American Water Works Association

Errata to
ANSI/AWWA C904-06
Standard
for

Cross-Linked Polyethylene (PEX) Pressure Pipe, ½ In. (12 mm) Through 3 In. (76 mm), for Water Service

(December 2006, first edition)

1. On page ix – x, Eq F.1 and Eq F.2 should read:

$$\alpha = \frac{A_1}{\left[1 + \frac{K\ (SDR\ -\ 2)}{E}\right]^{1/2}} \qquad \text{(Eq F.1)}$$

$$P_s = \alpha\left(\frac{\Delta v}{A_2}\right) \qquad \text{(Eq F.2)}$$

where:

α	=	wave velocity, in ft/sec (m/sec)
A_1	=	4,675 ft/sec (1,433 m/sec)
K	=	bulk modulus of water = 294,000 psi (2,053.5 MPa)
SDR	=	standard dimension ratio (see Sec. 3.3)
E	=	modulus of elasticity of pipe material [for PEX 1006, E = 93,000 psi (630 MPa) at 73.4°F (23°C)].
P_s	=	surge pressure (gauge), in psig (kPa)
Δv	=	velocity change, in ft/sec (m/sec), occurring within a critical time denoted by 2L/α, where L is the pipe length in ft (m)
A_2	=	2.31g [g is gravitational acceleration of 32.2 ft/sec^2 (9.81 m/sec^2)]

NOTE: E varies specific to the PEX material used. E typically ranges between 91,000 psi and 105,000 psi [secant modulus of one percent at 73.4°F (23°C) per ASTM D638].

2. Section 4.3.4, page 6: "D1598" should read "ASTM D1598."

3. Section 4.3.6, page 6: "D1598" should read "ASTM D1598."

4. Table 2, page 6, first column (nominal pipe size), second row: garbled number should read 5/8".

5. Section 6.1.2.2., page 9: Material designation (e.g., PEX 1006).

ANSI/AWWA C904--06
First Edition

American Water Works Association

The Authoritative Resource on Safe Water®

AWWA Standard

Cross-Linked Polyethylene (PEX) Pressure Pipe, ½ In. (12 mm) Through 3 In. (76 mm), for Water Service

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6666 West Quincy Avenue
Denver, CO 80235-3098
T 800.926.7337
www.awwa.org

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Sections

AWWA Standard

This document is an American Water Works Association (AWWA) standard. It is not a specification. AWWA standards describe minimum requirements and do not contain all of the engineering and administrative information normally contained in specifications. The AWWA standards usually contain options that must be evaluated by the user of the standard. Until each optional feature is specified by the user, the product or service is not fully defined. AWWA publication of a standard does not constitute endorsement of any product or product type, nor does AWWA test, certify, or approve any product. The use of AWWA standards is entirely voluntary. AWWA standards are intended to represent a consensus of the water supply industry that the product described will provide satisfactory service. When AWWA revises or withdraws this standard, an official notice of action will be placed on the first page of the classified advertising section of *Journal AWWA*. The action becomes effective on the first day of the month following the month of *Journal AWWA* publication of the official notice.

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Science and Technology

AWWA unites the entire water community by developing and distributing authoritative scientific and technological knowledge. Through its members, AWWA develops industry standards for products and processes that advance public health and safety. AWWA also provides quality improvement programs for water and wastewater utilities.

Committee Personnel

The AWWA Standards Committee on Polyolefin Pressure Pipe and Fittings, which reviewed and approved this standard, had the following personnel at the time of approval:

Michael G. Boyle, *Chair*

General Interest Members

W.I. Adams, Batavia, Ill. (AWWA)

J.B. Allen,* Standards Engineer Liaison, AWWA, Denver, Colo. (AWWA)

J.P. Castronovo, CH2M Hill, Gainesville, Fla. (AWWA)

K.C. Choquette, Iowa Department of Public Health, Des Moines, Iowa (CSSE)

W.J. Dixon,* Standards Council Liaison, Dixon Engineering Inc., Lake Odessa, Mi. (AWWA)

D.E. Duvall, Engineering Systems Inc., Aurora, Ill. (AWWA)

D.L. McPherson, MWH Americas Inc., Cleveland, Ohio (AWWA)

M.L. Magnant, Iowa Department of Public Health, Des Moines, Iowa (AWWA)

S.A. Mruk, Consultant, New Providence, N.J. (AWWA)

J.R. Paschal, Bodycote–Broutman, Ypsilanti, Mich. (NSF)

J.R. Peters, M.D. Wessler & Associates Inc., Indianapolis, Ind. (AWWA)

S. Ziobro, FM Approvals,West Glocester, R.I. (FMRC)

Producer Members

J.M. Craig, McElroy Manufacturing Inc., Tulsa, Ok. (AWWA)

L.J. Gill, Ipex Inc., Mississauga, Ont., Canada (AWWA)

S.C. Rademacher, Uponor Wirsbo Company, Apple Valley, Minn. (AWWA)

C.G. Rubeiz, Plastics Pipe Institute, Washington, D.C. (AWWA)

H. Svetlik, Independent Pipe Products Inc., Grand Prairie, Texas (AWWA)

*Liaison, nonvoting

User Members

M.G. Boyle, Pflugerville, Texas	(AWWA)
J.D. Cox, Stockton, Calif.	(AWWA)
M.R. Falarski, East Bay Municipal Utilities District, Oakland, Calif.	(AWWA)
R.P. Fuerst, Bureau of Reclamation, Denver, Colo.	(AWWA)
W.F. Guillaume, Orlando, Fla.	(NEWWA)

Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

Foreword

This foreword is for information only and is not part of ANSI/AWWA C904.

I. Introduction.

I.A. *Background.* This standard describes cross-linked polyethylene (PEX) pressure pipe for use primarily as service lines in the construction of underground water distribution systems.

This standard describes pipe and tubing made with a materials designation code of PEX 1006 in ASTM* F876. This standard describes pipe in sizes ½ in. through 3 in. (12 mm through 76 mm) with a standard dimension ratio of 9 (SDR9) and pressure class of 160 psi.

I.B. *History.* On June 18, 2002, the American Water Works Association (AWWA) Committee on Polyolefin Pressure Pipe and Fittings was approached to develop a standard describing PEX for water service applications. On June 15, 2004, the Polyolefin Committee unanimously approved and authorized the development of a new standard for PEX Pressure Pipe, ½ In. (12 mm) Through 3 In. (76 mm), for Water Service. A new PEX subcommittee was also formed at this time to begin development of this standard within AWWA. This first edition of C904 was approved by the AWWA Board of Directors on June 11, 2006.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for indirect drinking water additives. Other members of the original consortium included the American Water Works Association Research Foundation (AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in, or in contact with, drinking water rests with individual states.† Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health

*ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

†Persons outside the United States should contact the appropriate authority having jurisdiction.

effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. An advisory program formerly administered by USEPA, Office of Drinking Water, discontinued on Apr. 7, 1990.

2. Specific policies of the state or local agency.

3. Two standards developed under the direction of NSF, NSF*/ANSI† 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.

4. Other references, including AWWA standards, *Food Chemicals Codex, Water Chemical Codex,*‡ and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 61. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdiction. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

Annex A, "Toxicology Review and Evaluation Procedures," to NSF/ANSI 61 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of "unregulated contaminants" are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA C904 does not address additives requirements. Users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements, including applicable standards.

2. Determine the status of certifications by all parties offering to certify products for contact with, or treatment of, drinking water.

3. Determine current information on product certification.

II. Special Issues.

II.A. *Pipe Selection.*

*NSF International, 789 Dixboro Road, Ann Arbor, MI 48113.

†American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

‡Both publications available from National Academy of Sciences, 500 Fifth Street, N.W., Washington, DC 20001.

II.A.1 Selection of a pressure class. A pressure class of 160 psi (1,118 kPa) is recommended for general durability in handling and for use in typical AWWA water service installations. Lesser pressure classes may be appropriate for specific applications, but selection should be based on a detailed evaluation of factors, such as installation configuration (Sec. II.C), fitting type, joining methods, use of coiled or straight products, and potential for significant surge pressure.

The minimum pressure class of the pipe selected should be equal to or greater than the system working pressure. The sum of the system working pressure and surge pressure should not exceed 1.5 times the pressure class of the pipe. If surge pressures govern the selection of the pressure class, consideration should be given to removal of the surge pressures or to the incorporation of surge suppressors in the system.

II.A.2 Calculation of surge pressure. Surge pressure generated by velocity changes in PEX water service lines may be estimated using the formulas provided in this section. In addition, surges occurring either upstream in mains or downstream in a user's plumbing system should be considered for their effect on the service line.

The wave velocity and surge pressure that result from abrupt changes in the velocity of a column of water moving through a restrained pipe may be calculated using the following formulas:

$$\alpha = \frac{A_1}{\left[1 + \frac{K(SDR-2)}{E}\right]^{1/2}} \qquad \text{(Eq F.1)}$$

$$P_s = \alpha\left(\frac{\Delta v}{A_2}\right) \qquad \text{(Eq F.2)}$$

Where:

α = wave velocity, in ft/sec (m/sec)

A_1 = 4,675 ft/sec (1,433 m/sec)

K = bulk modulus of water = 294,000 psi (2,053.5 MPa)

SDR = standard dimension ratio (see Sec. 3.3)

E = modulus of elasticity of pipe material [for PEX 1006, E = 93,000 psi (630 MPa) at 73.4°F (23°C)].

P_s = surge pressure (gauge), in psig (kPa)

$\triangle v$ = velocity change, in ft/sec (m/sec), occurring within a critical time denoted by $2L/\alpha$, where L is the pipe length in ft (m)

A_2 = 2.31g [g is gravitational acceleration of 32.2 ft/sec^2 (9.81 m/sec^2)]

NOTE: E varies specific to the PEX material used. E typically ranges between 91,000 psi and 105,000 psi [secant modulus of one percent at 73.4°F, (23°C) per ASTM D638].

Where:

L = pipe length, in ft (m)

Table F.1 Includes the surge pressures resulting from an instantaneous change in velocity of 1 ft/sec (0.3048 m/sec), as calculated from the earlier equations. The anticipated surge pressure and the instantaneous change in velocity are directly related; therefore, the surge resulting from higher velocity changes is a multiple of the values given in this table (i.e., the surge anticipated at a flow rate of 5 ft/sec (1.5 m/sec) is five times the value at 1 ft/sec (0.30 m/sec).

II.A.3 Temperature effects. The pressure class of pipe in ANSI/AWWA C904 is based on a water temperature of 73.4°F (23°C). PEX piping intended for use where water service temperatures may exceed this value for prolonged periods should have a hydrostatic design basis (HDB) established in accordance with ASTM D2837 for the specified (or higher) temperature. An elevated-temperature HDB value can be obtained from the pipe manufacturer for the specific polyethylene resin being used. An elevated-temperature class can then be calculated using Eq 1 (Sec. 3[6]), with elevated-temperature HDB used as the value for HDB in the equation. An alternative method of establishing an elevated-temperature pressure class is to multiply the pressure class at 73.4°F (23°C) by an interpolated temperature compensation factor recommended by the pipe manufacturer.

Table F.1 Calculated surge pressures for an instantaneous change in velocity of 1 ft/sec (0.30048 m/sec) in PEX pipe

Standard Dimension Ratio (SDR)	Surge Pressures
9.0	13.0 psi/89.4 kPa

II.B. *Design Criteria.*

II.B.1. Hydrostatic design stress. For PEX materials covered by this standard, the value of the hydrostatic design stress (HDB multiplied by the design factor, which is 0.5 in this standard) is given in Table F.2. This value is for service temperatures of 73.4°F (23°C) or lower and should be modified for higher service temperatures (see Sec. II.A.3).

II.B.2. Oxidative stability in chlorinated water applications. PEX piping intended for use in the transport of potable water shall have a minimum estimated time-to-time failure of 50 years when tested in accordance with ASTM F2023 and F876.

II.B.3. Design factor. Because the strength of PEX materials depends on the duration of application loading, the effective safety factor that corresponds to a design factor of 0.5 will vary with actual end-use conditions. For the PEX materials covered by this standard, the effective safety factor under hydrostatic pressure ranges from at least 3 for short-term loading to approximately 2 for long-term (100,000 hr) sustained loading at the maximum recommended system working pressure and service temperature. The design factor is also intended to account for unknown local effects, such as ovalling and longitudinal bending, that occur in installed buried pipe.

II.B.4. External loads.

II.B.4.1 Earth loads. For properly installed small-diameter pipe, the effects of distributed earth loads can usually be disregarded.

II.B.4.2 Live loads. Pipe should be installed to preclude construction loads and subsequent traffic loads. If the installation is to be subjected to surface traffic, a minimum cover of 24 in. (610 mm) should be provided, and trench backfill in the pipe zone should be compacted to at least 90 percent of the laboratory maximum density of the backfill soil as determined in accordance with ASTM D698.

Table F.2 Hydrostatic design basis and hydrostatic design stress for PEX pipe and tubing

Standard PEX Code	Hydrostatic Design Basis at 73.4°F (23°C)		Hydrostatic Design Stress at 73.4°F	
	psi	*kPa*	psi	*kPa*
PEX 1006	1,250	8,620	630	4,340

II.B.4.3 Concentrated loads. Pipe installations should be designed and constructed to preclude localized concentrated loadings such as point contact with stones; the effects of differential earth settlement, particularly at points of connection with rigidly anchored fittings; and excessive bending as a result of the installation configuration, especially at the fittings.

II.C. *Installation.*

II.C.1 Storage and handling. PEX pipe should be stored in a way that prevents damage as a result of crushing or piercing, excessive heat, harmful chemicals, or exposure to sunlight for prolonged periods. The allowable duration for exposure to sunlight depends on the stabilization package contained in the material. Consult the pipe manufacturer for specific storage limitations and recommendations.

PEX is not subject to breakage during normal handling. However it is subject to damage from hard objects with a cutting edge during installation. Handling operations, trench installation, and backfill operations should be performed with reasonable care to prevent scratches, nicks, and gouges in the conduit.

Practices such as dragging pipe over rough ground and installing by pulling through auger or bored holes containing sharp-edged material should be avoided to prevent damage by excessive abrasion and cutting. Uncoiling and other handling should be done to avoid kinking. If pipe is cut to a depth greater than 10 percent of its wall thickness, the damaged portion should be removed, discarded, and replaced.

II.C.2 Bending. Bends in PEX pipe are not permitted closer than 10 pipe diameters from any fitting or valve. The recommended minimum radius of curvature is 30 diameters, or the coil radius when bending with the coil. Furthermore, bending of coiled pipe against the coil (reverse bending) should not go beyond straight.

II.C.3 Joining methods and fittings. Fittings used on service line applications should be insert-stiffener type complying with the material and performance requirements of ANSI/AWWA C800 and the manufacturer's requirements for dimensions and tolerances. The use of fittings that are not covered by a nationally accredited standard is subject to the judgment and discretion of the purchaser. Each such fitting should be qualified before use by investigation and by tests when necessary to determine the fitting is suitable and safe for the intended service.

Qualify each fitting by independent third-party test results when necessary to determine if the fitting is safe for the intended service.

PEX pipe can be joined to other PEX pipe or fittings or to pipe or appurtenances of other materials using one or more joining systems. The purchaser should verify

with the pipe and fittings manufacturer that fittings are capable of restraining PEX pipe from pullout, especially for larger-diameter products with thicker walls. Pressure classes for pipe and fittings should be the same or compatible. Further information and specific procedure may be obtained from the pipe and fittings manufacturers.

II.C.3.1 Cold Expansion Fittings (ASTM F1960). Cold expansion fittings with PEX reinforcing rings are available for PEX pipe in a variety of configurations including couplings, tees, and adapters. Pipe ends should be prepared for such fittings by cutting the pipe end square, using a cutter tool designed for cutting plastic pipe. Connections are made by sliding a PEX ring over the PEX pipe and expanding the ring and pipe simultaneously. The expanded pipe and PEX ring then slide over the cold expansion fitting. The connection is made as the PEX pipe/flex ring shrinks over the inserted fitting. Do not install cold expansion fittings in temperatures below 5°F (–15°C).

II.C.3.2 Cold expansion fittings (ASTM F2080). Cold expansion fittings with metal compression-sleeves are available for PEX pipe in a variety of configurations including couplings, tees, and adapters. Align the PEX pipe, brass sleeve and cold expansion fitting. Expand the PEX pipe end and then ratchet the brass sleeve over the cold expansion fitting and tubing until the sleeve is seated against the shoulder of the cold expansion fitting.

II.C.3.3 Metal insert fittings (ASTM F1807). Metal insert fittings utilizing a copper crimp ring are available for PEX pipe in a variety of configurations including couplings, tees, and adapters. Connections are made by the compression of a copper crimp ring around the outer circumference of the tubing, forcing the pipe material into the annular spaces formed by the ribs of the fitting.

II.C.4 Embedment of pipe and tubing. In underground installations, PEX pipe should be installed in trench bottoms that provide continuous support and are free from rocks, stones, and debris (see ASTM D2774). The initial backfill, from 3 in. (76 mm) below the pipeline to 4 in. to 6 in. (100 mm to 150 mm) above the pipe, should be sand or other materials, as allowed in ASTM D2774. To prevent freezing in the water lines, the pipe should be installed below the frost line.

II.C.5 Testing. The purchaser should test the system for leakage in accordance with the applicable code or engineering standards.

II.D. *Water System Disinfection.* PEX pipe should be disinfected in accordance with ANSI/AWWA C651, Standard for Disinfecting Water Mains.

II.E. *Squeeze-off.* The use of squeeze-off techniques for emergency shutoff should be performed only on materials, wall thicknesses, and pipe diameters with tools and methods as recommended by the pipe manufacturer.

II.F. *References.* The latest editions of the following documents are incorporated by reference in Section 2 to the extent specified. In case of conflict, the provisions of Section 2 shall prevail. These references are provided for information only and are not part of ANSI/AWWA C904.

ANSI/AWWA C651—Disinfection of Water Mains.

ANSI/AWWA C800—Underground Service Line Valves and Fittings.

ASTM D698—Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 [600 kN-m/m^3]).

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 or Pressure Design Basis for Thermoplastic Pipe Products.

ASTM F876—Standard Specification for Cross-linked Polyethylene (PEX) Tubing.

ASTM F1807—Standard Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Cross-linked Polyethylene (PEX) Tubing.

ASTM F1960—Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) Tubing.

ASTM F2023—Standard Test Method for Evaluating the Oxidative Resistance of Cross-linked Polyethylene (PEX) Tubing and Systems to Hot Chlorinated Water.

ASTM F2080—Standard Specification for Cold-Expansion Fittings with Metal Compression-Sleeves for Cross-linked Polyethylene (PEX) pipe.

III. Use of this Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

III.A. *Purchaser Options and Alternatives.* The following items should be provided by the purchaser:

1. Standard used, that is, ANSI/AWWA C904, Standard for Cross-linked Polyethylene (PEX) Pressure Pipe, ½ In. (12 mm) Through 3 In. (76 mm), for Water Service, of latest revision.

2. Whether compliance with NSF/ANSI 61, Drinking Water System Compo-

nents—Health Effects, is required, in addition to the requirements of the Safe Drinking Water Act.

3. Pipe

a. Standard code designation of the PEX material (Sec. 4.2.1 and Table 1).

b. Nominal size, pressure rating, standard dimension ratio, form (straight or coiled), length of individual pieces, and total linear feet (linear meters) for each different item to be furnished (Tables 2 through 4 and Sec. 4.3.)

4. Specifications. The following requirements should be specified:

a. Details of other federal, state, or provincial, and local requirements (Sec. 4.2).

b. Special quality-control tests and records (Sec. 5).

c. Plant inspection (Sec. 5.6).

d. Special preparation for shipment (Sec. 6.2).

e. Affidavit of compliance (Sec. 6.3).

f. Special marking (Sec. 6.1).

III.B. *Modification of Standard.* Any modification to the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions. This is a new standard.

V. Comments. If you have any comments or questions about this standard, please call the AWWA Volunteer & Technical Support Group at 303.794.7711, FAX at 303.795.7603, write to 6666 West Quincy Avenue, Denver CO, 80235-3098, or e-mail standards@awwa.org.

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ANSI/AWWA C904-06
(First Edition)

American Water Works Association

AWWA Standard

Cross-linked Polyethylene (PEX) Pressure Pipe, ½ In. (12 mm) Through 3 In. (76 mm), for Water Service

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes Cross-linked Polyethylene (PEX) pressure pipe made from material having a standard PEX material designation code of PEX 1006 in ASTM* F876 for use as underground water service lines in sizes ½ in. (12 mm) through 3 in. (76 mm) that conform to a standard dimension ratio of SDR9.

Included in this standard are criteria for classifying PEX plastic pipe materials, a system of nomenclature, requirements, and test methods for materials and pipe. Methods of marking are given. Design, installation, and application considerations are discussed in the foreword of this standard.

*ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

Sec. 1.2 Purpose

The purpose of this standard is to provide the requirements for materials, design, testing and inspection, and shipping of PEX pipe for use as service lines in the construction of underground water distribution systems.

Sec. 1.3 Application

This standard can be referenced for purchasing and receiving PEX pressure pipe for use as service lines in the construction of underground water distribution systems. This standard can be used as a guide for manufacturing PEX pipe. The stipulations of this standard apply when this document has been referenced and only to PEX pipe.

SECTION 2: REFERENCES

This standard references the following documents. In their latest editions, these documents form a part of this standard to the extent specified within the standard. In any case of conflict, the requirements of this standard shall prevail.

ANSI*/AWWA C800—Underground Service Line Valves and Fittings.

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 Pressure of Plastic Pipe, Tubing and Fittings.

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

ASTM D2837—Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.

ASTM D3350—Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

ASTM F412—Standard Terminology Relating to Plastic Piping Systems.

*American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

†ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.