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Standard Specification for Large Diameter Polybutylene Plastic Pipe[1]

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ϵ[1] NOTE—F 809 and F 809M were combined editorially with no change in technical requirements in September 1996.

1. Scope

1.1 This specification covers polybutylene (PB) pipe made in dimensions based on outside diameters from 3.5 to 42 in. [90 to 1000 mm] in six standard dimension ratios, namely 11, 13.5, 17, 21, 26, and 32.5.

1.2 The outside diameter sizing system is known as the IPS [ISO] system, whose measurements are in inch-pound [SI] units.

1.3 The piping is intended for new construction and insertion renewal of old piping systems used for the transport of water, municipal sewage, industrial process liquids, effluents, slurries, etc. in both pressure and nonpressure systems. The components covered by this specification are intended for use in commercial and industrial process piping at temperatures up to 180°F [82°C].

NOTE 1—The user must consult the manufacturer to assure himself that any degradation of the polybutylene pipe caused by the material being transported will not affect the service life beyond limits acceptable to the user.

1.4 All pipes produced under this specification are pressure-rated.

1.5 This specification includes criteria for classifying PB plastic pipe material and pipe, together with performance requirements and test methods for determining conformance to the requirements.

1.5.1 Quality control measures to be taken by manufacturers are outlined in the appendix as a nonmandatory part of this specification.

1.6 The values stated in either inch-pound or SI units are to be regarded separately as standard. Within the text, SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.7 The following safety hazards caveat pertains only to the test method portion, Section 7, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure[3]

D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings[3]

D 1603 Test Method for Carbon Black in Olefin Plastics[4]

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings[3]

D 2290 Test Method for Apparent Tensile Strength of Ring or Tubular Plastics and Reinforced Plastics by Split Disk Method[3]

D 2321 Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications[3]

D 2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading[3]

D 2581 Specification for Polybutylene (PB) Plastics Molding and Extrusion Materials[4]

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[3]

F 412 Terminology Relating to Plastic Piping Systems[3]

2.2 *ANSI Standard:*

ANSI B 36.10 Standard Dimensions of Steel Pipe (IPS)[5]

2.3 *ISO Standard:*

ISO 3607 Polyethylene (PE) Pipes—Tolerances on Outside Diameters and Wall Thicknesses[5]

2.4 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[6]

2.5 *Military Standard:*

[1] This specification is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.26 on Olefin Based Pipe.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.04.

[4] *Annual Book of ASTM Standards*, Vol 08.02.

[5] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

MIL-STD-129 Marking for Shipment and Storage[6]

2.6 *NSF Standards:*

Standard No. 14 for Plastic Piping Components and Related Materials[7]

Standard No. 61 for Drinking Water Systems Components—Health Effects[7]

3. Terminology

3.1 *Definitions:*

3.1.1 Terms used in this specification are as defined in Terminology F 412. The abbreviation for polybutylene is PB.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *relation between dimension ratio, hydrostatic design stress, and hydrostatic pressure*—the following expression is used in this specification to relate the dimension ratio, hydrostatic stress, and pressure:

P =

$$\frac{2S}{SDR - 1} + \frac{2S}{(D_O/t - 1)}$$

where:

S = hydrostatic design stress, psi, [MPa]
P = internal pressure, psi, [MPa]
D_O = average outside diameter, in. [mm],
t = minimum wall thickness, in. [mm], and
D_O/t = dimension ratio = SDR.

3.2.2 *relation between hydrostatic design basis and hydrostatic design stress*—the hydrostatic pressure rating of pipes described in this specification is based on the use of a (service) design factor in accordance with the instruction given in Test Method D 2837 (see Annex A1).

3.2.3 *standard thermoplastic pipe materials designation code*—the pipe materials designation code shall consist of the abbreviation PB for the type of plastic, followed by the ASTM type and grade in Arabic numerals and the hydrostatic design stress at 73°F [23°C]. Where the hydrostatic design stress code contains less than two fingers, a cipher shall be used before the number. Thus a complete number code shall consist of two letters and four figures for PB plastic pipe materials, for example, PB2110.

4. Pipe Classification

4.1 *General*—This specification covers PB pipe made from PB plastic pipe material in six standard dimension ratios and water pressure ratings.

4.2 *Standard Thermoplastic Pipe Dimension Ratios (SDR)*—This specification covers PB pipe in six standard dimension ratios, namely: 11, 13.5, 17, 21, 26, and 32.5. These are referred to as SDR11, SDR13.5, SDR17, SDR21, SDR26, and SDR32.5, respectively. The pressure rating is uniform for all nominal pipe sizes for a given PB pipe material and SDR (see Table X1.1, Appendix).

5. Materials

5.1 *General*—Polybutylene plastics used to make pipe meeting the requirements of this specification are categorized by means of two criteria: (*1*) short-term strength tests (burst), and (*2*) sustained pressure tests. Because the maximum physical properties of the pipe are not developed until 10 days after extrusion, short-term (burst) and sustained pressure testing must be delayed for this period (see Annex A1.2).

NOTE 2—Piping used at elevated temperatures should be produced from the appropriate PB grade intended for this use.

5.2 *Basic Materials*—This specification covers PB pipe made from Type II, Grade 1 (PB) plastic as defined in Specification D 2581.

5.3 *Compound*—The PB plastic extrusion compound shall meet the requirements of Type II, Grade 1, Class B with antioxidants or Class C as described in Specification D 2581.

5.4 *Rework Material*—Clean, rework material generated from the manufacturer's own pipe production, may be used by the same manufacturer, as long as the pipe produced meets all the requirements of this specification.

6. Product Requirements

6.1 *Workmanship*—The pipe shall be homogeneous throughout and essentially uniform in color, opacity, density, and other properties. The inside and outside surfaces shall be semi-matte or glossy in appearance and free of sticky or tacky material. The pipe walls shall be free of cracks, holes, blisters, voids, foreign inclusion, or other defects that are visible to the naked eye and that may affect the wall integrity.

6.2 *Dimensions and Tolerances*:

6.2.1 *Outside Diameters*—The outside diameter shall be in accordance with Table 1 when measured in accordance with 7.4.1.

6.2.2 *Wall Thicknesses*—The minimum thicknesses shall be in accordance with Table 3 when measured in accordance with 7.4.2.

6.2.3 *Eccentricity*—The wall thickness range shall not exceed 12 % for any cross-section when measured in accordance with 7.4.3.

6.3 *Carbon Black*—The pipe shall contain at least 2 %

TABLE 1 Outside Diameters and Tolerances IPS (inch/pound units) Sizing System (ANSI B 36.10)

Nominal Pipe Size, in.	Actual Outside Diameters, in.	
	Nominal	Tolerance[A]
3	3.500	±0.016
4	4.500	±0.020
5	5.563	±0.025
6	6.625	±0.030
8	8.625	±0.039
10	10.750	±0.048
12	12.750	±0.057
14	14.000	±0.063
16	16.000	±0.072
18	18.000	±0.081
20	20.000	±0.090
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

[A] As specified in ISO 3607.

[7] Available from the National Sanitation Foundation, P.O. Box 1468, Ann Arbor, MI 48106.

TABLE 3 Minimum Wall Thickness IPS (ANSI B 36.10) Sizing System, in. [mm]

Nominal Pipe Size, in. [mm]	SDR					
	32.5	26	21	17	13.5	11
3 [90]	. . . . .	0.135 [3.5]	0.167 [4.3]	0.206 [5.3]	0.259 [6.7]	0.318 [8.2]
4 [110]	0.138 [3.4]	0.173 [4.2]	0.214 [5.2]	0.265 [6.5]	0.333 [8.1]	0.409 [10.0]
5 [160]	0.171 [4.9]	0.214 [6.2]	0.265 [7.6]	0.327 [9.4]	0.412 [11.9]	0.506 [14.5]
6 [200]	0.204 [6.2]	0.255 [7.7]	0.315 [9.5]	0.390 [11.8]	0.491 [14.8]	0.602 [18.2]
8 [250]	0.265 [7.7]	0.332 [9.6]	0.411 [11.9]	0.507 [14.7]	0.639 [8.5]	0.784 [22.7]
10 [280]	0.331 [8.6]	0.413 [10.8]	0.512 [13.3]	0.632 [16.5]	0.796 [20.7]	0.977 [25.5]
12 [315]	0.392 [9.7]	0.490 [12.1]	0.607 [15.0]	0.750 [18.5]	0.944 [23.3]	1.159 [28.6]
14 [355]	0.431 [10.9]	0.538 [13.7]	0.667 [16.9]	0.824 [20.9]	1.037 [26.3]	1.273 [32.3]
16 [400]	0.492 [12.3]	0.615 [15.4]	0.762 [19.0]	0.941 [23.5]	1.185 [29.6]	1.455 [36.4]
18 [450]	0.554 [13.8]	0.692 [17.3]	0.857 [21.4]	1.059 [26.5]	1.333 [33.3]	1.636 . . .
20 [500]	0.615 [15.4]	0.769 [19.2]	0.952 [23.8]	1.176 [29.4]	1.481 [37.0]	. . . . .
22 [560]	0.677 [17.2]	0.846 [21.5]	1.048 [26.7]	1.294 [32.9]	1.630 [41.5]	. . . . .
24 [630]	0.738 [19.4]	0.923 [24.2]	1.143 [30.0]	1.412 [37.1]	1.778 [46.7]	. . . . .
28 [710]	0.862 [21.8]	1.077 [27.3]	1.333 [33.8]	1.657 [41.8]	. . . [52.6]	. . . . .
32 [800]	0.985 [24.6]	1.231 [30.8]	1.524 [38.1]	1.882 [47.1]	. . . . .	. . . . .
36 [900]	1.108 [27.7]	1.385 [34.6]	1.714 [42.9]	. . . . .	. . . . .	. . . . .
42 [1000]	1.292 [30.8]	1.615 [38.5]	. . . [47.6]	. . . . .	. . . . .	. . . . .

carbon black when testing in accordance with Test Method D 1603.

6.4 *Sustained Pressure*—The pipe shall not fail in less than 100 h at the test pressures given in Table 4, when tested in accordance with 7.5.1.

6.5 *Burst Pressure*—The minimum burst pressure shall be as given in Table 5, when determined in accordance with 7.5.2.

NOTE 3—For direct burial applications, pipe stiffness values are discussed in Annex A 1.3.

7. Test Methods

7.1 *Conditioning*—Because of the crystalline transformation that takes place after polybutylene resins are cooled from the melt, it is necessary to delay physical testing until 10 days after pipe extrusion. During this 10-day period, the pipe should be stored at temperatures between 40 and 100°F [4 and 38°C]. The test specimen should be taken after 8 days and conditioned at 73 ± 4°F [23 ± 2°C] for not less than 40 h prior to test in accordance with Practice D 618, for those tests where conditioning is required and in all cases of disagreement.

7.2 *Test Conditions*—Conduct the tests in the Standard Laboratory Atmosphere of 73 ± 4°F [23 ± 2°C] unless otherwise specified in the test methods or in this specification.

7.3 *Sampling*—The selection of the sample or samples of pipe shall be as agreed upon between the purchaser and the seller. In case of no prior agreement, any sample selected by the testing laboratory shall be deemed adequate.

TABLE 4 Sustained Pressure Test Conditions in Water for SDR-PR PB Plastic Pipe[A]

Standard Dimension Ratio	Pressure Required for Test, psi [MPa]	
	73°F [23°C][B]	180°F [82°C][C]
11	400 [2.76]	200 [1.38]
13.5	320 [2.21]	160 [1.10]
17	250 [1.72]	125 [0.86]
21	200 [1.38]	100 [0.69]
26	160 [1.10]	80 [0.55]
32.5	125 [0.86]	60 [0.41]

[A] Test duration, 100 h.
[B] The fiber stress used to derive these pressures from PB 2110 at 73°F [23°C] is 2000 psi [13.8 MPa].
[C] The fiber stress used to derive these pressures for PB 2110 at 180°F [82°C] is 1000 psi [6.9 MPa].

TABLE 5 Burst Pressure Requirements in Water for SDR-PR PB Plastic Pipe

Standard Dimension Ratio	Min Burst Pressure, psi [MPa]	
	73°F [23°C][A]	180°F [82°C][B]
11	440 [3.03]	220 [1.52]
13.5	350 [2.41]	175 [1.21]
17	275 [1.90]	135 [0.93]
21	220 [1.52]	110 [0.76]
26	175 [1.21]	85 [0.59]
32.5	135 [0.93]	65 [0.45]

[A] The fiber stress used to derive the test pressure for PB 2110 at 73°F [23°C] is 2000 psi [15.2 MPa].
[B] The fiber stress used to derive the test pressure for PB 2110 at 180°F [82°C] is 1100 psi [7.59 MPa].

7.4 *Dimensions and Tolerances*—Any length of pipe agreed upon between the purchaser and the seller may be used to determine the dimensions. Measure in accordance with Test Method D 2122.

7.4.1 *Outside Diameter*—Measure the outside diameter of the pipe in accordance with Test Method D 2122, using the circumferential wrap tape technique.

7.4.2 *Wall Thickness*—Measure the wall thickness in accordance with Test Method D 2122, to determine the maximum and minimum values. Measure the wall thickness at both ends of the pipe to 0.001 in. [0.02 mm].

7.4.3 *Wall Thickness Range*—Measure the maximum, *A*, and minimum, *B*, wall thicknesses of each cross section. Calculate the wall thickness range, *E*, in percent, for each cross section as follows:

$$E = [(A - B)/A] \times 100$$

7.5 *Test Methods*:

7.5.1 *Sustained Pressure Tests*—Tests shall be conducted in accordance with Test Method D 1598. The test pressures are given in Table 4. Tests shall be conducted in either a "water inside/water outside" or "water inside/air outside" environment. The quantity of test specimen shall be agreed upon between the seller and the purchaser.

7.5.2 *Short-Term Pressurization Tests*—Tests shall be conducted in accordance with Test Method D 1599, except no

failure shall occur at a test pressure less than the value given in Table 5. Record burst pressure and time-to-failure. The quantity of test specimens shall be agreed upon between the seller and the purchaser.

NOTE 4—Elevated temperature testing should be undertaken at the recommended pressures specified for that temperature in Table 4, for sustained-pressure testing, or Table 5, for burst-pressure testing.

NOTE 5—**Precaution:** Pressurization of specimens being tested in accordance with 7.5.1 or 7.5.2 should not commence until it is certain that all entrapped air has been bled from the water-filled specimens.

8. Retest

8.1 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 product represented by the test(s) does not meet the requirements of this specification.

9. Certification

9.1 A manufacturer's certification of conformance that the product was manufactured and tested in accordance with this specification shall be furnished upon request to the original purchaser. That certification along with test results and the dates of each test shall be furnished to the original purchaser when requested at the time the order or contract is placed. Each certification shall be signed by an authorized quality control representative or executive officer of the manufacturer or his authorized representative.

NOTE 6—A project is underway in Committee F-17 to establish lot size and frequency of sampling requirements for the various plastic piping standards. Until established, the lot size and sampling used by the manufacturer shall be accepted, unless otherwise mutually agreed upon between the producer and the consumer.

10. Marking

10.1 The markings shall be applied to the pipe in such a manner that they remain legible after installation and inspection have been completed.

10.2 Marking on the pipe shall include the following and shall be placed at least at each end of each shipped length of pipe or spaced at intervals of not more than 5 ft in a color that contrasts with that of the pipe.

10.2.1 Manufacturer's name, tradename, or trademark.

10.2.2 The letters "ASTM" followed by the number of this specification.

10.2.3 The letters "PB" followed by the classification number Specification D 2581 of the raw material used, such as, PB2110.

10.2.4 Outside diameter in accordance with Table 1.

10.2.5 Dimensional ratio or pressure rating, or both, shown as "XXX psi" ["XXX MPa"].

10.2.6 Production code from which location and date of manufacture can be identified.

10.2.7 Pipe intended for the transport of potable water or other medium shall also include the seal or mark of the laboratory making the evaluation for this purpose, spaced at intervals specified by the laboratory (see A1.2).

NOTE 7—Manufacturers using the seal of approval of an accredited laboratory must obtain prior authorization from the laboratory concerned.

11. Quality Assurance

11.1 When the product is marked with this designation, F 809/F 809M, the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

SUPPLEMENTARY REQUIREMENTS

POTABLE WATER REQUIREMENT

This requirement applies whenever a Regulatory Authority or user calls for product to be used to convey or to be in contact with potable water.

S1. Products intended for contact with potable water shall be evaluated, tested and certified for conformance with ANSI/NSF Standard No. 61 or the health effects portion of NSF Standard No. 14 by an acceptable certifying organization when required by the regulatory authority having jurisdiction.

ADDITIONAL SUPPLEMENTARY REQUIREMENTS

GOVERNMENT/MILITARY PROCUREMENT

These requirements apply *only* to Federal/Military procurement, not domestic sales or transfers.

S2. *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless the purchaser disapproves. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

NOTE 8—In U.S. Federal contracts, the contractor is responsible for inspection.

S3. *Packaging and Marking for U.S. Government Procurement:*

S3.1 *Packaging*—Unless otherwise specified in the contract, the materials shall be packaged in accordance with the supplier's standard practice in a manner ensuring arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.

S3.2 *Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

NOTE 9—The inclusion of U.S. Government procurement requirements should not be construed as an indication that the U.S. Government uses or endorses the products described in this document.

ANNEX

(Mandatory Information)

A1. DESIGN CONSIDERATIONS

A1.1 Design Factor

A1.1.1 This factor is valid for water transported at temperatures for which a HDB has been established when the pipe is installed in accordance with the appropriate standard procedures. Smaller design factors should be applied to systems operating at higher temperatures, or when high surge pressures resulting from changing velocity may occur, or where pipe is to be used for the transport of industrial effluents known to have some degrading effect on the properties of polybutylene, or where erosion of the pipe wall by the fluid being transported will adversely affect the service life of the system. The actual choice of design factor for a given installation should be reviewed by the designing engineer, taking into account the transportation and on-site handling conditions, the difficulties of site preparation, the contractual specifications for trenching, bedding, haunching, backfilling, and the possibility of deviation from operating at hydrostatic pressures or external load conditions specified for the use of the piping system. A further uncertainty factor should be applied at the designing engineer's discretion where warranted by consideration of these conditions.

A1.2 Pipe Stiffness

A1.2.1 The predominant source of supporting strength of a flexible conduit is the lateral pressure of the soil at the sides of the pipe. The pipe itself contributes relatively little bending strength and its ability to support loads must be derived from the passive pressures induced as the sides of the pipe move outward against the soil. For this reason good flexible pipe performance depends largely on compaction of soil on the side of the pipe, which in turn is dependent on good installation such as prescribed in Practice D 2321, and the designer should be so warned. It should be noted here that the above recommendation considers pipes of minimum pipe stiffness *(F/ΔY)* of 25 psi [0.17 MPa] suitable for embediment in Class I, II, and III materials.

A1.2.2 Calculations show that polybutylene pipe of SDR21 has a pipe stiffness of not less than 25 psi [0.17 MPa] and SDR26 pipe has a stiffness of not less than 15 psi [0.10 MPa]. It is felt that any pipe of down to 15 psi [0.10 MPa] stiffness can be successfully installed in Type III embediment materials.

NOTE A1.1—See research report[8] for the development of equations in Annex A 1.3.

A1.2.3 To relate the deformation behavior of buried flexible conduits, Spangler of Iowa State College developed the following relationship which has come to be widely relied upon for the determination of the supporting strength of flexible pipes:

$$X = \frac{D_1 K W c}{0.149(F/\Delta Y) + 0.061\, E'}$$

[8] Supporting data are available from ASTM Headquarters. Request RR: F 17-1021.

where:

X = deflection (horizontal or vertical) of the pipe, in. [mm],
D_1 = deflection lag factor, compensating for time dependence of soil/pipe deformation, dimensionless,
E' = modulus of soil reaction, psi [MPa],
K = bedding constant, dependent on angle subtended by the pipe bedding, dimensionless, and
Wc = vertical load on the pipe, lb/lineal, in. [N/M].

Pipe stiffness =

$$\frac{F}{\Delta Y} = \frac{EI}{0.149 \cdot r^3} = \frac{241\ 600}{(SDR - 1)^3}$$

where:

I = moment of inertia per unit length of cross section of the pipe wall, $in.^4/in.$ [mm^4/mm],
r = mean radius of pipe, in. [mm], and
E = modulus of elasticity of pipe material, psi; (E for typical polybutylene pipe is 54 000 psi [372.4 MPa]).

A1.2.4 The pipe stiffness values in Table A1.1 may be used for this specification. For further data, see manufacturer's literature.

TABLE A1.1 Minimum Pipe Stiffness Values for Polybutylene Pipe of Various SDR's, psi [MPa]

SDR	11	13.5	17	21	26	32.5
73°F [23°C]	200 [1.37]	120 [0.82]	55 [0.38]	30 [0.21]	15 [0.10]	6 [0.04]
180°F [82°C]	95 [0.65]	50 [0.34]	25 [0.17]	10 [0.07]	6 [0.04]	3 [0.02]

A1.2.5 *Allowable Deflection Limits*

Recognizing that for relatively small pipe deflections, the change in horizontal diameter is essentially equal to the change in vertical diameter. The pipe stiffness, EI, may be established from parallel plate testing, in accordance with Test Method D 2412.

A1.2.6 For determining percent deflection of pipe, the Iowa equation may be rewritten to give the following:

Deflection, % =

$$\frac{D_1 KWc}{0.149(F/\Delta Y) + 0.061E'} \cdot \frac{100}{D}$$

where:

D = original outside diameter of pipe, in. [mm].

A1.2.7 According to this expression the percent pipe deflection is, for a pipe of a given SDR installed in a soil of E' reaction modulus, a straight line relationship with unit load. The percent deflection can be calculated by assuming values for deflection lag factor, bedding constant and soil modulus. Typical values for deflection lag factor is 1.50 and 0.10 for bedding constant. These values were used to calculate the deflection for pipes of SDR ranging from 9 to 32.5 buried in soil with a reaction soil modulus of 300 psi (65 % compaction) and 760 psi (90 % compaction). The calculated results of percent deflection versus applied earth load are graphically illustrated in Fig. A1.1 and Fig. A1.2.

A1.2.8 Using Fig. A1.1 and Fig. A1.2, all one needs to know to estimate the deflection of a pipe is the SDR, the soil reaction modulus (the type of installation), and the load of the pipe.