

Specification for Polyethylene Line Pipe (PE)

API SPECIFICATION 15LE
THIRD EDITION, APRIL 1, 1995

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005



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Exploration and Production Department

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FOREWORD

This specification is under the jurisdiction of the API Committee on Standardization of Plastic Pipe and includes changes adopted at the 1992 conference. Since this edition is an extensive revision of the prior edition, bar notations in the margins have not been used to identify the changes.

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

Specification for Polyethylene Line Pipe (PE)

1 Scope

1.1 PURPOSE

1.1.1 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 service for the oil and gas producing industries.

1.1.2 Technical content provides requirements for performance, design, materials, tests and inspection, marking, handling, storing and shipping.

1.2 APPLICATIONS

1.2.1 Equipment

This specification covers polyethylene line pipe utilized for the production of oil, gas and non-potable water. Specific equipment covered by this specification is listed as follows:

- Polyethylene line pipe.
- Polyethylene fittings.

1.2.2 Service Conditions

The standard service conditions for the Specification 15LE Standard Pressure Rating are as follows:

- Service life is 50 years.
- Service temperature is 73° F.
- The fluid environment is salt water.
- Axial loads shall include end loads due to pressure only.

Service conditions other than the standard Specification 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. SI (metric) unit conversions are described in Appendix B.

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 *Pipe Flanges and Flanged Fittings*

ASTM

D618 *Method for Conditioning Plastics and Electrical Insulating Materials for Testing*

- D1238 *Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer*
- D1248 *PE Plastics Moldings and Extrusion Materials*
- D1505 *Test Method for Density of Plastics by the Density-Gradient Technique*
- D1598 *Test Method for Time-to-Failure of Plastic Pipe Under constant Internal Pressure*
- D1599 *Test Method for Short-Time, Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings*
- D1603 *Test Method for Carbon Black in Olefin Plastics*
- D2122 *Determining Dimensions of Thermoplastics Pipe and Fittings*
- D2290 *Apparent Tensile Strength of Ring of Tubular Plastic by Split Disk Method*
- D2513 *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings*
- D2657 *Heat Joining Polyolefin Pipe and Fittings*
- D2683 *Socket-Type PE Fittings for Outside Diameter-Controlled PE Pipe and Tubing*
- D2774 *Underground Installation of Thermoplastic Pressure Pipe and Fittings*
- D2837 *Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials*
- D3035 *Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter*
- D3140 *Recommended Practice for Flaring Polyolefin Pipe and Tubing*
- D3261 *Butt Heat Fusion PE Plastic Fittings for PE Plastic Pipe and Tubing*
- D3350 *PE Plastic Pipe and Fitting Material*
- F412 *Standard Definitions of Terms Relating to Plastic Piping Systems*
- F714 *Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter*

Code of Federal Regulations (Office of Pipeline Safety)

Title 49, Part 192 *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards*

PPI

TN-10 *Description of Plastic Piping Joints*

- TR-4 *Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe and Fittings Compounds*
 TR-20 *Joining Polyolefin Pipe*
 TR-31 *Underground Installation of Polyolefin Piping*

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

Other nationally or internationally recognized standards shall be submitted to and approved by API for inclusion in this specification prior to use as equivalent standards.

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: A fusing of polyethylene materials per a qualified procedure that entails squaring and aligning the pipe materials, heating the pipe ends to a condition as described by the qualified procedure, pressuring the two aligned ends together as required by the qualified procedure and a predetermined cooling time as specified by the qualified procedure which results in a joining of two pipe materials which will exhibit a hydrostatic strength equal to the parent pipe.

3.1.4 cell classification: This term applies to use of ASTM D3350 in specifying the polyethylene material parameters.

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

3.1.6 fittings: Tee's, 90's and 45's.

3.1.7 flanges: Face flanges with bolt circle per ANSI B16.5. Incorporates use of polyethylene flange and metallic backup ring.

3.1.8 hydrostatic design basis: This is the design stress for polyethylene pipe as determined by use of test method ASTM D2837. The design basis for polyethylene materials is reduced as the temperature goes up, therefore the design basis used should be that for the maximum service temperature expected.

3.1.9 hydrostatic design stress: This stress is the hydrostatic design basis divided by two and is the recommended

maximum hoop stress that can be applied continuously with a degree of certainty that failure of the pipe will not occur.

3.1.10 hydrostatic working pressure: Pressure which the pipe may withstand in actual service. This pressure is calculated based on the applicable safety factors required by regulation and also by use of the appropriate hydrostatic design stress for the applicable temperature.

3.1.11 long term hydrostatic hoop strength: Strength exhibited by the polyethylene pipe material when exposed to testing parameters as defined in ASTM D1598.

3.1.12 lot number: Assignment of a unique code to each lot of components to maintain traceability.

3.1.13 ovality: This is a measurement of the deflected set in a cross section of pipe and is expressed as a percentage. It is measured by taking the maximum measured diameter minus the minimum measured diameter and dividing that sum by the average measured diameter and multiplying that resultant by 100.

3.1.14 point of fusion: The end of pipe or fitting which is available for trimming, heating, and pressing together during the heat fusion process.

3.1.15 records: Retrievable information.

3.1.16 reducers: Components that allow pipes of different sizes 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 hoop strength: Strength exhibited by the polyethylene piping material when exposed to testing parameters as defined per ASTM D1599.

3.1.19 socket fusion: A joining process of polyethylene pipe and socket type polyethylene fittings manufactured per ASTM D2683. The preparing, heating, and pressing together of components shall be defined in a qualified procedure.

3.1.20 Specification 15LE standard pressure rating: Pressure rating using the manufacturer's pressure rating methodology.

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

3.2 ABBREVIATIONS

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

4 Purchasing Guidelines

4.1 GENERAL

This section provides recommended guidelines for inquiry and purchase of API Specification 15LE pipe or fittings as follows:

Specification	API Specification 15LE
Type	Polyethylene 6.2
Quantity	Feet or pieces
Nominal Size	Table 3
SDR	Table 3
Length	5.2.2
Delivery date & shipping instructions	As requested
Fittings	Tables 4 and 5

5 Design

5.1 DESIGN

5.1.1 Hydrostatic Design Basis (HDB)

The Hydrostatic Design Basis is established by the manufacturer in accordance with ASTM D2837: Standard Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials. The Hydrostatic Design Basis may and probably will vary based on temperature and environmental conditions. The manufacturer should be consulted for recommended values based on the intended use.

5.1.2 Hydrostatic Design Stress (HDS)

Hydrostatic Design Stress is the estimated maximum tensile stress in the wall of the pipe in the circumferential orientation due to internal hydrostatic pressure that can be applied continuously for a satisfactory and safe pipe operation. Hydrostatic Design Stress is obtained by multiplying the Hydrostatic Design Basis by the Design Service Factor.

5.1.3 Design Service Factor (DSF)

The Design Service Factor in Table 1 is a derating factor to compensate for system variables in a thermoplastic piping installation and includes the possible effects of the transported medium on the long-term performance of the piping, hazardous nature of the application and governmental regulations. Use the Design Service Factor as shown in Table 1 to obtain the hydrostatic working pressure per 5.1.6.

5.1.4 Temperature Service Factors

A temperature service factor is not required for materials with an HDB established at elevated temperature. In most circumstances, the HDB obtained at 73°F can be used for applications up to 100°F without further derating. Materials

without an HDB at elevated temperature should not be used for any sustained period of time at temperatures above 100°F.

Table 1—Design Service Factor

Environment	Factor
Potable Water	0.5
Waste or Drain Water	0.5
Acetic, Basic or Saltwater	0.5
Dry Natural Gas (gathering)	0.5
Natural Gas (Distribution) (Note 1)	0.32
Liquid Hydrocarbons (crude oil, etc.) (Note 2)	0.25

Notes:

1. The DSF for natural gas distribution has been established by Department of Transportation, Office of Pipeline Safety Regulations, Title 49 CFR 192.
2. The DSF for crude oil and other oilfield liquid hydrocarbons has been found satisfactory for long-term service and is suggested if more precise data is not available.

5.1.5 Hydrostatic Strength

Design stresses are based on a design service factor applied to the hydrostatic design basis. Materials designated as PE2406 meeting this specification have a hydrostatic design basis of 1,250 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 PE3408 meeting this specification have a hydrostatic design basis of 1,600 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).

The hydrostatic design basis in 5.1.1 at 73°F shall be validated by additional long-term stress rupture testing at 140°F (60°C) and evaluated in accordance with the requirements of Method ASTM D2837 with the 100,000 hour intercept not less than 600 psi. These tests may be conducted with natural gas, other fuel gas or water as the pressure media.

Information regarding commercial compounds meeting the design stress requirements of this specification is provided in the Technical Report TR-4, published by and available from the Plastics Pipe Institute (PPI), 1275 K Street N.W., Suite 400, Washington, D.C. 20005.

Examples:

1. Determine the Hydrostatic Design Stress for a PE3408 pipe system to handle water at 73.4°F (23°C).

Hydrostatic Design Basis for water at 73.4°F (23°C) is 1600 psi (11030 kPa).

Hydrostatic Design Stress = Hydrostatic Design Basis (1600 psi) × Design Service Factor (.5) = 800 psi (5515 kPa).

2. Determine the Hydrostatic Design Stress for a PE3408 pipe system to handle oil with brief temperature excursions of up to 95°F (35°C). Hydrostatic Design Basis for water at 73.4°F (23°C) is 1600 psi (11030 kPa).

Design Service Factor = .25 for liquid hydrocarbons

Hydrostatic Design Stress = Hydrostatic Design Basis
(1600 psi) × Design Service Factor (.25) = 400 psi (2758 kPa).

3. Determine the Hydrostatic Design Stress for a PE3408 pipe system to handle oil at a service temperature of 140°F (60°C).

If the Hydrostatic Design Basis for water at 140°F (60°C) is 800 psi*

Hydrostatic Design Stress = Hydrostatic Design Basis (800 psi) × Design Service Factor (.25) = 200 psi (1379 kPa)

5.1.6 Hydrostatic Working Pressure

The working pressure of a pipe can be established from its dimensions and the pipe material Hydrostatic Design Stress through the following formula:

$$P = \frac{2St}{D}$$

Where:

P = Hydrostatic Working Pressure, psig

S = Hydrostatic Design Stress, psi

D = Mean Diameter = OD - t or ID + t , in.

t = Minimum Pipe Wall Thickness, in.

Therefore, the working pressure for nominal size one inch SDR 11 pipe (Table 2) using the hydrostatic design stress of 400 psi calculated in example 2 of paragraph 5.1.5 (PE3408 with oil at 95°F, 35°C) would be as follows:

$$P = \frac{(2)(400)(0.119)}{(1.315 - 0.119)} = 79.6 \text{ psig} \quad (548.8 \text{ kPa})$$

Note: Table 2 lists working pressure for PE pipe for specific temperature and environmental conditions.

5.2 DIMENSIONS AND TOLERANCES

5.2.1 Size

Pipe furnished to this specification shall comply with the dimensions and tolerances given in Table 3 as specified on the purchase order.

5.2.1.1 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 3 when measured at any point within 1.5 pipe diameters or 11.8 in. (300mm), whichever is less, to the cut end of the pipe length.

5.2.2 Length

Pipe shall be furnished in cut lengths or coils as specified

*See HDB definition

on the purchase order. Jointers (two pieces fused together to make a length) are not acceptable.

5.2.3 Fittings

Fittings furnished to this specification shall comply with the dimensions and tolerances given in Tables 4 and 5.

5.2.4 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, and fabrication.

6.2 MATERIAL

Polyethylene pipe and fittings shall be made from Grade P24 Type II Class B or C or Grade P34 Type III Class B or C compounds meeting the requirements set forth in ASTM D1248: Polyethylene Plastics Molding and Extrusion Materials. The compounds shall also be described according to appropriate cell classifications as defined in ASTM D3350: "Standard Specification for Polyethylene Pipe and Fittings Materials", as shown in Table 6.

The standard designations for PE pipe compounds classified as above and meeting all applicable short-term and long-term requirements of Sections 5 and 7 of this specification are, respectively, PE2406 and PE3408. In addition, the material shall have a PPI recommended long term hydrostatic stress rating.

6.3 REWORK MATERIAL

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

6.4 FITTINGS

Fittings for use with this pipe are defined by ASTM 3261: Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene Pipe and Fittings, and ASTM D2683: Socket Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pie and Tubing. Refer to Tables 4 and 5. Fitting

Table 2—Polyethylene Pressure Rating

(1) Nominal Size (inches)	(2) Schedule or SDR	(3) Outside Diameter (inches)	(4) Minimum Wall Thickness (inches)	(5) Maximum Allowable Operating Pressure (psig) at 73.4°F (23°C) (Note 3)					
				(6) Water		(7) Crude		(8) Natural Gas	
				(9) HDS 630	(10) HDS 800	(11) HDS 630	(12) HDS 800	(13) HDS 630	(14) HDS 800
1/2	SDR 21	0.840	0.062	100	130	50	65	64	83
	SDR 17		0.062	100	130	50	65	64	83
	SDR 13.5		0.062	100	130	50	65	64	83
	SDR 11		0.076	125	160	60	80	80	100
	SDR 9		0.093	160	200	80	100	100	100
	SDR 7.3		0.115	200	255	100	125	100	100
3/4	SDR 21	1.050	0.062	80	100	40	50	51	64
	SDR 17		0.062	80	100	40	50	51	64
	SDR 13.5		0.078	100	125	50	60	64	83
	SDR 11		0.095	125	160	60	80	80	100
	SDR 9		0.117	160	200	80	100	100	100
	SDR 7.3		0.144	200	255	100	125	100	100
1	SDR 21	1.315	0.062	60	80	30	40	38	51
	SDR 17		0.077	80	100	40	50	51	64
	SDR 13.5		0.097	100	125	50	60	64	83
	SDR 11		0.119	125	160	60	80	80	100
	SDR 9		0.146	160	200	80	100	100	100
	SDR 7.3		0.180	200	255	100	125	100	100
1 1/4 through 5	SDR 21	See Table 3		60	80	30	40	38	51
	SDR 17			80	100	40	50	51	64
	SDR 13.5			100	125	50	60	64	83
	SDR 11			125	160	60	80	80	100
	SDR 9			160	200	80	100	100	100
	SDR 7.3			200	255	100	125	100	100
6 through 54	SDR 32.5			40	50	20	25	25	30
	SDR 26			50	64	25	30	30	40
	SDR 21			60	80	30	40	40	50
	SDR 17			80	100	40	50	50	65
	SDR 15.5			85	105	45	60	60	70
	SDR 13.5			100	130	50	65	65	80
	SDR 11			125	160	60	80	80	100
	SDR 9			155	200	80	100	100	100
	SDR 7.3			200	255	100	125	100	100
	SDR 7			210	265	105	135	100	100

Notes:

- Columns 5 through 8 have been rounded to the nearest five (5) psig.
- A service factor of 0.25 was used to calculate a pressure rating for crude oil and is suggested if more precise data is not available.
- Columns 9 and 10 were calculated based on federal regulations with 100 psig the maximum allowable pressure for plastic pipe. Currently there is no provision in the code for the higher pressure ratings afforded by the PE3408 resins. For more information see: Department of Transportation, Hazardous

- Materials Registration Board, Title 49, Part 192, Transportation of Natural Gas by Pipeline Minimum Federal Safety Standards, Federal Register, Volume 35, No. 161, Wednesday, August 19, 1970 and amendments.
- HDS 630 refers to those resins with a 630 psi Hydrostatic Design Stress at 73.4°F (23°C), i.e., PE 2406 and 3406. HDS 800 refers to those resins with a 800 psi Hydrostatic Design Stress, i.e., PE 3408.

Table 3—Dimensions and Tolerances Based on Outside Diameters

(1) Nominal Size in.	(2) Outside Diameter, Average		(4) Schedule or SDR	(5) Wall Thickness, Minimum		(6)
	in.	mm		in.	mm	
1/2	0.840 ± 0.004	21.34 ± 0.10	SDR 21	0.062 + 0.015	1.58 + 0.38	
			SDR 17	0.062 + 0.015	1.58 + 0.38	
			SDR 13.5	0.062 + 0.015	1.58 + 0.38	
			SDR 11	0.076 + 0.018	1.93 + 0.46	
			SDR 9	0.093 + 0.020	2.36 + 0.51	
3/4	1.050 ± 0.004	26.67 ± 0.10	SDR 21	0.062 + 0.015	1.58 + 0.38	
			SDR 17	0.062 + 0.015	1.58 + 0.38	
			SDR 13.5	0.078 + 0.018	1.59 + 0.46	
			SDR 11	0.095 + 0.020	2.41 + 0.51	
			SDR 9	0.117 + 0.026	2.97 + 0.66	
1	1.315 ± 0.005	33.40 ± 0.13	SDR 21	0.062 + 0.015	1.58 + 0.38	
			SDR 17	0.077 + 0.015	1.96 + 0.46	
			SDR 13.5	0.097 + 0.020	2.46 + 0.66	
			SDR 11	0.119 + 0.026	3.02 + 0.66	
			SDR 9	0.146 + 0.026	3.71 + 0.66	
1 1/4	1.660 ± 0.005	42.16 ± 0.13	SDR 21	0.079 + 0.018	2.01 + 0.48	
			SDR 17	0.098 + 0.020	2.49 + 0.51	
			SDR 13.5	0.123 + 0.026	3.12 + 0.66	
			SDR 11	0.151 + 0.026	3.84 + 0.66	
			SDR 9	0.184 + 0.026	4.67 + 0.66	
1 1/2	1.900 ± 0.006	48.26 ± 0.15	SDR 21	0.090 + 0.020	2.27 + 0.51	
			SDR 17	0.112 + 0.020	2.84 + 0.51	
			SDR 13.5	0.141 + 0.020	3.58 + 0.51	
			SDR 11	0.173 + 0.026	4.39 + 0.66	
			SDR 9	0.211 + 0.026	5.36 + 0.66	
2	2.375 ± 0.006	60.33 ± 0.15	SDR 21	0.113 + 0.020	2.97 + 0.51	
			SDR 17	0.140 + 0.020	3.56 + 0.51	
			SDR 13.5	0.176 + 0.021	4.47 + 0.53	
			SDR 11	0.216 + 0.026	5.49 + 0.66	
			SDR 9	0.264 + 0.031	6.70 + 0.79	
3	3.500 ± 0.008	88.90 ± 0.20	SDR 21	0.167 + 0.020	4.24 + 0.51	
			SDR 17	0.206 + 0.025	5.23 + 0.64	
			SDR 13.5	0.259 + 0.031	6.58 + 0.79	
			SDR 11	0.318 + 0.038	8.08 + 0.97	
			SDR 9	0.389 + 0.045	9.88 + 1.14	
4	4.500 ± 0.009	114.30 ± 0.23	SDR 21	0.214 + 0.026	5.44 + 0.66	
			SDR 17	0.264 + 0.032	6.71 + 0.81	
			SDR 13.5	0.333 + 0.040	8.46 + 1.02	
			SDR 11	0.409 + 0.048	10.39 + 1.24	
			SDR 9	0.500 + 0.060	12.70 + 1.52	
5	5.563 ± 0.010	141.30 ± 0.25	SDR 21	0.265 + 0.032	6.73 + 0.81	
			SDR 17	0.328 + 0.039	8.33 + 0.99	
			SDR 13.5	0.413 + 0.050	10.49 + 1.27	
			SDR 11	0.506 + 0.061	12.85 + 1.55	
			SDR 9	0.618 + 0.075	15.65 + 1.90	
6	6.625 ± 0.011	168.28 ± 0.28	SDR 7.3	0.762 + 0.090	19.35 + 2.29	
			SDR 7	0.795 + 0.095	20.19 + 2.42	
			SDR 32.5	0.204 + 0.024	5.14 + 0.61	
			SDR 26	0.255 + 0.031	6.48 + 0.79	

Table 3—Dimensions and Tolerances Based on Outside Diameters (Continued)

(1) Nominal Size in	(2) Outside Diameter, Average		(4) Schedule or SDR	(5) Wall Thickness, Minimum		
	in	mm		(3)	(6)	
					in.	mm
8	8.625 ± 0.015	219.08 ± 0.38	SDR 21	0.316 + 0.038	8.03 + 0.97	
			SDR 17	0.390 + 0.047	9.91 + 1.19	
			SDR 13.5	0.491 + 0.059	12.47 + 1.50	
			SDR 11	0.602 + 0.072	11.53 + 1.83	
			SDR 9	0.736 + 0.090	18.69 + 2.29	
			SDR 7.3	0.908 + 0.110	23.06 + 2.79	
			SDR 7	0.946 + 0.114	24.03 + 2.88	
10	10.750 ± 0.015	273.05 ± 0.38	SDR 32.5	0.265 + 0.032	6.73 + 0.81	
			SDR 26	0.332 + 0.040	8.44 + 1.02	
			SDR 21	0.410 + 0.049	10.41 + 1.24	
			SDR 17	0.508 + 0.061	12.90 + 1.55	
			SDR 13.5	0.639 + 0.077	16.23 + 1.96	
			SDR 11	0.785 + 0.094	19.94 + 2.39	
			SDR 9	0.958 + 0.113	24.33 + 2.87	
			SDR 7.3	1.182 + 0.139	30.02 + 3.53	
12	12.750 ± 0.017	323.85 ± 0.43	SDR 7	1.232 + 0.148	31.29 + 3.76	
			SDR 32.5	0.331 + 0.040	8.41 + 1.02	
			SDR 26	0.413 + 0.050	10.49 + 1.27	
			SDR 21	0.511 + 0.061	12.98 + 1.55	
			SDR 17	0.633 + 0.076	16.08 + 1.93	
			SDR 13.5	0.797 + 0.096	20.24 + 2.44	
			SDR 11	0.978 + 0.117	24.84 + 2.97	
			SDR 9	1.194 + 0.139	30.33 + 3.53	
14	14.000 ± 0.063	355.6 ± 1.60	SDR 7.3	1.473 + 0.150	37.44 + 3.81	
			SDR 7	1.536 + 0.184	39.01 + 4.68	
			SDR 32.5	0.392 + 0.047	9.96 + 1.19	
			SDR 26	0.490 + 0.059	12.45 + 1.50	
			SDR 21	0.608 + 0.073	15.44 + 1.85	
			SDR 17	0.750 + 0.090	19.05 + 2.29	
			SDR 13.5	0.945 + 0.113	24.00 + 2.87	
			SDR 11	1.160 + 0.139	29.46 + 3.53	
16	16.000 ± 0.072	406.4 ± 1.83	SDR 9	1.417 + 0.150	35.99 + 3.81	
			SDR 7.3	1.747 + 0.175	44.37 + 4.45	
			SDR 7	1.821 + 0.219	46.25 + 5.55	
			SDR 32.5	0.431 + 0.052	10.95 + 1.32	
			SDR 26	0.538 + 0.065	13.67 + 1.65	
			SDR 21	0.667 + 0.080	16.94 + 2.03	
			SDR 17	0.824 + 0.099	20.93 + 2.51	
			SDR 11	1.273 + 0.153	32.33 + 3.89	
18	18.000 ± 0.081	457.2 ± 2.05	SDR 9	1.556 + 0.187	39.52 + 4.75	
			SDR 7.3	1.918 + 0.230	48.72 + 5.84	
			SDR 7	2.000 + 0.240	50.80 + 6.10	
			SDR 32.5	0.492 + 0.059	12.50 + 1.52	
			SDR 26	0.615 + 0.074	15.62 + 1.88	
			SDR 21	0.762 + 0.091	19.35 + 2.31	
			SDR 17	0.941 + 0.113	23.90 + 2.87	
			SDR 11	1.455 + 0.175	36.96 + 4.45	
20	20.000 ± 0.090	508.0 ± 2.29	SDR 9	1.778 + 0.213	45.16 + 5.41	
			SDR 7	2.286 + 0.274	58.06 + 6.97	
			SDR 32.5	0.554 + 0.066	14.07 + 1.68	
			SDR 26	0.692 + 0.083	17.58 + 2.11	
			SDR 21	0.857 + 0.103	21.77 + 2.62	
			SDR 17	1.059 + 0.127	26.90 + 3.23	
			SDR 11	1.636 + 0.196	41.55 + 4.98	
			SDR 9	2.000 + 0.240	50.80 + 6.10	
20	20.000 ± 0.090	508.0 ± 2.29	SDR 32.5	0.615 + 0.074	15.62 + 1.88	
			SDR 26	0.769 + 0.092	19.53 + 2.34	
			SDR 21	0.952 + 0.114	24.18 + 2.90	
			SDR 17	1.176 + 0.141	29.87 + 3.58	
			SDR 11	1.818 + 0.218	46.18 + 5.54	
SDR 9	2.222 + 0.267	56.44 + 6.77				

Table 3—Dimensions and Tolerances Based on Outside Diameters (Continued)

(1) Nominal Size in.	(2) Outside Diameter, Average		(4) Schedule or SDR	(5) Wall Thickness, Minimum		(6)
	in.	mm		in.	mm	
21.5	21.500 ± 0.97	546.1 ± 2.46	SDR 32.5	0.662 + 0.079	16.81 + 2.02	
			SDR 26	0.827 + 0.099	21.01 + 2.51	
			SDR 21	1.024 + 0.123	26.01 + 3.12	
			SDR 19	1.132 + 0.136	28.75 + 3.45	
			SDR 17	1.265 + 0.152	32.13 + 3.86	
			SDR 15.5	1.387 + 0.166	35.23 + 4.23	
			SDR 13.5	1.593 + 0.191	40.46 + 4.86	
			SDR 11	1.955 + 0.235	49.66 + 5.96	
22	22.000 ± 0.099	558.8 ± 2.51	SDR 32.5	0.677 + 0.081	17.20 + 2.06	
			SDR 26	0.846 + 0.102	21.49 + 2.58	
			SDR 21	1.048 + 0.126	26.62 + 3.19	
			SDR 17	1.294 + 0.155	32.87 + 3.94	
			SDR 11	2.000 + 0.240	50.80 + 6.10	
24	24.000 ± 0.108	609.6 ± 2.74	SDR 32.5	0.738 + 0.089	18.75 + 2.25	
			SDR 26	0.923 + 0.111	23.44 + 2.81	
			SDR 21	1.143 + 0.137	29.03 + 3.48	
			SDR 17	1.412 + 0.169	35.86 + 4.30	
			SDR 11	2.182 + 0.262	55.42 + 6.65	
28	28.000 ± 0.126	711.2 ± 3.20	SDR 32.5	0.862 + 0.103	21.89 + 2.63	
			SDR 26	1.077 + 0.129	27.36 + 3.28	
			SDR 21	1.333 + 0.160	33.86 + 4.06	
			SDR 17	1.646 + 0.198	41.83 + 5.02	
			SDR 15.5	1.806 + 0.217	45.87 + 5.50	
			SDR 13.5	2.074 + 0.249	52.68 + 6.32	
			SDR 11	2.545 + 0.305	64.64 + 7.76	
30	30.000 ± 0.135	762 ± 3.43	SDR 32.5	0.923 + 0.111	23.44 + 2.81	
			SDR 26	1.154 + 0.138	29.31 + 3.52	
			SDR 21	1.429 + 0.171	36.30 + 4.36	
			SDR 19	1.574 + 0.189	39.98 + 4.80	
			SDR 17	1.765 + 0.212	44.83 + 5.38	
			SDR 15.5	1.935 + 0.232	49.15 + 5.90	
			SDR 13.5	2.222 + 0.267	56.44 + 6.77	
			SDR 11	2.727 + 0.327	69.27 + 8.31	
32	32.000 ± 0.144	812.8 ± 3.66	SDR 32.5	0.985 + 0.118	25.02 + 3.00	
			SDR 26	1.231 + 0.148	31.27 + 3.75	
			SDR 21	1.524 + 0.183	38.71 + 4.65	
			SDR 17	1.882 + 0.226	47.80 + 5.74	
			SDR 15.5	2.065 + 0.248	52.45 + 6.65	
			SDR 13.5	2.370 + 0.284	60.20 + 7.22	
			SDR 11	2.909 + 0.349	73.89 + 8.87	
34	34.000 ± 0.153	863.6 ± 3.89	SDR 32.5	1.046 + 0.126	26.57 + 3.19	
			SDR 26	1.308 + 0.157	33.22 + 3.99	
			SDR 21	1.614 + 0.194	40.00 + 4.80	
			SDR 19	1.789 + 0.215	45.44 + 5.45	
			SDR 17	2.000 + 0.240	50.80 + 6.10	
			SDR 15.5	2.194 + 0.263	55.70 + 6.69	
			SDR 13.5	2.519 + 0.302	64.00 + 7.68	
			SDR 11	3.091 + 0.371	78.51 + 9.42	
36	36.000 ± 0.162	914.4 ± 4.11	SDR 32.5	1.108 + 0.133	28.14 + 3.38	
			SDR 26	1.385 + 0.166	35.18 + 4.22	
			SDR 21	1.714 + 0.206	43.54 + 5.22	
			SDR 17	2.118 + 0.254	53.80 + 6.46	
			SDR 15.5	2.323 + 0.279	56.64 + 6.80	
			SDR 13.5	2.667 + 0.320	67.74 + 8.13	
			SDR 11	3.273 + 0.393	83.13 + 9.98	
42	42.000 ± 0.189	1066.8 ± 4.80	SDR 32.5	1.292 + 0.155	32.82 + 3.94	
			SDR 26	1.615 + 0.194	41.02 + 4.93	
			SDR 21	2.000 + 0.240	50.80 + 6.10	
			SDR 17	2.471 + 0.297	62.76 + 7.54	
			SDR 15.5	2.710 + 0.325	68.83 + 8.26	
48	48.000 ± 0.216	1219.2 ± 5.49	SDR 32.5	1.477 + 0.177	37.52 + 4.50	

Table 3—Dimensions and Tolerances Based on Outside Diameters (Continued)

(1) Nominal Size in.	(2) Outside Diameter, Average		(4) Schedule or SDR	(6) Wall Thickness, Minimum	
	in.	mm		in.	mm
54	54.000 ± 0.243	1371.6 ± 6.17	SDR 26	1.846 + 0.222	46.89 + 5.64
			SDR 21	2.286 + 0.274	58.06 + 6.96
			SDR 32.5	1.662 + 0.194	42.21 + 4.93
			SDR 26	2.077 + 0.249	52.76 + 6.33
			SDR 21	2.571 + 0.309	65.30 + 7.85

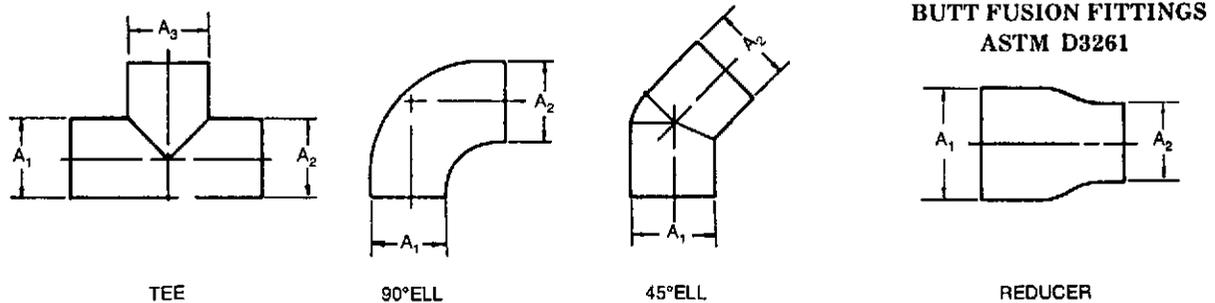
Notes:

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. D2513 Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings. D3035 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR), Based on Outside Diameters. F714 Standard Specification for 3 - 63-in. (SDR-PR) Polyethylene Pipe.
2. The Standard Dimension Ratios (SDR) are a series of numbers in which the dimension ratios are constants for all sizes of pipe. The dimension ratio is the specified diameter divided by the minimum wall thickness. Standard dimension ratios use the ANSI Preferred Number Series 10 modified by +1. The ANSI Preferred Number Standard Z17.1 is referenced in ASTM F412 in the SDR definition.
3. Exceptions to the Standard Dimension Ratios are:

Size, in. 1/2	SDR 21 SDR 17 SDR 13.5	Size, in. 3/4	SDR 21 SDR 17 SDR 13.5	Size, in. 1	SDR 21 SDR 17	Size, in. 1 1/4	SDR 21
						1 1/2	SDR 21

Wall thickness in these products are minimums and are not a function of SDR.

Table 4—Fittings Outlet Dimensions for PE Pipe



BUTT FUSION FITTINGS
ASTM D3261

Nominal Iron Pipe Size (IPS) Sizing System Outside Diameters and Tolerances for Fittings for Use with Polyethylene Plastic Pipe, in.

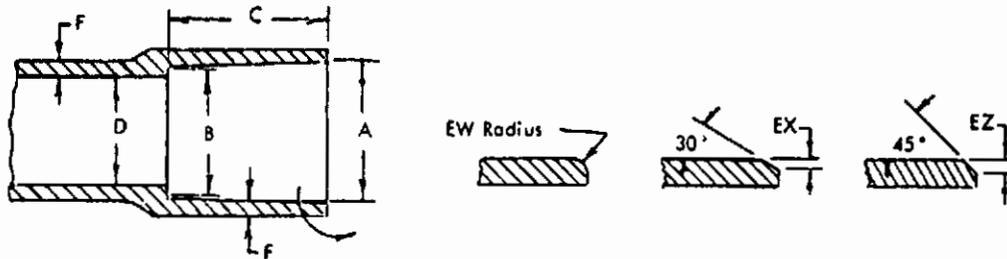
Nominal Pipe Size	Average Outside Diameter at Area of Fusion "A _x " (Note 2)	Tolerance (Note 3)
1/2	0.840	±0.008
3/4	1.050	±0.008
1	1.315	±0.010
1 1/4	1.660	±0.010
1 1/2	1.900	±0.010
2	2.375	±0.010
3	3.500	±0.012
4	4.500	±0.015
6	6.625	±0.018
8	8.625	+0.025
10	10.750	±0.027
12	12.750	±0.036
14	14.000	±0.063
16	16.000	±0.072
18	18.000	±0.081
20	20.000	±0.090

Nominal Pipe Size	Average Outside Diameter at Area of Fusion "A _x " (Note 2)	Tolerance (Note 3)
21.5	21.500	±0.097
22	22.000	±0.099
24	24.000	±0.108
28	28.000	±0.126
32	32.000	±0.144
36	36.000	±0.162
42	42.000	±0.189
48	48.000	±0.216
54	54.000	±0.243

Notes:

1. Additional sizes and schedules are available and are listed in ASTM D3261.
2. Defined as measured 1/4 inch (6.4 mm) from outlet extremity
3. Further, fabricated fittings are to be measured in accordance with 5.2.1.1.

Table 5—Dimensions of PE Socket Fitting for OD Controlled PE Pipe ASTM D 2683

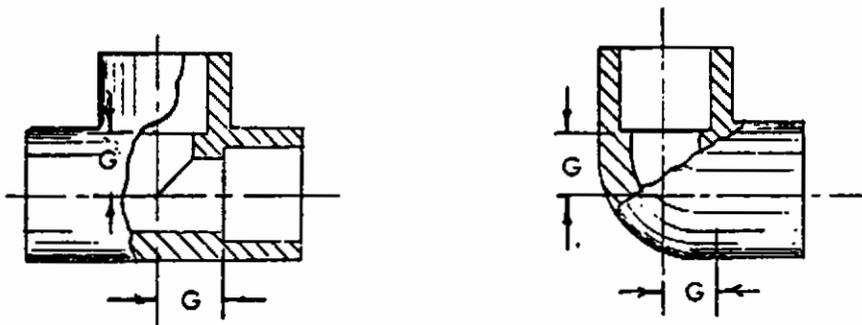


Nominal Pipe Size	A Socket Entrance Diameter			B ^b Socket Bottom Diameter			C	D	E	F	EW	EX	EZ
	Average Diameter	Tolerance On Diameter	Maximum Out-of-Round	Average Diameter	Tolerance On Diameter	Maximum Out-of-Round	Socket Length, min	Inside Diameter, min	Wall Thickness, min		Entrance, min		
1/2	0.810	±0.005	±0.008	0.804	±0.005	±0.008	0.575	0.700	0.112	0.118	1/32	1/32	1/32
3/4	1.020	±0.008	±0.010	1.012	±0.008	±0.010	0.625	0.920	0.119	0.125	1/32	1/32	1/32
1	1.275	±0.008	±0.010	1.267	±0.008	±0.010	0.687	1.100	0.149	0.157	1/32	1/32	1/32
1 1/2	1.620	±0.008	±0.012	1.612	±0.008	±0.012	0.875	1.300	0.189	0.199	1/32	1/32	1/32
2	2.335	±0.010	±0.012	2.324	±0.010	±0.012	0.875	1.500	0.216	0.231	1/32	1/32	1/32
3	3.455	±0.015	±0.015	3.439	±0.015	±0.015	1.000	2.800	0.395	0.420	1/32	1/32	1/32
4	4.450	±0.015	±0.015	4.434	±0.015	±0.015	1.125	3.600	0.500	0.540	1/32	1/32	1/32

^a Minimum dimensions have zero negative tolerance. The sketches and designs of fittings are illustrative only.

^b For certain fittings such as extruded couplings, dimension B equals di-

mension A and dimension F equals dimension E. The final taper is formed by the heat fusion tool.



Nominal Pipe Size	G, min
1/2	5/8
3/4	3/4
1	7/8
1 1/8	1
1 1/2	1 1/4
2	2 3/4
3	2 3/4
4	4

materials shall be compatible (joints equal in strength with the pipe section) with the pipe material used for a specific system. Metal insert fittings similar to those in ASTM D2609, compression type, and flare fittings may also be used.

6.5 FINISH AND WORKMANSHIP

Table 6—Specification D3350 Cell Classifications of Polyethylene Pipe and Fittings Materials

Physical Properties:	PE Material Designation Code:		
	PE2406	PE3406	PE3408
Density	2	3	3
Melt index	1,2 or 3	2,3,4,5 or 6	3,4, or 5
Flexural modulus	3 or 4	4 or 5	4 or 5
Tensile strength	3 or 4	4 or 5	4 or 5
Environmental stress crack resistance	2 or 3	3	3
Hydrostatic design basis	3	3	4

6.5.1 Pipe Ends

Pipe ends shall be plain and square ends.

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.

6.6 SPECIAL PROCESSES

Extrusion, which includes the melting, converging and forming of the tubular product, is the special process for polyethylene line pipe.

7 Quality Program

7.1 QUALITY MANUAL

The manufacturer shall maintain a quality manual which describes the quality program. All prior revisions shall be retained for a period of not less than five years.

7.2 PROCESS CONTROL REQUIREMENTS

Manufacturer shall institute and maintain a process documentation program to assure communication of approved manufacturing procedures to qualified receiving, manufacturing and quality control personnel, and their respective supervisor personnel inclusive of:

- Raw material acceptance.
- Extrusion procedures.
- Fittings manufacturing practices.

7.3 QUALITY CONTROL EQUIPMENT

7.3.1 General

Equipment used to inspect, test or examine material or other equipment shall be identified, controlled, calibrated and adjusted at specified intervals in accordance with documented Manufacturer instructions, and consistent with referenced industry standards to maintain the accuracy required by this specification.

7.3.2 Dimensional Measuring Equipment

Dimensional measuring equipment shall be controlled and calibrated by the Manufacturer's written specification.

7.3.3 Pressure Measuring Devices

- Test pressure measuring devices shall be either pressure gauges or pressure transducers.
- All pressure measuring devices shall be calibrated to a certified standard annually.

7.4 QUALITY CONTROL TESTS

7.4.1 Conditioning

7.4.1.1 Quality Control Testing

Unless otherwise specified, condition specimens for a minimum of 4 hrs. prior to test in air or 1 hr. in water at 73.4 +/- 3.6 degrees F (23 +/- 2 degrees C). Test the specimens at 73.4 +/- 3.6 degrees F without regard to relative humidity.

7.4.1.2 Referee Testing

When conditioning is required for referee tests, or in cases of disagreement, condition the specimens in accordance with Procedure A of ASTM Method D618 at 73.4 +/- 3.6 degrees F (23 +/- degrees C) and 50 +/- 5% relative humidity for not less than 40 hrs. prior to test. Conduct tests under the same conditions of temperature and humidity, unless otherwise specified.

7.4.2 Test Conditions

7.4.2.1 Conduct tests at the Standard Laboratory temperature of 73.4 +/- 3.6 degrees F (23 +/- 2 degrees C) unless otherwise specified in the test methods or in this specification. In case of disagreement, the tolerance shall be +/- 1.8 degrees F (+/- 1 degree C).

7.4.3 Pipe Requirements and Frequency

7.4.3.1 Physical Properties

Long term and elevated temperature strength shall be verified annually by the manufacturer on one size as specified in Table 7 or on any change in formulation or extrusion technique. Six specimens selected at random shall be used for long term hydrostatic strength tests at 73°F. Each specimen

shall be maintained at the stress corresponding to the minimum strength values in Table 7 for 1000 hours at 73°F. Six additional specimens selected at random shall be used for elevated temperature hydrostatic strength tests. Each specimen shall be maintained at the stress(s) and time (hours to failure) as selected per the proper pipe test category listed in Table 8.

Table 7—Pipe Requirements

Physical Property	Method of Test ASTM	Min. Strength	
		psi	MPa
Short Term Hydrostatic Hoop Strength	D1599*	2520	17.4
Long Term Hydrostatic Hoop Strength (PE2406, PE3406) (PE3408)	D1598	1320	9.1
	D1598	1600	11.0
Elevated Temperature Hydrostatic Hoop Strength	D1598	Table 8	

*Ring Tensile ASTM D2290 may be used as alternative on sizes above 4" O.D.

7.4.3.2 Test Description and Frequency

The following tests shall be conducted per the prescribed frequencies.

Property: Outside Diameter. Method: ASTM D2122.

Property: Wall Thickness. Method: ASTM D2122.

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

Property: Burst Pressure (sizes thru 4"). Method: ASTM D1599.

Property: Ring Tensile. Method: ASTM D2290.

Frequency: Once every 8 hours or once every coil, whichever is less frequent.

Property: Strength (above 4" IPS). Method: ASTM D2122.

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

Property: Out of Roundness. Method: ASTM D2122.

Frequency: Once per lot.

Property: Ovality. Method: ASTM D2122.

Property: Density. Method: ASTM D1505.

Property: Melt Index. Method: ASTM D1238.

Property: Carbon Black (PE3408). Method: ASTM D1603.

Frequency: Once per lot. (Production run)

7.4.4 Fittings Requirements and Frequency

7.4.4.1 Socket Fittings

The following tests shall be conducted per the prescribed frequencies.

Property: Socket Entrance, Bottom Diameters, & Inside Diameters. Method: ASTM D2122.

Frequency: Once an hour or 1 out of 10 fittings, whichever is less frequent.

Property: Wall Thickness. Method: ASTM D2122.

Frequency: At the beginning of each production setup for each cavity.

Property: Knit Line Strength (one of the following)

a. Crush. Method: ASTM D2513.

b. Apparent Tensile. Method: ASTM D2290.

c. Quick Burst. Method: ASTM D1599.

Frequency: At the beginning of each production setup, whenever production conditions change, or when resin lot is changed.

7.4.4.2 Butt Fittings—Molded

Property: Outside Diameter. Method: ASTM D2122.

Property: Wall Thickness. Method: ASTM D2122.

Table 8—176°F (80°C) Sustained Pressure Requirements for Water Pipe

Pipe Test Category*	Base Resin Melt Index D1238 (g/10 min.)	Base Resin Density D1505 (g/cc)	Minimum Average Hours to Failure		
			S=725psi (5 MPa)	S=580psi (4 MPa)	S=435psi (3 MPa)
C-1	<0.05	0.941-0.948	100	200	--
C-2	<0.05	0.935-0.940	100	200	--
C-3	0.05-0.25	0.941-0.948	60	150	--
C-4	0.05-0.25	0.935-0.940	60	150	--
C-5	>0.25	0.941-0.948	45	100	--
C-6	>0.25	0.935-0.940	45	100	--
C-7	>0.50	0.926-0.940	--	80	150

*PE pipe material test category to be established for each specific PE commercial pipe composition based on the average values of the melt index and the density of the base PE resin when measured according to the test methods specified in ASTM D3350. The manufacturer shall retain a copy of this information from the material supplier. The material test category may not be determined from the PE material cell classification because the density and melt index ranges given in this table are narrower than those used by ASTM D3350 to establish the cell classification.

Frequency: Once an hour or 1 out of 10 fittings, whichever is less frequent.

Property: Knit Line Strength (one of the following)

- a. Crush. Method: ASTM D2513.
- b. Apparent Tensile. Method: ASTM D2290.
- c. Quick Burst. Method: ASTM D1599.

Frequency: At the beginning of each production setup, when production conditions change, or when resin lot is changed.

7.4.4.3 Butt Fittings—Fabricated

Property: Outside Diameter. Method: ASTM D2122.

Property: Wall Thickness. Method: ASTM D2122.

Frequency: One out of every 10 fittings of same size.

7.4.5 Retest and Rejection

7.4.5.1 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.

7.4.5.2 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.

7.4.6 Failure

Pipe failure is any continuous loss of pressure caused by the transmission of the test liquid through the body of the pipe under test: ballooning, bursting, seepage or weeping.

7.4.6.1 Ballooning

Any abnormal localized expansion of a pipe specimen while under internal hydraulic pressure.

7.4.6.2 Bursting

Failure by a break in the pipe with immediate loss of test liquid and continued loss at essentially no pressure.

7.4.6.3 See page or Weeping

Failure that occurs through microscopic breaks in the pipe wall, frequently only at or near the test pressure. At lower pressures, the pipe may carry liquids without evidence of loss of the liquids.

7.5 INSPECTION AND REJECTION

7.5.1 Purchaser Inspection

Unless otherwise provided the provisions of Appendix F shall apply.

7.5.2 Injurious Defects

Injurious defects are those which 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 3.

7.6 QUALITY CONTROL RECORDS REQUIREMENTS

7.6.1 Purpose

The quality control records required by this specification are necessary to substantiate that all materials and products made to meet this specification do conform to the specified requirements.

7.6.2 Records Control

7.6.2.1 Quality control records required by this specification shall be legible, identifiable, retrievable and protected from damage, deterioration or loss.

7.6.2.2 Quality control records required by this specification shall be retained by the Manufacturer for a minimum of five years following the date of manufacture.

7.6.2.3 All quality control records required by this specification shall be signed and dated by the manufacturer's designated authorized person.

7.6.3 Records to be maintained by manufacturer.

1. Quality manual in accordance with 7.1.
2. Test results in accordance with 7.4.
3. Hydrostatic Design Basis in accordance with 5.1.1.
4. Long term stress rupture testing at 140°F (60°C) in accordance with 5.1.5.

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 markings on pipe shall be paint stenciled, printed or labeled on the outside surface at intervals of not more than 5 feet (1.5m) on pipe or on each fittings. Indentation marking may be used provided: (1) the marking does not reduce the wall thickness to less than the minimum value for the pipe or tubing, (2) it is demonstrated that these marks have no affect on the long-term strength of the pipe or tubing, and (3) the marking will not provide leakage channels when elastomeric gasket compression fittings are used to make joints.

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

1. Manufacturer's name or trademarks.
2. Specification 15LE*.
3. Size (the nominal size in inches).
4. Date of manufacture.
5. SDR.
6. Material code (i.e., PE2406, PE3408).
7. Manufacturer's lot number.
8. Additional markings, except pressure ratings, as agreed upon between manufacturer and purchaser, are not prohibited.

9 Handling and Storage

9.1 STORAGE

Polyethylene pipe may be stored either under cover or in the open, if it is suitably protected from aging due to sun-

*Users of this specification should note that there is no longer a requirement for marking a product with the API monogram. The American Petroleum Institute continues to license use of the monogram on products covered by this specification, but it is administered by the staff of the Institute separately from the specification. The policy describing use of the monogram is contained in Appendix E herein. No other use of the monogram is permitted.

light. Protection against sunlight is accomplished by the addition of the appropriate quantity and type of carbon black or other additives during the manufacturing process. Non-weather resistant polyethylene pipe, however, must be stored under cover and protected from direct sunlight.

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. Coils of large diameter (1½" (38 mm) and larger) should not be stored on edge in hot weather or direct sun.

Straight lengths should be stored on horizontal racks giving support to prevent damage to the pipe.

9.2 HANDLING

Polyethylene is a tough resilient material which may be handled easily. However, because it is softer than metals, it is more prone to damage by abrasion and by objects with a cutting edge. Such practices as dragging pipe or coils over rough ground should therefore be avoided. If, due to unsatisfactory storage or handling, a pipe is damaged or "kinked", the damaged portion should be cut out completely.

APPENDIX A—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.

Examples of negative pressure situations are:

1. A buried gravity flow line
2. A vacuum line—a water suction line submerged 23 feet 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 com-

ing up the hill and cause a “negative pressure” to occur.

The ability of the pipe to resist the negative pressure is measured by its buckling strength (p_k) and is commonly referred to as the external loading capability of the pipe. In installations where negative pressure is anticipated, a pipe of sufficiently heavy wall thickness should be chosen so that the pipe will not be permanently damaged or deformed. Figure 1 shows the buckling pressures (without safety factors) for various SDR's of high density polyethylene pipe.

Ovality and temperature have a significant effect on the external loading capabilities of polyethylene pipe. The safety factor chosen by the engineer should be appropriate for the application. Safety factors of 2 to 2.3 are commonly used.

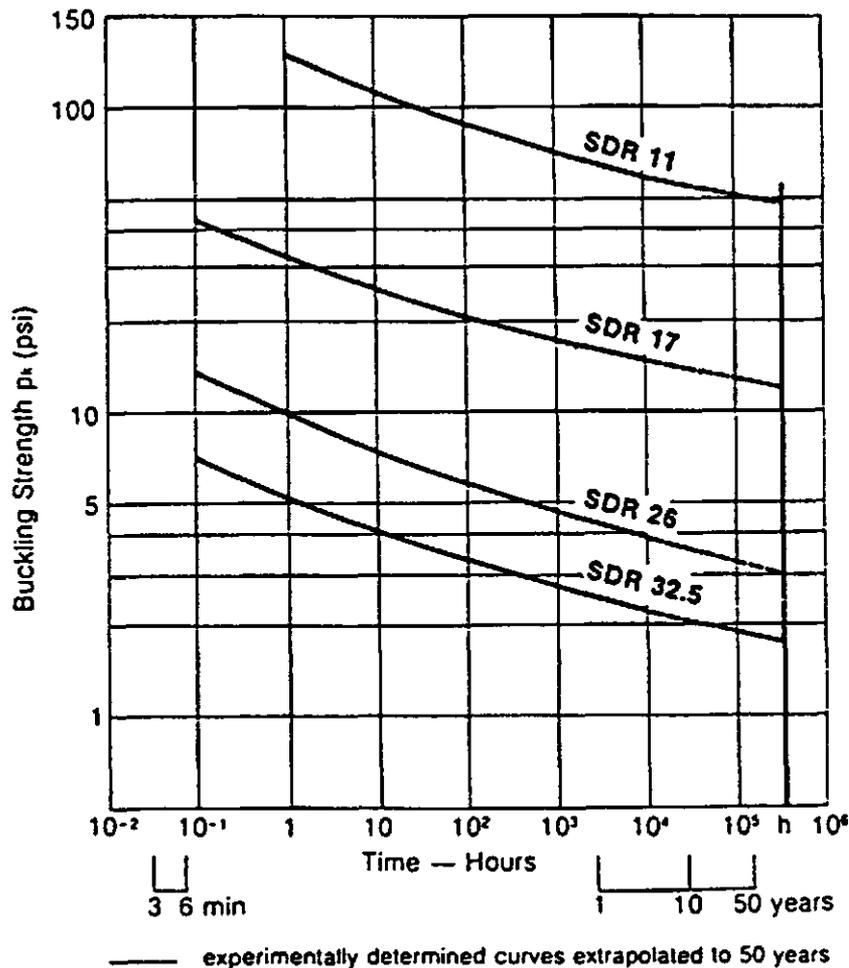


Figure 1—Buckling Strength of HDPE Pipe Under External Water Pressure, 68°F (No Safety Factor)

APPENDIX B—METRIC CONVERSIONS

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

Table B-1—Metric Conversions

Quantity	U.S. Customary Unit	SI Unit
Length	1 inch (in.)	25.4 millimetres (mm) exactly
Pressure	1 pound per square inch (psi) Note: 1 Bar = 100 kilopascals (kPa)	0.06894757 Bar
Strength or Stress	1 pound per square inch (psi)	0.006894757 Megapascals (MPa)
Impact Energy	1 foot-pound (ft-lb)	1.3588181 Joules (J)
Torque	1 foot-pound (ft-lb)	1.3558181 newton-metres (N·m)
Temperature	The following formula was used to convert degrees Fahrenheit (°F) to degrees Celsius (°C):	°C = 5/9 (F-32)
Mass	1 pound (lb)	0.4535924 kilograms (kg)

APPENDIX C—INSTALLATION

C.1 Support Spacing (See Table 9)

The pipe is supplied in coils or straight lengths. When pipe is cut from a coil, it should be supported to minimize stresses in installation. In no case should the pipe be subjected to reverse curvature. Plastic pipe hangers may be used to support the pipe. Care shall be taken not to over-tighten and cause the hanger clamps to cut into the pipe. Pipe hangers should be correctly aligned and should provide a flat smooth surface for contact with the pipe. Supports having sharp edges should be avoided. All types of manual controls and valves in particular, should be firmly anchored so as to prevent the turning movement imparted to the pipe by operation of the control valve.

Polyethylene pipe should not be installed in contact with or close to hot surfaces.

When not supported continuously in horizontal runs, hangers and brackets should be used at approximately the spacing given in Table 9.

Table 9—Support Centers for Horizontal Polyethylene Pipe*

(1) Nominal Size, Inches	(2) PE 3406, 2406, 3408		(3) Meters
	Feet and Inches		
1/4	1-6		.46
3/8	1-6		.46
1/2	2-0		.61
3/4	2-0		.61
1	2-0		.61
1 1/4	2-3		.69
1 1/2	2-3		.69
2	2-9		.84
2 1/2	2-9		.84
3	3-0		.91
4	3-6		1.07
6	4-3		1.30
8	5-3		1.60
10	6-6		1.98
12	7-6		2.29
14	7-6		2.29
16	8-0		2.44
18	9-0		2.74

*For temperatures above 80°F (26.7°C) closer supports are required. At 100°F (37.8°C) and above continuous support is necessary. These support spacings apply to pipe with SDR 17 or heavier walls. For diameters over 18 inches consult the manufacturer for recommendations.

C.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, compression fittings, hot flaring, cold flaring, and insert fittings. (Further information and specific procedures may be obtained from the pipe manufacturer. Also, PPI

Technical Report TR-20, *Joining Polyolefin Pipe* and TN-10, *Description of Plastic Piping Joints* contain details of the various joining procedures and can be obtained from The Plastics Pipe Institute, 1275 K Street, N.W., Suite 400, Washington, D.C 20005.)

C.2.1 HEAT FUSION

Joints can be made either pipe end to pipe end or pipe end to socket fitting by a heat fusion method. This method involves heating the surfaces to be joined to a temperature that will permit fusion of the surfaces when brought into intimate contact. Special tools are required for this method and the procedure is outlined in ASTM D2657. Care should be taken to ensure the compatibility of the PE plastics in the pipe and fittings.

C.2.2 FLARING

Polyethylene (PE) does not require an external source of heat to be flared. Tools designed for cold flaring PE have one or more tool projections that are rotated and fed into the end of the pipe, repeatedly and progressively flexing the pipe wall and expanding it until the designed flare diameter has been obtained. Since mechanical flexing of the plastic material produces substantial internal heating, best results are obtained by a rapid turning or cranking of the tool.

Hot flaring requires the application of heat from an external source to soften the plastic for forming, after which a cone of desired shape is pressed into the end of the pipe by screw or other means. Further information on flaring can be obtained from ASTM D3140: *Flaring Polyolefin Pipe and Tubing*.

C.2.3 COMPRESSION FITTINGS

The pipe should be cut square using a hacksaw or knife and deburred. The compression nut is slipped over the pipe, and a stainless or brass sleeve is inserted in the pipe end. The nut is then tightened on the fitting. The gasket in the nut is compressed against the pipe, providing a leakproof joint.

C.2.4 INSERT FITTINGS

Insert fittings are available for PE pipe in plastics or metallic materials and in a variety of styles - couplings, tees, ells, adapters. Pressure ratings for pipe and tube should be the same.

C.2.5 TRENCH INSTALLATION

Place pipe in trenches by progressive steps. Trench bottom should be smooth with gradual grade transitions. Pipe bends should be very shallow. Snake pipe in trench from side to side. Cover pipe with loose soil or sand without large aggre-

gates or lumps in 15 to 20 foot intervals before proof testing. After proof testing, cover remainder of pipe with loose soil or sand. Be careful not to bruise or crack pipe by dropping rocks, frozen clods, or other heavy objects during backfilling operations. Additional information is covered by ASTM D2774: *Underground Installation of Thermoplastic Pressure Piping*.

C.2.6 LEAK TEST

Air or gas may be used to check for leaks. The test pressure should not exceed 5 psi.

Note: During an air or gas pressure test, safety precautions should be instituted to protect personnel and property in case of a pipeline failure.

Anchor the pipe at 15 to 20 foot intervals with backfill material before pressuring with air or gas. Do not pull a vacuum on uncovered sunlight-heated pipe by siphoning or other means. This pipe can be collapsed by a combination of low atmospheric pressures and elevated temperature (Refer to Appendix A).

C.2.7 PROOF TEST

C.2.7.1 If hydrostatic proof testing is required, fill the pipeline with water after it has been laid; bleed off any trapped air. Subject the lowest element in the system to a test pressure that is 1.5 times the design pressure, and check for any leakage. When, in the opinion of the engineer, local conditions require that the trenches be backfilled immediately after the pipe has been laid, apply the pressure test after backfilling has been completed but not sooner than a time which will allow sufficient curing of any concrete that may have been used. Typical minimum concrete curing times are 36 hours for early strengths and 7 days for normal strengths.

C.2.7.2 The test procedure consists of two steps: the initial expansion and the test phase. When test pressure is applied to a water-filled pipe, the pipe expands. During the initial expansion of the pipe under test, sufficient make-up water must be added to the system at hourly intervals for 3 hours to maintain the test pressure. After about four hours, initial expansion should be complete and the actual test can start.

When the test is to begin, the pipe is full of water and is subjected to a constant test pressure of 1.5 times the system design pressure. *The test phase should not exceed three hours*, after which time any water deficiency must be replaced and measured. Add and measure the amount of make-up water required to return to the test pressure and compare this to the maximum allowances in Table 10.

An alternate leakage test consists of maintaining the test pressure (described above) over a period of four hours, and then dropping the pressure by 10 psi. If the pressure then remains within 5% of the target value for one hour, this indicates that there is no leakage in the system.

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

within this time limit (due to leakage, equipment failure, etc.), the test section shall be permitted to "relax" for eight (8) hours prior to the next test sequence.¹

Table 10—Allowance for Make-Up Water During Test Phase

These allowances apply to the test period only, and not to the initial expansion phase.

Nominal Pipe Size (in.)	Make-Up Water Allowance (U.S. Gallons/100 Feet of Pipe*)		
	1-Hour Test	2-Hour Test	3-Hour Test
3	0.10	0.15	0.25
4	0.13	0.25	0.40
6	0.30	0.60	0.90
8	0.50	1.0	1.5
10	0.75	1.3	2.1
11	1.0	2.0	3.0
12	1.1	2.3	3.4
14	1.4	2.8	4.2
16	1.7	3.3	5.0
18	2.2	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
28	5.5	11.1	16.8
32	7.0	14.3	21.5
36	9.0	18.0	27.0
40	11.0	22.0	33.0
48	15.0	27.0	43.0

*Metric conversion factor for Liters/100 Meters of Pipe = 1.15 × U.S. Gallons/100 Feet of Pipe

C.2.8 THERMAL EXPANSION

Polyethylene, like other plastics, has a thermal coefficient of expansion higher than metals. The value for polyethylene is about 6 to 9 to 10⁵ in/in/°F. Consequently, allowance for thermal expansion and contraction in service should be made during installation of the pipe. A practical allowance is one inch per 100 feet of pipe per 10°F change in temperature. In short runs, changes in direction of the pipeline will often give sufficient allowance for stresses arising from changes in operating temperature. Specific coefficient of linear thermal expansion can be obtained from the manufacturer for the specific material supplied.

C.2.9 RECOILING

The coil diameters should be sufficiently large to prevent excessive straining being applied to the pipe. The minimum recommended inside coil diameter may be determined by the following formula:

$$\text{Inside Coil Diameter} = \frac{\text{OD of Pipe}}{0.055}$$

These coiling diameters are based on longitudinal strain. This is not necessarily the maximum strain since buckling is an additional limiting factor. With very thin walled pipe, buckling may be the more important factor and the manufacturer should be consulted for proper coiling recommendations.

APPENDIX D—PURCHASER INSPECTION

D.1 Inspection Notice

Where the inspector representing the purchaser desires to inspect this pipe or witness quality control tests, reasonable notice by the manufacturer shall be given of the time at which the run is to be made.

D.2 Rejection

Material which shows injurious defects on plant inspection or subsequent to acceptance at the manufacturer's works

or which proves to be defective when properly applied in service may be marked and rejected and the manufacturer so notified.

D.3 Compliance

The manufacturer is responsible for complying with all of the provisions of this specification. The purchaser may make any investigation necessary to satisfy himself of compliance by the manufacturer and may reject any material that does not comply with the specification.

APPENDIX E—USE OF API MONOGRAM

Marking Requirements for API Licensees. Each pipe or fitting shall be marked with the following:

- a. Manufacturer's name or mark
- b. API monogram
- c. API license number
- d. Date of manufacture
- e. Nominal size (IPS)
- f. SDR number
- g. Material code (i.e., PE 2406, PE 3408)
- h. Manufacturer's lot number

PUBLICATIONS LIST

The following publications are under the jurisdiction of the API Committee on Standardization of Plastic Pipe and are available from the American Petroleum Institute, 1220 L Street, Northwest, Washington, DC 20005; (202) 682-8375.

SPECIFICATIONS

Spec 15HR *Specification for High Pressure Fiberglass Line Pipe*

Covers fiberglass line pipe suitable for use in conveying oil, gas or non-potable water in the oil and gas producing industries at high pressures.

Spec 15LE *Specification for Polyethylene Line Pipe, (Tentative).*

Provides standards for polyethylene (PE) line pipe suitable for use in conveying oil, gas and non-potable water in underground service for the oil and gas producing industries. Dimensions, materials, physical properties, and service factors are included.

Spec 15LR *Specification for Low Pressure Fiberglass Line Pipe*

Covers fiberglass line pipe suitable for use in conveying oil, gas, or non-potable water in the oil and gas producing industries at low pressures.

Spec 15LT *Specification for PVC Lined Steel Tubular Goods.*

Covers PVC lined steel pipe or tubing suitable for use in conveying oil or non-potable water in the petroleum industry.

RECOMMENDED PRACTICES

RP TL4 *Recommended Practice for Care and Use of Fiberglass Tubulars.*

Provides information on the transporting, handling, installing, and reconditioning of fiberglass tubulars for the oil and gas producing industries.

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