ANSI/AWWA C903-16
(Revision of ANSI/AWWA C903-05)

American Water Works Association

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AWWA Standard

Polyethylene–Aluminum–Polyethylene (PE–AL–PE) Composite Pressure Pipe, 12 mm (½ In.) Through 51 mm (2 In.), for Water Service

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AWWA Standard

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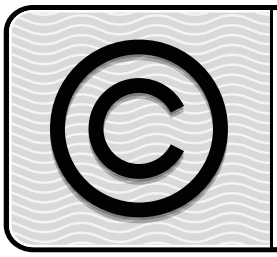

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA C903.*

I. Introduction.

I.A. *Background.* This standard describes the dimensions and requirements for polyethylene–aluminum–polyethylene composite pressure pipe (PE–AL–PE) for use primarily as water service lines in the construction of underground water distribution systems.

The pipe consists of a welded aluminum tube jacketed by protective inner and outer layers of polyethylene (PE). The inner and outer PE layers are adhesively bonded to the aluminum tube by a polymeric hot-melt adhesive. This standard describes pipe conforming to inside diameter nominal pipe size from 12 mm (½ in.) through 51 mm (2 in.).

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 PE–AL–PE and PEX–AL–PEX 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. The second edition was approved on June 12, 2005. This third edition of C903 was approved on June 19, 2016.

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 Water Research Foundation (formerly 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.

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

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. Specific policies of the state or local agency.
2. 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.
3. 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 jurisdictions. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

Annex A to NSF/ANSI 61, "Toxicology Review and Evaluation Procedures," 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 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. Information on product selection and installation is provided in this foreword for the benefit of the users of this standard. An AWWA manual on the design and installation of PE–AL–PE pipe is planned.

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

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

‡ Both publications available from National Academy of Science, 500 Fifth Street, NW, Washington, DC 20001.

II.A. *Pipe Selection.*

II.A.1 Pressure rating. The pipe pressure rating for a specific application should be based on a detailed evaluation of the operating pressure, the installation configuration, joining methods and fitting types, use of coiled or straight products, installed bend radii, working temperature, disinfection type and concentration, and surge pressure.

NOTE: The designer should consider the frequency of surge events and the magnitude of the surge pressure.

The pressure rating of the pipe selected should be equal to or greater than the sum of the maximum expected system operating pressure and maximum surge pressure not to exceed 200 psi. If the maximum expected system operating pressure and maximum surge pressure exceed 200 psi, consideration should be given to the removal of the cause of surge pressures, reduction of the surge pressure to an acceptable value, or the incorporation of surge suppressors in the system.

Pressure rating (*PR*), operating pressure ($P_{operating}$), and surge pressure (*PS*), are related by the following equation:

$$PR \geq P_{operating} + PS \qquad \text{(Eq F-1)}$$

The pressure rating for pipe specified in ANSI/AWWA C903 is given in Table 4 for use with water at 73.4°F (23°C). Consult the manufacturer for ratings at additional temperatures.

II.A.2 Calculation of surge pressure. Surge pressure generated by velocity changes in PE–AL–PE service lines may be estimated using the equations 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 equations:

$$a = \sqrt{\frac{\left(\frac{K}{\rho}\right)}{\left(1 + \frac{Kd}{E_{PE}(t_{PEi} + t_{PEo}) + E_{AL}\,(t_{AL})}\right)}} \qquad \text{(Eg F-2)}$$

$$P_s = \rho v_o a \qquad \text{(Eq F-3)}$$

Where:

a = wave velocity, ft/sec (m/sec)

K = bulk modulus of water 294,000 lb/in.^{2} (2,100 MPa)

ρ = density of water 0.036 lb/in.^{3} (1,000 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} = dynamic modulus of 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 (MPa)
v_o = change in flow velocity, 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]).

Because the end user cannot determine the rate of extinguished instant velocity (ft/sec), the service line designer should assume full flow at an expected delivery pressure, determine the worst case flow velocity, and determine the operating pressure rating (*PR*) from Figure F.1.

Table F.1 Surge pressures and maximum allowable instantaneous change in velocity in PE–AL–PE (PR 200 psi) pipe

Nominal ID Size	Surge Pressure		Maximum Allowable Instantaneous Change in Velocity*	
mm	*psig*	*(kPa)*	*ft/sec*	*(m/sec)*
12	29.6	(205.4)	3.4	(1.0)
16	29.0	(201.7)	3.4	(1.0)
20	26.5	(184.3)	3.8	(1.2)
25	25.0	(173.8)	4.0	(1.2)
32	23.3	(161.8)	4.3	(1.3)
41	22.2	(154.2)	4.5	(1.4)
51	19.5	(135.4)	5.1	(1.6)

* Note: Maximum allowable instantaneous change in velocity is based on a 100-psi maximum surge pressure.

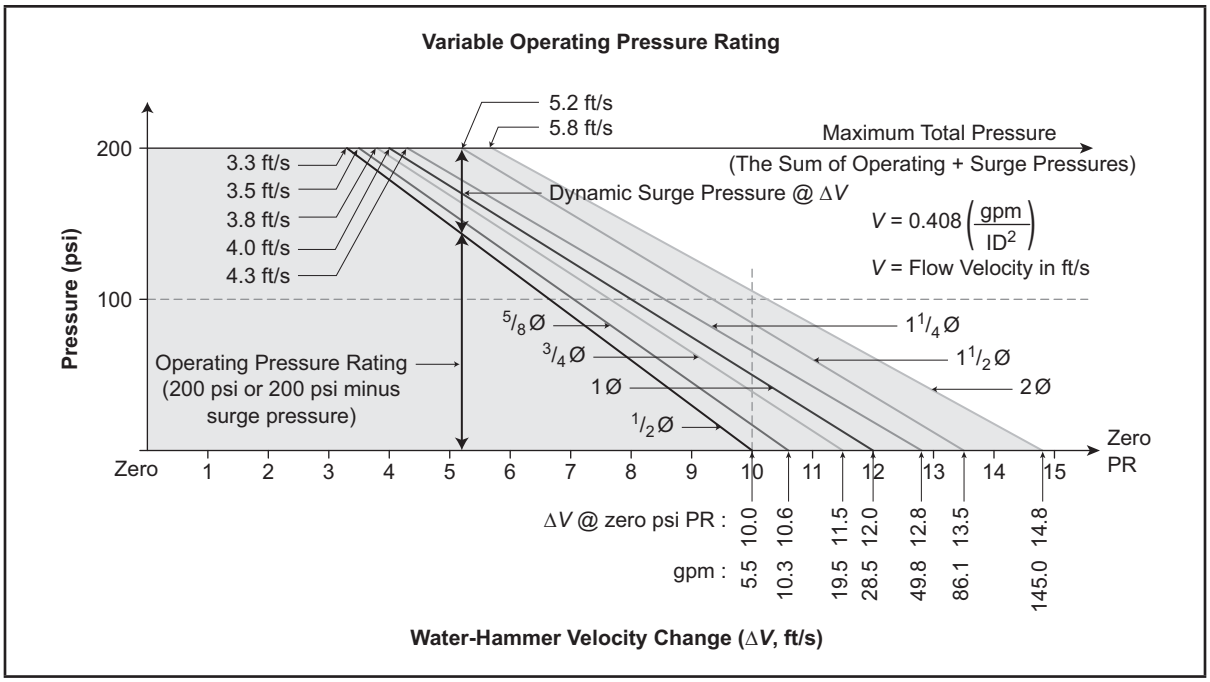

Figure F.1 Dynamic pressure rating chart

II.B. *Installation.*

II.B.1 Storage and handling. PE–AL–PE pipe should be stored and handled using methods that prevent damage caused by crushing, abrasion, piercing, excessive heat, harmful chemicals, or exposure to sunlight.

Therefore, handling operations, trench installation, and backfill should be performed with reasonable care.

To prevent damage by excessive abrasion and cutting, pipe should not be dragged over rough ground or over sharp-edged material. A pipe section that has been damaged such that the aluminum core is exposed shall be removed, discarded, and replaced.

II.B.2 Bending. Bends in PE–AL–PE pipe should be at least 10 diameters from any fitting or valve. The recommended minimum radius of curvature is shown in Table F.2. Observe the manufacturer's instructions and recommendations for bending pipe. Avoid bending in opposite directions as this could damage the pipe; follow manufacturer's instructions. If pipe becomes out of round from mishandling or bending, the section may be rerounded in accordance with manufacturer's instructions. Pipe shall not be kinked either during or after installation. Kinked pipe sections shall be removed, discarded, and replaced.

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

Nominal Pipe Size	Minimum Bending Radius*	
mm	*in.*	*(mm)*
12	3.2	(80)
16	4.0	(100)
20	5.0	(125)
25	6.3	(160)
32	7.5	(190)
41	8.8	(225)
51	11.6	(295)

* Manufacturer's recommendations, procedures, and equipment should be used when bending the pipe.

II.B.3 Fittings. PE–AL–PE pipe shall not be flared or threaded. Fittings and connectors (hereinafter referred to as *fittings*) used to join PE–AL–PE pipe shall meet the following requirements:

1. Fittings shall be specifically intended for use with AWWA C903 PE–AL–PE pipe and shall be so identified on packaging, installation instructions, or fitting markings.

2. Fittings shall conform to the sealing requirements of ASTM F1282.

3. Fittings shall have a pressure seal to the inner diameter (ID) or the inner surface to prevent water from touching the aluminum exposed at the end of the pipe. Pipe and fitting assemblies shall not separate or leak when tested in accordance with Sec. 4.3.5 and Sec. 4.3.7.

4. Fittings shall comply with ASTM F1282, ASTM F1974, or CSA B137.9, and ANSI/AWWA C800.

5. The use of a fitting not covered by a nationally accredited standard is subject to the judgment and discretion of the purchaser. Each such fitting should be qualified for use by investigation and by tests when necessary to determine that the fitting is suitable and safe for the intended service.

II.B.4 Earth loads. For small-diameter pipe that is properly installed in accordance with ASTM D2774, the effects of distributed earth loads can usually be disregarded.

NOTE: ASTM D2774 does not strictly cover composites but general guidance can be obtained from ASTM D2774.

II.B.5 Embedment of pipe. In underground installations, PE–AL–PE pipe should be installed in trench bottoms that provide continuous support and are

uniform and free from rocks, stones, debris, or any substance that could impinge on the pipe (reference ASTM D2774). The initial backfill material around the pipe from 3 in. (8 cm) below the pipeline to 4–6 in. (10 cm–15 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. PE–AL–PE pipe should not be installed through auger or bore holes.

II.B.6 Live loads. Pipe should be installed using embedment and installation practices that limit construction loads, earth loads, and any static (structure) and dynamic (traffic) surface loads to the design capabilities of the pipe. If the installation is to be subjected to surface traffic, provide a minimum cover of at least 12 in. (30.5 cm). Determine embedment soil maximum density in accordance with ASTM D698. Install and compact embedment to at least 90 percent of the laboratory maximum density as determined using field soil density measurement equipment.

II.B.7 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.B.8 Under-slab installation. Properly embedded PE–AL–PE pipe with sufficient cover may be installed under a concrete slab if permitted by the authority having jurisdiction.

II.B.9 Testing. The installation should be tested for leakage in accordance with the applicable code or engineering standard before acceptance by the owner.

II.B.10 Permeation. Composite pipes described in this standard are manufactured with a welded aluminum tube jacketed by inner and outer layers of PE. The inner and outer layers are bonded to the aluminum tube by a polymeric hot-melt adhesive. This aluminum tube provides a barrier to the permeation of external contaminants. If an installation includes buried joints, the ability of the joint to resist permeation shall be considered. Damage that perforates the inner or outer PE layers or absorption by the outer layer of a permeating hydrocarbon may adversely affect the composite structure of the product and may result in increased susceptibility to permeation.

II.C. *Water System Disinfection.* Newly installed or replaced PE–AL–PE pipe should be disinfected in accordance with ANSI/AWWA C651, Disinfecting Water Mains. After disinfecting, the system should be immediately purged, including isolated

or stagnant service lines. Highly chlorinated solutions should not be left in the pipeline beyond the few hours needed to provide disinfection.

II.D. *References.* The latest editions of the following documents are referenced in the foreword. These references are provided for information only and are not a part of the foreword of ANSI/AWWA C903.

ANSI/AWWA C651—Disinfecting Water Mains.

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

ASTM* D698—Standard Test Methods 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 F1282—Standard Specification for Polyethylene/Aluminum/Polyethylene (PE–AL–PE) Composite Pressure Pipe.

ASTM F1974-09—Standard Specification for Metal Insert Fittings for Polyethylene/Aluminum/Polyethylene and Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene Composite Pressure Pipe.

CSA† B137.9 Polyethylene/Aluminum/Polyethylene (PE–AL–PE) Composite Pressure-Pipe Systems.

NSF‡/ANSI 61—Drinking Water System Components—Health Effects.

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, Polyethylene–Aluminum–Polyethylene (PE–AL–PE) Composite Pressure Pipe, 12 mm (½ In.) Through 51 mm (2 In.), for Buried 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.

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

4. Pipe

a. Standard code designation of the PE material (Sec. 4.2).

* ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.
† CSA Group, 5060 Spectrum Way, Suite 100, Mississauga, ON L4W 5N6, Canada.
‡ NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

b. Nominal size and pressure rating.

c. PE–AL–PE 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. Major changes made to the standard in this edition include the following:

1. PEX–AL–PEX was removed from the standard as this product is no longer manufactured in accordance with AWWA C903.

2. Pressure rating section revised to state that the pressure rating of the pipe should be equal to or greater than the sum of the expected system operating pressure and maximum surge pressure and should not exceed 200 psi (Sec. II.A.1).

3. Revised Table F.1 to include maximum allowable instantaneous change in velocity (Sec. II.A.2).

4. Added Figure F.1, Dynamic Pressure Rating Chart (Sec. II.A.2).

5. Revisions to the definitions for Composite Pipe, Modified Polyethylene Hot-Melt Adhesive, Pressure Design Basis, and Pressure Rating. Added definitions of Aluminum Alloy, Design Factor, Fitting, Inner Layer, Outer Layer, Out-of-Roundness, and Total Wall Thickness at Any Point. Removed definitions of PEX and Cross-Linking (Section 3).

6. PE material designations have been updated (Sec. 4.2.1).

7. Requirements for aluminum have been clarified and expanded (Sec. 4.2.4, 4.3.1.1, and 4.3.3).

8. Colors have been added for reclaimed water, wastewater, and potable water uses (Sec. 4.2.2).

9. Additional qualification testing (Sec. 5.2) has been added as follows: cold bend testing (Sec. 4.3.5), adhesion and delamination tests (Sec. 4.3.7), apparent tensile strength of pipe (Sec. 4.3.8), and pressure design basis (Sec. 4.3.13).

10. Requirements for chlorine resistance and associated marking have been added (Sec. 4.3.10 and Sec. 6.1.2).

11. Added appendix A, Bibliography for Additional Information Regarding Permeation of Polyolefin Pipes.

V. Comments. If you have any comments or questions about this standard, please call AWWA Engineering and Technical Services at 303.794.7711, FAX 303.795.7603; write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098; or email the group at standards@awwa.org.

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Polyethylene–Aluminum–Polyethylene (PE–AL–PE) Composite Pressure Pipe, 12 mm (½ In.) Through 51 mm (2 In.) for Water Service

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes the requirements for composite polyethylene–aluminum–polyethylene pipe (hereinafter referred to as PE–AL–PE) in metric nominal inside diameter (ID) sizes 12 mm (½ in.) through 51 mm (2 in.). The pipe described by this standard is intended to be used for potable cold water supply outside buildings as buried water main and service pipeline.

This standard specifies the general requirements, material requirements, process fabrication processes, test requirements, and performance requirements. PE–AL–PE pipe is based on five layers consisting of pipe-grade polyethylene thermoplastics adhesively bonded to the seam-welded aluminum tube of specified alloy, composition, and temper.

The typical PE–AL–PE construction, illustrated in Figure 1, is composed of five-layers consisting of (layer 1) a thick stress-bearing inner liner layer of extruded polyethylene fused to (layer 2) a thin melt-laminated or co-extruded maleic-anhydride modified linear low-density (LLD) polyolefin adhesive material layer that