket fusion is normally used with smaller OD pipes. The technique consists of simultaneously heating both the external surface of the pipe and the internal surface of the socket fitting until the material reaches fusion temperature; inspecting the melt pattern; inserting the pipe end into the socket; and holding it in place until the joint cools.

Mechanical equipment is used to hold the fitting and should be used for sizes larger than 2 in. CTS to attain the increased force required and to assist in alignment.

The following steps may be used to perform socket fusion joining:

1) select the equipment;

2) square and prepare the pipe ends;

3) heat the parts;

4) join the parts; and

5) allow to cool.

Socket fusion fittings are manufactured to ASTM D2683, *Socket-Type Polyethylene Fittings for Outside Diameter—Controlled Polyethylene Pipe and Tubing*. Pipe and tubing must be manufactured to OD controlled pipe or tubing specifications.

Field socket fusion tools are hand-held, and sizes above 2 in. two persons are usually required to make a joint.

E.2.1.3 Saddle Fusion

The technique for a saddle fusion or sidewall fusion consists mainly of simultaneously heating both the external surface of the pipe and the matching surface of the "saddle" type fitting with concave and convex shaped heating tools until both surfaces reach proper fusion temperature. This may be accomplished by using a saddle fusion or also called "sidewall fusion" equipment.

There are basically eight steps to effect a sidewall fusion joint. The eight basic steps used to perform a saddle fusion joint are as follows:

1) clean the pipe;

2) install heater saddle adapters;

3) install the saddle fusion machine on the pipe;

4) prepare the surfaces of the pipe and fitting;

5) align the parts;

6) heat both the pipe and the saddle fitting;

7) press and hold the parts together; and

8) cool the joint and remove the fusion machine.

E.2.2 Electrofusion

The electrofusion welding procedure differs somewhat from the conventional fusion joining procedures described above. The main difference between conventional heat fusion and electrofusion is the method by which the heat is applied. In conventional heat fusion joining, a heating tool is used to heat the pipe and fitting surfaces. The electrofusion joint is heated internally, either by a conductor at the interface of the joint or, as in one design, by a conductive polymer. Heat is created as an electric current is applied to the conductive material in the fitting.

Electrofusion is frequently used in oilfield applications where liquid hydrocarbon permeation has occurred in the interior pipe wall. It is also used where both pipes are constrained, such as for repairs or tie-in joints in the trench. Joints made between dissimilar polyethylene brands or grades are also made using electrofusion, as the procedure readily accommodates polyethylenes with different melt flow rates.

Electrofusion joining is performed using the following steps:

1) prepare the pipe (scrape, clean);

2) align the fitting and pipe with or without alignment clamps;

3) mark the pipe;

4) apply the electric current;

5) cool and remove the clamps; and

6) document the fusion procedures.

E.2.3 Flanging

Flanging is used when it is necessary to join polyethylene to steel, fiberglass and other piping materials that require an ANSI 150-lb flange connection. Flanging is also an option when it is required that a pipe section is capable of being disassembled for maintenance or where calculated accelerated wear requires fitting removal. The polyethylene flange adapter and back-up ring is a 2-part fitting that is designed so that one end is fusion welded to the polyethylene pipe and the other end is a flange-type configuration with a metal back-up ring that allows bolting to an ANSI 150-lb flange. (DR-5 400-psi application requires the use of ANSI 300-lb back-up rings or ANSI 300-lb lap joint flanges.)

Polyethylene flanges that do not incorporate the use a back-up ring are not recommended because polyethylene flanges require uniform pressure over the entire sealing surface. Without a back-up ring, a polyethylene flange could leak between the bolts.

A flange gasket may not be required for flanging polyethylene to polyethylene, especially at pressures below 80 psi. A flange gasket is always recommended when flanging polyethylene to any other material. Gasket manufacturers may be contacted to ensure that the intended service is recommended for the gasket material chosen and to confirm that the gasket material hardness is correct for the bolting pressures. Hard gaskets that require high bolting pressures may not seal when used with polyethylene flange adapters.

E.3 Trench Installation

Underground installations usually require trench excavation, placing pipe in the trench, placing embedment backfill around the pipe, and then placing backfill to the required finished grade.

There are many site and project specific parameters that affect the installation of polyethylene pipe. Pipe application and service requirements, size, type, soil conditions, backfill soil quality, burial depth and joining requirements all affect the installation.

Trench width varies depending on the depth of burial and the soil conditions. The width should be adequate to allow compaction in and around the pipe. Bedding material should be free of large clumps, oversize rock and other foreign materials. The bedding should consist of free flowing material such as gravel, sand, or similar material. More information can be found on suitable backfill and bedding materials in the standards mentioned below. Field bending the pipe can accommodate slight directional changes.

The care taken by the installer during installation can have a dramatic effect on how the system performs. A conscientious high quality installation in accordance with ASTM recommendations, engineering requirements and manufacturers specifications can ensure the polyethylene products perform as designed. On the other hand a low quality installation can cause substandard product performance. Additional information on the underground installation of polyethylene pipe can be found in ASTM D2774, *Standard Practice for Underground Installation of Thermoplastic Pressure Piping*; ASTM D2321, *Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications;* and ASTM F1668, *Standard Guide for Construction Procedures for Buried Plastic Pipe*.

E.4 Leak Test (Hydrostatic and Pneumatic Testing)

The premise of a leak test for polyethylene piping system is to locate any unacceptable fault in the system before it is put into service. A leak test should not be used to verify system pressure rating on existing pipe or potential application for service in existing pipe. The system design and the pipe pressure ratings using the equations found in Section 5 of this standard determine the systems pressure rating and long term performance. If leaks exist they usually occur in the joints or in connection to appurtenances in the system.

Pipeline failure during a leak test can be violent and dangerous. Especially if one is using pressurized gas for testing such as compressed air or nitrogen. When testing with compressed gas both the pressure stress on the system and the energy used to compress the gas are released at failure. The release is potentially violent and can be catastrophic. Where possible, a hydrostatic leak test should always be considered before a compressed gas leak test. Hydrostatic leak testing with water is the recommended and preferred method of testing.

E.4.1 References

1) ASTM F1417, *Standard Practice for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air*

2) ASTM F2164, *Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure*

3) PPI's *Handbook of Polyethylene Pipe,* Chapter 2, "Inspections, Tests and Safety Considerations"

4) ASME B31.3, *Process Piping*

E.4.2 Precautions

Where hydrostatic leak testing is required the following precautions are recommended: A more detailed procedure may be obtained by checking either of the above standards and guidelines.

1) the piping system under test should be checked to ensure that sections are fully restrained against sudden movement in case of rupture;

2) all air should be removed from the system before hydrostatic leak testing begins;

3) all heat fusion joints should be fully cooled before testing begins;

4) mechanical connections must be restrained and tied-in;

5) all fittings and appurtenances in the system should be verified to meet the test pressure;

6) all safety precautions to protect personnel in case of rupture should be in place: including suitable personal protective gear to prevent injury;

7) keep personnel a safe distance away during pneumatic testing.

E.4.3 Test Pressure

1) The maximum hydrostatic test pressure should be measured at the lowest point in the system.

2) The maximum hydrostatic leak test pressure is the lowest of:

   a) 150 % of the system design operating pressure;

   b) the pressure rating of the lowest rated component in the system.

3) The authority having jurisdiction may determine the maximum test pressure, as long as the test pressure does not exceed 150 % of the pipe's PR.

4) Elevated temperatures may reduce the maximum test pressure allowed depending on the specific site conditions.

E.4.4 Test Procedure (Hydrostatic)

1) Observe all safety precautions and site-specific safety regulations.

2) Remove all air from the test section by slowly filling with water and allowing entrapped air to escape through air release devices.

3) When the line is filled with water and all air is removed, gradually fill the pipe to the test pressure.

4) Maintain the pipe at test pressure for 3 hours. This is called the initial expansion phase. During this phase the polyethylene will expand slightly and the pressure will decrease. To maintain test pressure additional fluid will be required. It is not necessary to monitor the amount of water added during the initial expansion phase.

5) Immediately after the 3-hour Initial expansion phase is complete the test phase begins.

a) Reduce the test pressure by 10 psi.

b) Do not increase pressure or add additional make-up water.

c) Monitor the gauge for the next hour and record if the pressure remains steady (within 5 % of the test pressure).

6) If no visual leakage is indicated and the test pressure remains within 5 % of the test pressure value, the test is declared successful.

E.4.5 Test Procedure (Pneumatic)

1) Carefully consider if pneumatic testing should be authorized.

a) Approval should be sought from the owner and the project engineer.

2) Observe all safety precautions and site-specific safety regulations.

3) Keep personnel a safe distance away during pneumatic testing.

4) The pressure in the test section should be slowly increased to not more than half the system design test pressure.

5) Test pressure is temperature dependent.

6) Gradually increase test pressure in small increments (5 psi) up to 150 % of the system design pressure or to the authorized pneumatic test pressure.

7) Maintain the test pressure for ten (10) to sixty (60) minutes. This is the initial expansion phase for pneumatic testing.

8) Reduce test pressure to the system design pressure or to the authorized pneumatic test pressure and hold the pressure until such time to determine if a leak exists.

9) All safety precautions to protect personnel in case of rupture should be in place: including suitable personal protective gear to prevent injury if failure occurs.

NOTE Under no circumstances shall the total time under test exceed eight (8) hours at 1.5 times the system pressure rating. If the test is not complete during this time frame (due to leakage, equipment failure, etc.), the test section shall be depressurized and permitted to “relax” for eight (8) hours prior to the next test sequence.

E.5 Thermal Expansion and Contraction

The coefficient of thermal expansion and contraction for polyethylene pipe is about 10 times that of steel pipe. This means that an unrestrained polyethylene line will expand or contract about ten times the distance of a comparable steel pipe. When polyethylene pipe is restrained the stresses developed due to expansion and contraction are considerably less than those of a steel line. This is due to the lower Modulus of Elasticity of polyethylene pipe compared to steel pipe. When polyethylene is properly anchored and restrained changes in temperature and the related expansion and contraction have no adverse effect.

The equation to calculate expansion and contraction for polyethylene is given by:

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

where

ΔL is the length change, in.;

L is the pipe length, in.;

α is the thermal expansion coefficient, in./in./°F (9.0×10^{-5} in./in./°F);

ΔT is the temperature change, °F.

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