ANSI/AWWA C903-05
(Revision of ANSI/AWWA C903-02)

American Water Works Association

The Authoritative Resource on Safe Water℠

AWWA Standard

Polyethylene–Aluminum–Polyethylene & Cross-linked Polyethylene–Aluminum–Cross-linked Polyethylene Composite Pressure Pipes, ½ In. (12 mm) Through 2 In. (50 mm), for Water Service

ANSI American National Standards Institute

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AWWA Standard

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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:

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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 a part of ANSI/AWWA C903.

I. Introduction.

I.A. *Background.* This standard describes polyethylene–aluminum–polyethylene and cross-linked polyethylene–aluminum–cross-linked polyethylene composite pressure pipes for use primarily as water service lines in the construction of underground water distribution systems.

These composite pipes consist of a welded aluminum tube reinforcement between the inner and outer layers of polyethylene. The inner and outer polyethylene layers are bonded to the aluminum tube by a polymeric melt adhesive. This standard describes both linear polyethylene–aluminum–polyethylene configurations, defined as PE–AL–PE pipes, and cross-linked polyethylene–aluminum–cross-linked polyethylene configurations, defined as PEX–AL–PEX pipes. Pipes described by this standard are made from Grade PE20, PE23, PE30, or PE33, Class A, B, or C polyethylene material in combination with polymeric melt adhesive and aluminum tube, as defined further in this standard and in ASTM F1281 and ASTM F1282. This standard describes pipe conforming to outside diameter dimensions in nominal size from 1/2 in. (12 mm) through 2 in. (50 mm).

I.B. *History.* In the summer of 1997, the American Water Works Association (AWWA) Committee on Polyolefin Pressure Pipe and Fittings was approached to develop a standard describing polyethylene–aluminum–polyethylene and cross-linked polyethylene–aluminum–cross-linked polyethylene composite pressure pipes for water service. Formal application was made to the AWWA Standards Council for the creation of a new standard. The application was accompanied by a letter of endorsement from the Polyolefin Committee stating that it was willing to manage the creation of the standard.

In the fall of 1997, the AWWA Standards Committee authorized the project and a subcommittee was created under the Polyolefin Pressure Pipe and Fittings Committee to handle the task. The first edition of ANSI/AWWA C903 was approved by the AWWA Board of Directors on Jan. 20, 2002. This second edition of C903 was approved by the AWWA Board of Directors on June 12, 2005.

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 direct and 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 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 Chemicals 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

*Persons outside the US should contact the appropriate authority having jurisdiction.

†NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48105.

‡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.

guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA C903 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 parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

II. Special Issues. Although the topics of design and installation are being addressed in a new AWWA Manual on Design and Installation of Polyethylene Pipe currently under development, information is provided in this Foreword for the benefit of users of this standard. After publication of the new AWWA manual, it is expected that these sections will be removed from the Foreword of this standard.

II.A. *Pipe selection.*

II.A.1. Calculation of maximum allowable operating pressure or pressure rating. A minimum pressure rating (PR) of 160 psig (1,118 kPa) is recommended for general durability in handling and for use in typical water service installations. Lesser pressure ratings may be appropriate for specific applications, but selection should be based on a detailed evaluation of factors, such as installation configuration, fitting type, joining methods, use of coiled or straight products, working temperature, and potential for significant surge pressures.

The minimum pressure rating of the pipe selected should be equal to or greater than the maximum expected system operating pressure. The surge pressure should not exceed 50 percent of the maximum operating pressure. If the surge pressure exceeds 50 percent of the maximum operating pressure, consideration should be given to the removal of the cause of surge pressures or the incorporation of surge suppressors in the system.

II.A.2. Calculation of surge pressure. Surge pressure generated by velocity changes in PE–AL–PE or PEX–AL–PEX 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. Surge (water hammer) problems are complex; their solutions require specialized knowledge.

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:

$$a = \sqrt{\frac{K/\rho}{1 + [(Kd)/(tE_{PE})]}}$$

$$t = t_{PEi} + (E_{AL}/E_{PE}) + t_{AL} + t_{PEo}$$

$$P_s = \rho v_o a$$

Where:

a = wave velocity, in ft/sec (m/sec)
K = bulk modulus of water 294,000 lb/in.^{2} (2,100 MPa)
ρ = density of water 1,000 lb/in.^{3} (kg/m^3)
d = internal diameter, in. (mm)
t = equivalent thickness of polyethylene, in. (mm)
t_{PEi} = inner polyethylene layer thickness, in. (mm)
E_{AL} = elastic modulus of aluminum, 4.20 × 10^6 psi (30,000 MPa)
E_{PE} = elastic modulus of polyethylene, 150,000 psi (1,047 MPa)
E_{PEX} = elastic modulus of cross-linked polyethylene, 150,000 psi* (1,047 MPa)
t_{AL} = aluminum layer thickness, in. (mm)
t_{PEo} = outer polyethylene layer thickness, in. (mm)
P_s = surge pressure, psig (kPa)
v_o = change in flow velocity, in ft/sec (m/sec)

Table F.1 shows 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 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 velocity of 5 ft/sec [1.524 m/sec] is five times the value at 1 ft/sec [0.3048 m/sec]).

*If calculating surge pressure in PEX-AL-PEX service lines, use E_{PEX} instead of E_{PE}.

Table F.1 Calculated surge pressures for an instantaneous change in velocity of 1 ft/sec (0.3048 m/sec) in PE–AL–PE or PEX–AL–PEX pipe

Pipe Diameter		Surge Pressure	
in.	*(ID/OD mm)*	*psig*	*(kPa)*
1/2	(12 / 16)	29.6	(205.4)
5/8	(16 / 20)	29.0	(201.7)
3/4	(20 / 25)	26.5	(184.3)
1	(25 / 32)	25.0	(173.8)
1 1/4	(32 / 40)	23.3	(161.8)
1 1/2	(41 / 50)	22.2	(154.2)
2	(51 / 63)	19.5	(135.4)

NOTE: Metric nominal pipe size is described by a four-digit numbering system. The first two digits represent nominal inside diameter (ID) in mm. The last two digits represent nominal outside diameter (OD) in mm. As an example, nominal pipe size 12/16 has nominal ID of 12 mm and nominal OD of 16 mm.

II.A.3. Temperature effects. The pressure rating of PR 200 for pipes in ANSI/AWWA C903 is based on water temperatures of 73.4°F (23°C). For elevated temperatures, Table 7 details pressure ratings for pipes, 180°F (82°C), and 200°F (93°C).

These pressure ratings are obtained by multiplying the pressure design basis (PDB) by a 0.5 design factor, recommended by the Plastics Pipe Institute (PPI),* in keeping with PPI TR-3 and listed in PPI TR-4 for composite "multilayer" pipe.

II.B. *External Loads.*

II.B.1. Earth loads. For properly installed small-diameter conduit, the effects of distributed earth loads can usually be disregarded.

II.B.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 12 in. (30.5 cm) 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. Section II.C.4 of this Foreword provides further detail.

*Plastics Pipe Institute, 1825 Connecticut Ave., N.W., Suite 680, Washington, DC 20005.

II.B.3. Concentrated loads. Pipe installations should be designed and constructed to preclude localized concentrated loadings, such as point contact with stones; the effect of differential earth settlement, particularly at points of connection with rigidly anchored fittings; and excessive bending caused by installation configuration, especially fittings.

II.C. *Installation.*

II.C.1. Storage and handling. PE–AL–PE and PEX–AL–PEX pipe should be stored in a way that prevents damage caused by crushing, abrasion, piercing, excessive heat, harmful chemicals, or exposure to sunlight for prolonged periods. The manufacturer's recommendations regarding storage should be followed.

PE–AL–PE pipe and PEX–AL–PEX pipe are not subject to breakage during normal handling. However, they are subject to damage by hard objects with a cutting edge. Therefore, handling operations, trench installation, and backfill should be performed with reasonable care to prevent scratches, nicks, and gouges in the conduit.

Practices such as dragging coils of pipe over rough ground and installing by pulling through auger or bore holes containing sharp-edged material should be avoided to prevent damage by excessive abrasion and cutting. If pipe is cut to a depth exposing the aluminum core, the damaged portion should be removed, discarded, and replaced. If pipe becomes out of round from mishandling or bending, the section may be rerounded as per manufacturer's instructions. Kinked pipe sections should be removed, discarded, and replaced.

II.C.2. Bending. Bends in PE–AL–PE and PEX–AL–PEX pipe should not be permitted to occur closer than 10 diameters from any fitting or valve. The recommended minimum radius of curvature shall be as shown in Table F.2. Care should be taken to ensure that kinking does not develop either during or after installation. The manufacturer's instructions and recommendations for bending pipe should be followed.

II.C.3. Joining methods and fittings. Fittings used in service line applications should be insert types, 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 recognized standard is subject to the judgment and discretion of the purchaser. Each fitting should be qualified before use by investigation and by tests when necessary to determine that the fitting is suitable and safe for the intended service.

Table F.2 Minimum bending radius for PE–AL–PE and PEX–AL–PEX pipe

Nominal Pipe Size		Minimum Bending Radius*	
in.	*(ID/OD mm)*	*psig*	*(kPa)*
1/2	(12 / 16)	3.2	(80)
5/8	(16 / 20)	4.0	(100)
3/4	(20 / 25)	5.0	(125)
1	(25 / 32)	6.3	(160)
1 1/4	(32 / 40)	7.5	(190)
1 1/2	(41 / 50)	8.8	(225)
2	(51 / 63)	11.6	(295)

NOTE: Metric nominal pipe size is described by a four-digit numbering system. The first two digits represent nominal ID in mm. The last two digits represent nominal OD in mm. As an example, nominal pipe size 12/16 has nominal ID of 12 mm and nominal OD of 16 mm.

*Manufacturer's recommendations, procedures, and equipment should be used to achieve at least the minimum bending radii shown in Table F.2.

II.C.4. Embedment of pipe. In underground installations, PE–AL–PE and PEX–AL–PEX pipe should be installed in trench bottoms that provide continuous support and are uniform and free from rocks, stones, and debris (reference ASTM D2774). The initial backfill material, from 3 in. (7.6 cm) below the pipeline to 4–6 in. (10.2 cm–15.2 cm) above the pipe, should be as permitted in ASTM D2774. Excavated trench material may be used if it meets the requirements of ASTM D2774. In order to prevent freezing in water lines, pipe should be installed below the frost line.

II.C.5. Under-slab installation. PE-AL-PE and PEX-AL-PEX may be installed under a concrete slab.

II.C.6. Testing. The installation should be tested for leakage in accordance with the applicable code or engineering standard prior to acceptance by the owner.

II.D. *Water system disinfection.* PE–AL–PE and PEX–AL–PEX pipe should be disinfected in accordance with ANSI/AWWA C651, Standard for Disinfecting Water Mains. After disinfecting, the system should be purged, including isolated or stagnant service lines.

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

II.F. *References.* The latest edition of the following documents are incorporated by reference in the Foreword to the extent specified. In any case of conflict, the provisions of the Foreword should prevail. These references are provided for information only and are not a part of ANSI/AWWA C903.

ANSI/AWWA C651—Disinfecting Water Mains.

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

ASTM* D698—Standard 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 F1281—Standard Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe.

ASTM F1282—Standard Specification for Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure Pipe.

PPI TR-3/2004—Policies and Procedures for Developing Hydrostatic Design Bases (HDB), Pressure Design Bases (PDB), Strength Design Bases (SDB), and Minimum Required Strengths (MRS) Ratings for Thermoplastic Piping Materials or Pipe.

PPI TR-4/2004—PPI Listing of Hydrostatic Design Bases (HDB), Strength Design Bases (SDB), Pressure Design Bases (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or 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 C903, Standard for Polyethylene–Aluminum–Polyethylene & Cross-linked Polyethylene–Aluminum–Cross-linked Polyethylene Composite Pressure Pipes, 1/2 In. (12 mm) Through 2 In. (50 mm), for Water Service, of latest revision.

2. Whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, is required in addition to the requirements of the Safe Drinking Water Act.

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

3. Details of other federal, state, local, and provincial requirements (Sec. 4.2).
4. Pipe
    a. Standard code designation of the PE material (Sec. 4.2 and Table 1).
    b. Nominal size and pressure rating.
    c. PE–AL–PE or PEX–AL–PEX pipe material.
5. Specifications. The following requirements should be specified
    a. Testing frequency, quality control records, and plant inspection.
    b. Marking (Sec. 6.1).
    c. Special shipment (Sec. 6.2).
    d. Affidavit of compliance (Sec. 6.3).

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

IV. Major Revisions. Changes in material ratings.

V. Comments. If you have any comments or questions about this standard, please call the AWWA Volunteer and Technical Support Group at (303) 794-7711, FAX (303) 795-7603, write to the group at 6666 West Quincy Avenue, Denver, CO 80235-3098, or e-mail at standards@awwa.org.

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AWWA Standard

Polyethylene–Aluminum–Polyethylene and Cross-linked Polyethylene–Aluminum–Cross-linked Polyethylene Composite Pressure Pipes, 1/2 In. (12 mm) Through 2 In. (50 mm), for Water Service

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes coextruded polyethylene (PE) composite pressure pipes with a welded aluminum tube reinforcement between the inner and outer layers of PE, primarily for use as underground water service lines. The inner and outer layers are bonded to the aluminum tube by a polymeric melt adhesive. This standard describes both linear polyethylene–aluminum–polyethylene configurations, hereafter referred to as PE–AL–PE pipes, and cross-linked polyethylene–aluminum–cross-linked polyethylene configurations, hereafter referred to as PEX–AL–PEX pipes.

Pipes described in this standard are made from Grade PE20, PE23, PE30, or PE33, Class A, B, or C PE material in combination with polymeric melt adhesive and aluminum tube, as defined further in this standard and in ASTM* F1281 and ASTM F1282. This standard describes pipe conforming to outside diameter

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