ANSI/AWWA C905-10
(Revision of AWWA C905-97)

American Water Works Association

The Authoritative Resource on Safe Water®

AWWA Standard

Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm)

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AWWA Standard

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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 part of ANSI/AWWA C905-10.

I. Introduction.

I.A. *Background.* This standard pertains to 14-in. through 48-in. (350-mm through 1,200-mm) polyvinyl chloride (PVC) pressure pipe and fabricated fittings with cast-iron-pipe equivalent (CI) outside diameter (OD) dimensions, steel-pipe-equivalent (IPS) outside diameter (OD) dimensions, and wall-thickness dimension ratios (DRs) of 14, 18, 21, 25, 26, 32.5, 41, and 51. Design considerations are provided in AWWA M23, *PVC Pipe—Design and Installation*, which provides detailed information on PVC pipe covered by ANSI/AWWA C905. The manual includes chapters on general properties of PVC pipe; manufacturing, testing, and inspection; pressure capacity; design factors for external forces; hydraulics; receiving, storage, and handling; testing and maintenance; and service connections (tapping). Recommended installation guidance is provided in ANSI/AWWA C605, Standard for Underground Installation of PVC Pressure Pipe and Fittings for Water.

For PVC pipe and fittings with diameters below 14 in. (350 mm), refer to ANSI/AWWA C900, Standard for PVC Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Transmission and Distribution.

I.B. *History.* This is the third edition of ANSI/AWWA C905. In 1966, the American Water Works Association (AWWA) appointed Committee 8350 D to study and report on the adaptability of plastic pipe for use within the water industry. The committee presented its report on June 6, 1967, at AWWA's annual conference. The report included a recommendation that a task group be appointed to prepare standards for the use of plastic materials. The AWWA Standards Committee on Thermoplastic Pressure Pipe Standards Committee was established in 1968. The first and second editions of this standard were approved by the AWWA Board of Directors in June 1988 and June 1997, respectively.

In June 1988, the Thermoplastic Pressure Pipe Committee was divided into two separate committees: the Polyvinyl Chloride Pressure Pipe and Fittings Standards Committee and the Polyolefin Pressure Pipe and Fittings Standards Committee. This edition of ANSI/AWWA C905 was approved on Jan. 17, 2010.

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

* Persons outside the United States 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, NW, Washington, DC 20001.

ANSI/AWWA C905 does not address additives requirements. Thus, 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. The material presented in this standard will be addressed in a revision to AWWA Manual M23 that is currently in progress. The material is published here to ensure that the users of this standard will have continuous access to the most up-to-date design information. AWWA M23 and this standard will not be compatible until AWWA M23 is revised. Where the design manual does not match, the intent of the standard takes precedence and design matters in AWWA M23 that are inconsistent with this standard should be discussed with the manufacturer.

II.A. *Pipe Selection.*

II.A.1 Selection of pressure class. The minimum pressure class of the pipe or tubing selected should be equal to or greater than the system working pressure. The sum of the system working pressure and occasional surge pressure should not exceed 1.60 times the pressure class of the pipe. The system working pressure and recurring surge pressure should be analyzed using the method in II.A.2. If surge pressures govern the selection of the pressure class, consideration should be given to removal of the cause of surge pressures or to the incorporation of surge suppressors in the system.

II.A.2 Recurring surge pressures. Recurring surge pressures, while present in water distribution systems, are of such low amplitude that they typically do not govern the pipe selection. When analysis is deemed necessary, the method is found in appendix B.

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 to be used—that is, ANSI/AWWA C905, Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm), of latest revision.
2. Whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, is required.

3. Details of other federal, state or provincial, and local requirements (Sec. 4.2.1).

4. Pipe and fabricated fittings.*

a. Nominal size (for example, 14 in.).

b. Working, occasional, and recurring surge pressures (Section 4).

c. Pressure class or DR (see Table 1).

d. Linear feet of each pressure class or DR for each nominal pipe size to be furnished.

e. Number, nominal size, pressure class, or DR and configuration for fittings and couplings (for example, 17, nominal 24-in. DR 25, 45° bends, IPS).*

5. When desired, requirements such as the following should be specified in the purchase contract:

a. Standard lengths (Sec. 4.3.2.3).

b. Shipping and delivery (Sec. 6.2).

c. Affidavit of compliance (Sec. 6.3).

6. Plant inspection. If plant inspections are desired, provisions must be specified in the purchase contract (Sec. 5.3).

a. Production notice. The manufacturer should be required to give adequate advance notice of when and where production of ordered materials will start.

b. Inspection aids. The manufacturer should be required to make available, without charge, to the purchaser's inspector such tools and assistance as are necessary for inspection and handling of materials.

c. Inspection limitations. To exclude inspection of proprietary manufacturing processes, the manufacturer should be required to give adequate advance notice to the purchaser.

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. Treatment of surge pressures was expanded to include occasional (emergency) surge and recurring (cyclic) surge.

* Note: Purchase documents may allow or require the use of fittings other than those described in ANSI/AWWA C905. Some examples of compatible fittings include those covered in ANSI/AWWA Standards C208, C153, and C110.

2. Appendix B, Recurring Surge Tables and Design Example, was added.
3. Pressure classes remain unchanged from 14-in. to 48-in. pipe.

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 at 303.795.7603, write to the group at 6666 West Quincy Avenue, Denver, CO 80235-3098, or e-mail the group at standards@awwa.org.

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American Water Works Association

AWWA Standard

Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm)

SECTION 1: GENERAL

Sec. 1.1 Scope

Pipe manufactured to this standard is generally well suited for conveying potable water, reclaimed water, irrigation water, wastewater, or any fluid compatible with nonplasticized PVC. The standard includes eight dimension ratio (DRs) and nominal pipe sizes ranging from 14 in. through 48 in. (350 mm through 1,200 mm). Pipe outside diameters (ODs) conform to those established for cast-iron-equivalent ODs (CIOD) and steel-pipe-equivalent ODs (IPS). Pressure classes range from 80 psi (550 kPa) to 305 psi (2,100 kPa).

Sec. 1.2 Purpose

The purpose of this standard is to provide purchasers, manufacturers, and suppliers with the minimum manufacturing, verification, and delivery requirements for PVC pressure pipe and fabricated fittings, 14 in. (350 mm) through 48 in. (1,200 mm).

Sec. 1.3 Application

This standard can be referenced in documents for purchasing and receiving PVC pressure pipe and fabricated fittings, 14 in. (350 mm) through 48 in. (1,200 mm). The stipulations of this standard apply when this document has been referenced and then only to PVC pressure pipe and fabricated fittings, 14 in. (350 mm) through 48 in. (1,200 mm).

SECTION 2: REFERENCES

This standard references the following documents. In their latest editions, they 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.

ASTM* D1598—Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure.

ASTM D1599—Standard Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings.

ASTM D1784—Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

ASTM D2122—Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.

ASTM D2152—Standard Test Method for Adequacy of Fusion of Extruded Poly(Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion.

ASTM D2241—Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).

ASTM D2290—Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe by Split Disk Method.

ASTM D2412—Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

ASTM D2564—Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.

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

ASTM D2855—Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.

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

ASTM D3139—Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

ASTM F412—Standard Terminology Relating to Plastic Piping Systems.

ASTM F477—Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

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

PPI† TR-3—Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Constructor:* The party that provides the work and materials for placement or installation.

2. *Design factor (DF):* The design factor is the inverse of the safety factor. It is used to reduce the hydrostatic design basis (HDB) to arrive at the hydrostatic design stress (HDS) from which the pressure class (PC) is calculated. Unless otherwise noted, the design factor used in this standard is 0.5.

NOTE: Because the effective strength of PVC materials depends on the temperature and on the duration of stress application, the effective safety factor when using a DF of 0.5 will vary with end-use conditions. For the PVC material described in this standard, the effective safety factor against sustained pressures is at least 2:1. The actual value is generally larger and depends on the magnitude of the applied transient and sustained pressures as well as on the operating temperature.

3. *Dimension ratio (DR):* The ratio of a pipe's specified average OD to its specified minimum wall thickness. For inch-pound units, the specified average OD is used for establishing pipe DR. For metric units, the minimum specified average OD is used.

4. *Fabricated PVC fitting:* Fabricated fittings comprise single or multiple segments of PVC pipe cut into wedge shapes, or otherwise prepared to accept leg insertions, and joined under factory-controlled conditions to form an essentially homogeneous structure. Reinforcement may be applied and permanently bonded to

* NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48105.
† Plastics Pipe Institute, 105 Decker Court, Suite 825, Irving, TX 75062.

the outside surfaces of the fitting. The different types of fittings configurations are as follows:

a. Tees have an outstanding leg that is 90 degrees from the running leg. Tee configurations are as follows:

1. Tees whose outstanding leg is of the same diameter as the running leg.
2. Tees whose outstanding leg is less than half the diameter of the running leg.
3. Tees whose outstanding leg is at least one-half of but less than the diameter of the running leg.

b. Crosses have two outstanding legs that are opposite each other. Cross configurations are as follows:

1. Crosses whose outstanding leg is of the same diameter as the running leg.
2. Crosses whose outstanding leg is less than half the diameter of the running leg.
3. Crosses whose outstanding leg is at least half but not less than the diameter of the running leg.

c. Bends may be standard angles (11.25, 22.5, 45, and 90 degrees) or any custom-built angle. Bend configurations are as follows:

1. Bends from 1 to 22.9 degrees.
2. Bends from 23 to 45.9 degrees.
3. Bends from 46 to 67.9 degrees.
4. Bends from 68 to 89.9 degrees.
5. Bends of 90 degrees.

d. Couplings are used to join two similar-diameter pipes.

e. Reducers are used to abruptly join two different pipe diameters. Reducer configurations are as follows:

1. Reducers whose small-end diameter is less than one-half the large-end diameter.
2. Reducers whose small-end diameter is greater than one-half the large-end diameter.

f. Adapters are to be used to join two different pipe diameters when the difference in pipe diameters is one inch or less.

g. Tapers are used to reduce hydraulic losses when joining two different pipe diameters. Taper configurations are as follows:

1. Tapers whose small-end diameter is less than one-half the large-end diameter.
2. Tapers whose small-end diameter is greater than one-half the large-end diameter.

5. *Hydraulic transients:* Hydraulic transients (sometimes called water hammer) are pressure fluctuations caused by a rapid change in the velocity of the water column. Hydraulic transients are the result of normal or emergency operations. The pressure fluctuations can be positive or negative and are caused by operating a valve or by starting or stopping a pump. (See surge pressure.) Hydraulic transients caused by normal pump and valve operation require the pipe system to withstand the resultant positive and negative pressures.

NOTE: For further information, see AWWA Manual M23, *PVC Pipe—Design and Installation*.

6. *Hydrostatic design basis (HDB):* The categorized long-term strength in the circumferential or hoop direction as established from long-term pressure tests in accordance with ASTM D2837. This standard requires the use of PVC compounds that qualify for an HDB rating of 4,000 psi (27.58 MPa).

7. *Hydrostatic design stress (HDS):* The maximum allowable working hoop stress in the pipe wall when the pipe is subject to sustained long-term hydrostatic pressure. The HDS in this standard is established by multiplying the HDB by the DF of 0.5.

8. *Inspector:* The authorized representative of the purchaser who is entrusted with the inspection of products and production records. The inspector also observes the production operations and quality-control tests to ensure that products comply with the requirements of this standard and the purchaser.

9. *Lot:* Pipe manufactured during a production run.

10. *Manufacturer:* The party that manufactures, fabricates, or produces materials or products.

11. *Occasional (emergency or transient) surge pressure (P_{OS}):* Surge pressures caused by emergency operations, usually the result of a malfunction (such as power failure, sudden valve closure, or system component failure).

12. *Polyvinyl chloride plastic (PVC):* PVC resin, the basic building block of PVC pipe, is a polymer derived from salt water, air, and natural gas or petroleum. PVC resin is combined with heat stabilizers, lubricants, and other ingredients to make PVC compounds that can be extruded into pipe or molded into fittings.

13. *Potable water:* Water that is safe and satisfactory for drinking and cooking.

14. *Pressure class (PC):* The design capacity to resist working pressure up to 73.4°F (23°C) sustained operating temperature. The methods for determining PC are stated in Sec. 4.7.

15. *Production run:* The length of time a particular piece of extrusion equipment is producing a certain size of pipe. The term *production run* is not applicable to fabricated fittings.

16. *Purchaser:* The person, company, or organization that purchases any materials or work to be performed.

17. *Reclaimed water:* Wastewater that becomes suitable for beneficial use as a result of treatment.

18. *Recurring (cyclic) surge pressure (P_{RS}):* Surge pressures that occur frequently and are inherent to the design and operation of the system (such as normal pump startup or shutdown and normal valve opening or closure). Recurring surge pressures may occur up to millions of times in a piping system's lifetime.

19. *Standard dimension ratio (SDR):* A dimension ratio that corresponds to one of the numbers in the standard series of preferred dimension ratios that has been established by ASTM International (ASTM F412).

20. *Supplier:* The party that supplies material or services. A supplier may or may not be the manufacturer.

21. *Surge pressure (P_s):* The maximum hydraulic transient pressure increase (sometimes called water hammer) in excess of the operating pressure that is anticipated in the system as the result of sudden changes in velocity of the water column. For purposes of product selection and design, this document considers the following two types of surges:

a. Recurring (cyclic) surge pressure (P_{RS}).
b. Occasional (emergency or transient) surge pressure (P_{OS}).

NOTE: Occasional transients caused by emergency pump and valve operations are usually severe. The system should be designed to withstand positive and negative pressures caused by these emergency operations. Water column separation may occur if the negative pressure is reduced to the vapor pressure of the liquid. Rejoining of the separated water column typically results in a large pressure rise, which will possibly damage the pipe system. Whenever possible, water column separation should be avoided.

22. *Sustained operating temperature:* The continuous long-term temperature of the pipe wall during service. A short-term rise in service temperature above 73°F (for example, for a few weeks during summer) does not require use of temperature coefficients for pipeline design.

23. *Wastewater:* A combination of the liquid and water-carried waste from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and stormwater that may be present.

24. *Working pressure (WP):* The maximum anticipated, sustained operating pressure applied to the pipe exclusive of transient pressures.

SECTION 4: REQUIREMENTS

Sec. 4.1 Permeation*

The selection of materials is critical for water service and distribution piping in locations where there is likelihood the pipe will be exposed to significant concentrations of pollutants comprised of low-molecular-weight petroleum products or organic solvents or their vapors. Research has documented that pipe materials such as polyethylene, polybutylene, PVC, and asbestos cement; and elastomers, such as used in jointing gaskets and packing glands, are subject to permeation by lower-molecular-weight organic solvents or petroleum products. If a water pipe must pass through such a contaminated area or an area subject to contamination, consult with the manufacturer regarding permeation of pipe walls, jointing materials, etc., *before* selecting materials for use in that area.

Sec. 4.2 Materials

4.2.1 *Materials.* Materials shall comply with the requirements of the Safe Drinking Water Act and other federal regulations for potable water and wastewater systems as applicable.

4.2.2 *Pipes and fabricated fittings.* PVC pipes and fabricated fittings shall be made from virgin PVC resin that has been compounded to provide physical and chemical properties that equal or exceed cell class 12454 as defined in ASTM D1784. Pipe and fittings shall also qualify for a minimum HDB of 4,000 psi (27.58 Mpa) at 73.4°F (23°C) per the requirements of PPI TR-3.

* Note: Guidance regarding the permeation resistance of pipe and pipe gasket materials is available in "Impact of Hydrocarbons on PE/PVC Pipes and Pipe Gaskets," AwwaRF Report 91204, Denver, CO 2007.

4.2.3 *Rework materials.* Clean rework materials derived from a manufacturer's own pipe or fitting product may be used by the same manufacturer for similar purposes provided that (1) the cell classification of the rework material is identical to the material to which it will be added; (2) the rework material complies with applicable requirements of Sec. 4.2 of this standard; and (3) the finished products comply with the requirements of this standard.

4.2.4 *Certification for potable-water service.* PVC compounds and products shall be tested for chemical extractants and certified as suitable for potable water service by an accredited testing agency acceptable to the purchaser. The basis of certification shall be the requirements specified in NSF/ANSI 61.

4.2.5 *Gaskets and lubricants.* Gaskets and lubricants intended for use with PVC pipe and fabricated fittings shall be made from materials that are compatible with the pipe and with each other when used together. Gaskets and lubricants shall not adversely affect the potable quality of the water that is to be transported (see foreword, Sec. I.C).

4.2.5.1 Elastomeric gaskets. One gasket shall be furnished with each bell end of every pipe, fitting, and coupling. Elastomeric gaskets shall meet the requirements of ASTM F477 for high-head (50 ft of head or higher) applications.

4.2.6 *Fabricated fitting overwrap reinforcement.* Optional reinforcement, either PVC or non-PVC, may be applied by the manufacturer to meet the requirements of this standard.

4.2.6.1 Resin. Resin used shall be a commercial grade of unsaturated polyester resin or epoxy resin.

4.2.6.2 Glass. Glass reinforcing materials shall be commercial "E" type glass in the form of mat, continuous roving or roving fabric, or a combination of these, having a coupling agent that bonds the glass reinforcement and the resin.

Sec. 4.3 Pipe Requirements

4.3.1 *Workmanship.* When manufactured, pipe shall be homogeneous throughout; free from voids, cracks, inclusions, and other defects; and as uniform as commercially practical in color, density, and other physical properties. Pipe surfaces shall be free from nicks and significant scratches.* The joining surfaces of pipe spigots and integral-bell and sleeve-reinforced bell sockets shall be free from imperfections that might cause leakage at joints.

* Scratches that extend 10 percent or more into the pipe wall shall be considered significant

Table 1-A Dimensions, pressure classes, and dimension ratios for PVC pipe with IPS outside diameter

Nominal Size	Pressure Class at 73.4°F (23°C)		Dimension Ratio	Outside Diameter *in. (mm)*		Wall Thickness *in. (mm)*	
in.	*psi*	*(kPa)*	(DR)	Average	Tolerance	Minimum	Tolerance
14	100	(690)	41.0	14.000 (355.6)	±0.015 (0.38)	0.341 (8.66)	+0.048 (1.22)
	125	(860)	32.5	14.000 (355.6)	±0.015 (0.38)	0.430 (10.92)	+0.052 (1.32)
	160	(1,100)	26.0	14.000 (355.6)	±0.015 (0.38)	0.538 (13.67)	+0.064 (1.63)
	200	(1,380)	21.0	14.000 (355.6)	±0.015 (0.38)	0.666 (16.92)	+0.080 (2.03)
16	100	(690)	41.0	16.000 (406.4)	±0.019 (0.48)	0.390 (9.91)	+0.055 (1.40)
	125	(860)	32.5	16.000 (406.4)	±0.019 (0.48)	0.492 (12.50)	+0.059 (1.50)
	160	(1,100)	26.0	16.000 (406.4)	±0.019 (0.48)	0.615 (15.62)	+0.074 (1.88)
	200	(1,380)	21.0	16.000 (406.4)	±0.019 (0.48)	0.762 (19.35)	+0.091 (2.31)
18	100	(690)	41.0	18.000 (457.2)	±0.019 (0.48)	0.439 (11.15)	+0.061 (1.55)
	125	(860)	32.5	18.000 (457.2)	±0.019 (0.48)	0.554 (14.07)	+0.066 (1.68)
	160	(1,100)	26.0	18.000 (457.2)	±0.019 (0.48)	0.692 (17.58)	+0.083 (2.11)
	200	(1,380)	21.0	18.000 (457.2)	±0.019 (0.48)	0.857 (21.77)	+0.103 (2.62)
20	100	(690)	41.0	20.000 (508.0)	±0.023 (0.58)	0.488 (12.40)	+0.068 (1.73)
	125	(860)	32.5	20.000 (508.0)	±0.023 (0.58)	0.615 (15.62)	+0.074 (1.88)
	160	(1,100)	26.0	20.000 (508.0)	±0.023 (0.58)	0.769 (19.53)	+0.092 (2.34)
	200	(1,380)	21.0	20.000 (508.0)	±0.023 (0.58)	0.952 (24.18)	+0.114 (2.90)
24	100	(690)	41.0	24.000 (609.6)	±0.031 (0.79)	0.585 (14.86)	+0.082 (2.08)
	125	(860)	32.5	24.000 (609.6)	±0.031 (0.79)	0.738 (18.75)	+0.088 (2.24)
	160	(1,100)	26.0	24.000 (609.6)	±0.031 (0.79)	0.923 (23.44)	+0.111 (2.82)
	200	(1,380)	21.0	24.000 (609.6)	±0.031 (0.79)	1.143 (29.03)	+0.137 (3.48)
30	100	(690)	41.0	30.000 (762.0)	±0.041 (1.04)	0.732 (18.59)	+0.102 (2.59)
	125	(860)	32.5	30.000 (762.0)	±0.041 (1.04)	0.923 (23.44)	+0.111 (2.82)
	160	(1,100)	26.0	30.000 (762.0)	±0.041 (1.04)	1.154 (29.31)	+0.138 (3.51)
	200	(1,380)	21.0	30.000 (762.0)	±0.041 (1.04)	1.428 (36.27)	+0.171 (4.34)
36	100	(690)	41.0	36.000 (914.4)	±0.050 (1.27)	0.878 (22.30)	+0.123 (3.12)
	125	(860)	32.5	36.000 (914.4)	±0.050 (1.27)	1.108 (28.14)	+0.133 (3.38)
	160	(1,100)	26.0	36.000 (914.4)	±0.050 (1.27)	1.385 (35.18)	+0.166 (4.22)
	200	(1,380)	21.0	36.000 (914.4)	±0.050 (1.27)	1.714 (43.54)	+0.205 (5.21)

Note: HDS = 2,000 psi.

Table 1-B Dimensions, pressure classes, and dimension ratios for PVC pipe with CI outside diameter

Nominal Size *in.*	Pressure Class at 73.4°F (23°C) *psi*	*(kPa)*	Dimension Ratio (DR)	Outside Diameter *in. (mm)* Average	Tolerance	Wall Thickness *in. (mm)* Minimum	Tolerance
14	100	(690)	41.0	15.300 (388.6)	±0.015 (0.38)	0.373 (9.47)	+0.052 (1.32)
	125	(860)	32.5	15.300 (388.6)	±0.015 (0.38)	0.471 (11.96)	+0.056 (1.42)
	165	(1,140)	25.0	15.300 (388.6)	±0.015 (0.38)	0.612 (15.54)	+0.073 (1.85)
	200	(1,380)	21.0	15.300 (388.6)	±0.015 (0.38)	0.729 (18.51)	+0.088 (2.22)
	235	(1,620)	18.0	15.300 (388.6)	±0.015 (0.38)	0.850 (21.59)	+0.102 (2.59)
	305	(2,100)	14.0	15.300 (388.6)	±0.015 (0.38)	1.093 (27.76)	+0.131 (3.33)
16	100	(690)	41.0	17.400 (442.0)	±0.020 (0.51)	0.424 (10.77)	+0.059 (1.50)
	125	(860)	32.5	17.400 (442.0)	±0.020 (0.51)	0.535 (13.59)	+0.064 (1.63)
	165	(1,140)	25.0	17.400 (442.0)	±0.020 (0.51)	0.696 (17.68)	+0.084 (2.13)
	200	(1,380)	21.0	17.400 (442.0)	±0.020 (0.51)	0.829 (21.05)	+0.100 (2.54)
	235	(1,620)	18.0	17.400 (442.0)	±0.020 (0.51)	0.967 (24.56)	+0.116 (2.95)
	305	(2,100)	14.0	17.400 (442.0)	±0.020 (0.51)	1.243 (31.57)	+0.149 (3.78)
18	80	(550)	51.0	19.500 (495.3)	±0.020 (0.51)	0.382 (9.70)	+0.053 (1.35)
	100	(690)	41.0	19.500 (495.3)	±0.020 (0.51)	0.476 (12.09)	+0.067 (1.70)
	125	(860)	32.5	19.500 (495.3)	±0.020 (0.51)	0.600 (15.24)	+0.072 (1.83)
	165	(1,140)	25.0	19.500 (495.3)	±0.020 (0.51)	0.780 (19.81)	+0.094 (2.39)
	200	(1,380)	21.0	19.500 (495.3)	±0.020 (0.51)	0.929 (23.60)	+0.111 (2.82)
	235	(1,620)	18.0	19.500 (495.3)	±0.020 (0.51)	1.083 (27.51)	+0.130 (3.30)
	305	(2,100)	14.0	19.500 (495.3)	±0.025 (0.64)	1.200 (30.48)	+0.167 (4.24)
20	80	(550)	51.0	21.600 (548.6)	±0.025 (0.64)	0.424 (10.77)	+0.059 (1.50)
	100	(690)	41.0	21.600 (548.6)	±0.025 (0.64)	0.527 (13.39)	+0.074 (1.88)
	125	(860)	32.5	21.600 (548.6)	±0.025 (0.64)	0.665 (16.89)	+0.080 (2.03)
	165	(1,140)	25.0	21.600 (548.6)	±0.025 (0.64)	0.864 (21.95)	+0.104 (2.64)
	200	(1,380)	21.0	21.600 (548.6)	±0.025 (0.64)	1.029 (26.14)	+0.123 (3.12)
	235	(1,620)	18.0	21.600 (548.6)	±0.025 (0.64)	1.200 (30.48)	+0.144 (3.66)
24	80	(550)	51.0	25.800 (655.3)	±0.030 (0.76)	0.506 (12.85)	+0.071 (1.80)
	100	(690)	41.0	25.800 (655.3)	±0.030 (0.76)	0.629 (15.98)	+0.088 (2.24)
	125	(860)	32.5	25.800 (655.3)	±0.030 (0.76)	0.794 (20.17)	+0.095 (2.41)
	165	(1,140)	25.0	25.800 (655.3)	±0.030 (0.76)	1.032 (26.21)	+0.124 (3.15)
	200	(1,380)	21.0	25.800 (655.3)	±0.030 (0.76)	1.229 (31.22)	+0.147 (3.73)
	235	(1,620)	18.0	25.800 (655.3)	±0.030 (0.76)	1.433 (36.40)	+0.172 (4.37)
30	80	(550)	51.0	32.000 (812.8)	±0.040 (1.02)	0.627 (15.93)	+0.088 (2.24)
	100	(690)	41.0	32.000 (812.8)	±0.040 (1.02)	0.780 (19.81)	+0.109 (2.77)

(Table continued next page)

Table 1-B Dimensions, pressure classes, and dimension ratios for PVC pipe with CI outside diameter (continued)

Nominal Size *in.*	Pressure Class at 73.4°F (23°C) *psi*	*(kPa)*	Dimension Ratio (DR)	Outside Diameter *in. (mm)* Average	Tolerance	Wall Thickness *in. (mm)* Minimum	Tolerance
	125	(860)	32.5	32.000 (812.8)	±0.040 (1.02)	0.985 (25.02)	+0.118 (3.00)
	165	(1,140)	25.0	32.000 (812.8)	±0.040 (1.02)	1.280 (32.51)	+0.154 (3.91)
	200	(1,380)	21.0	32.000 (812.8)	±0.040 (1.02)	1.524 (38.71)	+0.183 (4.65)
	235	(1,620)	18.0	32.000 (812.8)	±0.040 (1.02)	1.778 (45.16)	+0.213 (5.41)
36	80	(550)	51.0	38.300 (972.8)	±0.050 (1.27)	0.751 (19.08)	+0.105 (2.67)
	100	(690)	41.0	38.300 (972.8)	±0.050 (1.27)	0.934 (23.72)	+0.131 (3.33)
	125	(860)	32.5	38.300 (972.8)	±0.050 (1.27)	1.178 (29.92)	+0.141 (3.58)
	165	(1,140)	25.0	38.300 (972.8)	±0.050 (1.27)	1.532 (38.91)	+0.184 (4.67)
	200	(1,380)	21.0	38.300 (972.8)	±0.050 (1.27)	1.824 (46.33)	+0.219 (5.56)
42	80	(550)	51.0	44.500 (1,130.3)	±0.060 (1.52)	0.872 (22.15)	+0.122 (3.10)
	100	(690)	41.0	44.500 (1,130.3)	±0.060 (1.52)	1.085 (27.56)	+0.152 (3.86)
	125	(860)	32.5	44.500 (1,130.3)	±0.060 (1.52)	1.369 (34.77)	+0.164 (4.17)
	165	(1,140)	25.0	44.500 (1,130.3)	±0.060 (1.52)	1.780 (45.21)	+0.214 (5.44)
48	48	(550)	51.0	50.800 (1,290.3)	±0.075 (1.90)	0.996 (25.30)	+0.139 (3.53)
	100	(690)	41.0	50.800 (1,290.3)	±0.075 (1.90)	1.239 (31.47)	+0.173 (4.39)
	125	(860)	32.5	50.800 (1,290.3)	±0.075 (1.90)	1.563 (39.70)	+0.188 (4.78)
	165	(1,140)	25.0	50.800 (1,290.3)	±0.075 (1.90)	2.032 (51.61)	+0.24 4 (6.20)

NOTE: HDS = 2,000 psi.

4.3.2 *Dimensions.*

4.3.2.1 Pipe barrel. The dimensions and tolerances of the pipe barrel shall conform with the applicable requirements listed in Tables 1-A or 1-B when measured as specified in ASTM D2122.

4.3.2.2 Elastomeric-gasket bell ends. The dimensions of the integral bell ends shall meet one of the following requirements when measured according to ASTM D2122.

a. The bell wall thickness at any point shall conform to the dimension ratio of the pipe except in the annular gasket ring groove and bell entry lip portions where the wall shall be at least the minimum thickness of the pipe barrel (Table 1-A or 1-B).

b. Designs not meeting the requirements of Sec. 4.3.2.2(a) shall be tested to verify the joint assemblies qualify for an HDB category of 4,000 psi (2,758 MPa) when tested in accordance with ASTM D2837 as modified in ASTM D3139.

Table 2 Pressure-test requirements

	Pressure Class		Sustained-Test Pressure		Hydrostatic-Test Pressure		Burst-Test Pressure	
DR	*psi*	*(kPa)*	*psi*	*(kPa)*	*psi*	*(kPa)*	*psi*	*(kPa)*
51	80	(550)	170	(1,180)	160	(1,110)	260	(1,800)
41	100	(690)	210	(1,450)	200	(1,380)	315	(2,180)
32.5	125	(860)	270	(1,870)	250	(1,730)	400	(2,760)
26	160	(1,100)	340	(2,350)	320	(2,210)	500	(3,450)
25	165	(1,140)	350	(2,420)	330	(2,280)	535	(3,690)
21	200	(1,380)	420	(2,900)	400	(2,760)	630	(4,350)
18	235	(1,620)	500	(3,450)	470	(3,240)	755	(5,210)
14	305	(2,100)	650	(4,490)	610	(4,210)	985	(6,800)

4.3.2.3 Standard lengths. Pipe shall be furnished in standard laying lengths of 20 ft ± 1 in. (6.1 m ± 25 mm) unless otherwise agreed on at the time of purchase.

4.3.3 *Physical properties.*

4.3.3.1 Sustained pressure. The pipe or fabricated fitting shall not fail, balloon, burst, or weep, as defined in ASTM D1598, at the applicable sustained pressure listed in Table 2 when one specimen is tested for 1,000 hr as specified in ASTM D2241. Either free-end or restrained-end closures that are free of leaks at maximum pressure shall be used.

4.3.3.2 Burst pressure. The quick-burst strength of pipe, including any integral bell end, shall meet the applicable minimum pressure requirement listed in Table 2 when tested in accordance with the specimen and sample sizes, conditioning, and procedural requirements listed in ASTM D1599. At least three of the five test specimens shall have a portion of the required markings located at least one pipe diameter away from an end closure. For bell-end pipe, the bell shall be included as a part of at least two specimens. The ability to attain hydrostatic pressure equal to or greater than the values in Table 2 within 60–70 sec shall indicate passing this test requirement.

4.3.3.3 Hydrostatic integrity. The pipe, including any integral bell end, shall not fail, balloon, burst, or weep when subjected to an internal pressure equal to 2.0 times its designated PC, as listed in Table 2, for a minimum dwell of 5 sec. Integral bells shall be tested with the pipe. When the test temperature (the temperature of the pipe wall) is higher than 73.4°F (23°C), the test pressure may be reduced by

Table 3 Temperature coefficients, F_T

Pipe Temperature		
°F	(°C)	Pressure Rating Reduction Coefficient
80	(27)	0.88
90	(32)	0.75
100	(38)	0.62
110	(43)	0.50
120	(49)	0.40
130	(54)	0.30
140	(60)	0.22

applying the appropriate temperature coefficient from Table 3. Test temperature shall be estimated by measuring the temperature on the pipe's outside surface within 20 min after hydrotesting is completed.

4.3.3.4 Flattening. Three specimens of pipe, a minimum of 6 in. (150 mm) long shall be flattened between parallel plates in a suitable press until the distance between the plates is 40 percent of the outside diameter of the pipe. The three specimens shall be oriented in accordance with the section entitled "Procedure" of ASTM D2412; except, if no minimum wall thickness has been identified, a spider line shall be used as the base line. The rate of flattening shall be uniform and such that the compression is completed within 2 to 5 min. The applied load shall then be removed and the specimen examined. There shall be no evidence of splitting, cracking, or breaking.

4.3.3.5 Extrusion quality. The pipe shall not fail when tested by the acetone-immersion method as specified in ASTM D2152.

Sec. 4.4 Machined Coupling Requirements

4.4.1 *Workmanship.* The body and joining surfaces of couplings machined from extruded pipe shall conform to the same requirements as specified for pipe in Sec. 4.3.

4.4.2 *Dimensions.* The computed dimension ratio of gasketed PVC couplings machined from extruded pipe shall not be greater than the DR of the pipe, except in the annular gasket space and coupling entry where the wall thickness shall be at least the minimum wall thickness of the pipe (Table 1-B).

4.4.3 *Burst pressure.* The quick-burst strength of couplings shall not be less than the minimum burst pressure specified for the pipe with which the couplings are designed to be used when tested as specified in Sec. 4.3.3.2.

4.4.4 *Hydrostatic integrity.* Couplings shall not fail, balloon, burst, or weep when subjected to an internal pressure equal to 2.0 times the designated PC of the pipe with which it is designed to be used, as listed in Table 2, for a minimum dwell of 5 sec. When the test temperature (the temperature of the pipe wall) is higher than 73.4°F (23°C), the test pressure may be reduced by applying the appropriate temperature coefficient from Table 3. Test temperature shall be estimated by taking readings on the fitting's outside surface within 20 min after hydrotesting is completed.

4.4.5 *Standard quantities.* If elastomeric-gasketed couplings are to be used as the primary pipe-joining method, one such coupling of a corresponding size and PC shall be furnished with each length of plain-end pipe.

Sec. 4.5 Fabricated Fitting Requirements

4.5.1 *Workmanship.* Fittings shall be fabricated from PVC pipe meeting the requirements of this standard. The component pipe segments and the bonds between them shall be free from voids, cracks, inclusions, and other defects. The joining surfaces of spigots and bells shall be free from imperfections that could cause leaks. When component segments are joined using solvent cement, the procedure shall conform with the standard practice for making pressure joints outlined in ASTM D2855.

4.5.2 *Dimensions.*

4.5.2.1 Fitting barrel. Edge-joined segments of a fabricated fitting shall have the same dimension ratio.

4.5.2.2 Standard configurations. Standard configurations shall include customary angles for branch connections or bends. Nonstandard angles of branch connections or bends may be specified. Leg lengths shall be the minimum practical for the method of fabrication, unless otherwise specified.

4.5.2.3 Reinforcement of solvent cement joints. Fitting segments, which are joined by solvent cementing, shall be designed on the basis of a maximum lap shear strength of the solvent cement joint of 900 psi (6.2 MPa). Overwrapped reinforcement shall not be considered in design of the solvent cement joint.

4.5.3 *Segment joint quality.*

4.5.3.1 Butt-fusion or thermal weld. A suitable probe, energized with 25,000 V, shall be swept along the joint line approximately 0.1 in. (3 mm) away from the PVC surface of the joined segments on the side opposite to the grounding medium. The grounding medium shall be a metallic conductor held against the seam surface opposite the probe. For thermally welded seams other than butt-

fusion, the test shall be conducted only after the first 20 percent or less of the weld thickness is applied. Any discontinuity in the segment joint is indicated by the jump of an arc (sparking) from the probe tip and shall be cause for rejection of the fitting until such a time that the weld is repaired.

4.5.3.2 Solvent-cemented bond quality. Specimens for lap shear testing shall be prepared in accordance with the requirements of ASTM D2564, except as modified herein. The test specimens shall be obtained from a sample solvent-cemented joint produced by solvent-cementing component pipe segments identical to those that are to be used to fabricate fittings. After at least a 72-hr solvent cement curing time at 73.4 ± 3.6°F (23 ± 2°C), three specimens shall be tested per segment joint. Each specimen shall be a section of the segment joint measuring approximately 1 in. × 2 in. (25 mm × 50 mm) and shall not include any overwrapping reinforcement. A portion of each test specimen shall be machined off as needed to obtain a specimen similar to that shown in Figure 1. After placing the specimen in a testing device similar to that shown in Figure 1, apply the force at a shear speed of 0.05 in. (1.25 mm)/min. The minimum average lap shear strength of three specimens shall be 900 psi (6.2 MPa).

NOTE: Where mechanical joint restraint devices are used to control thrust movements of fabricated fittings, consult with the fittings manufacturer to determine the tensile thrust limitations for the specific sizes, configurations, and pressure classes specified.

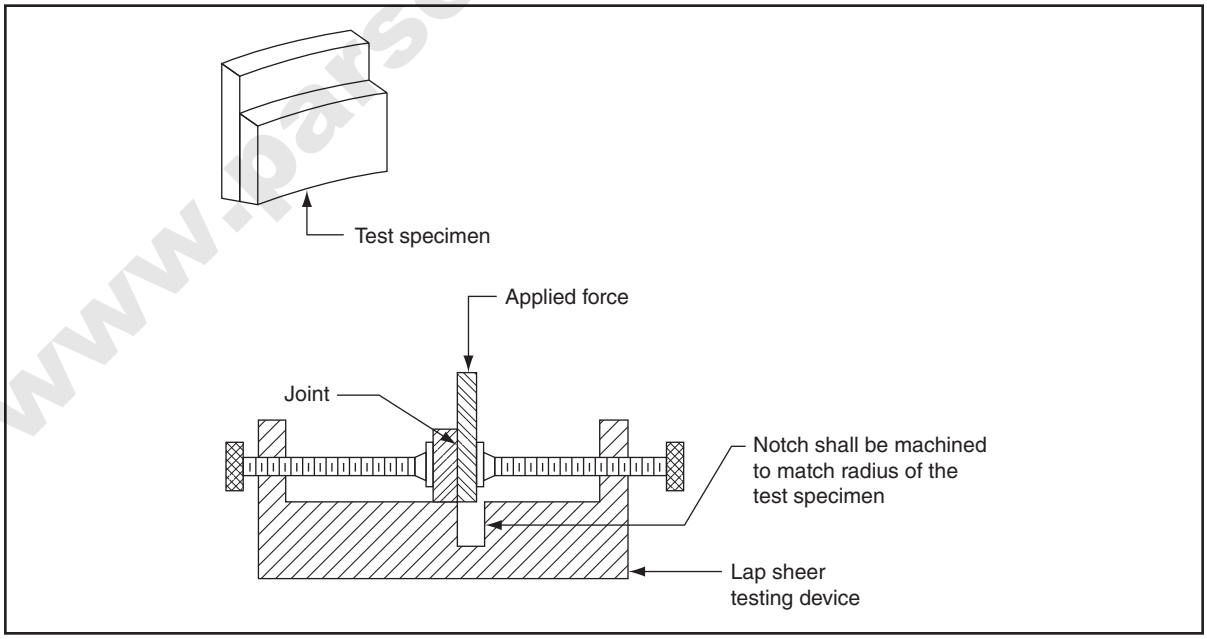

Figure 1 Lap shear test

4.5.4 *Pressure test.* The fabricated fitting shall not fail, balloon, burst, or weep when subjected to an internal pressure equal to 2.0 times the PC shown in Table 2 for a minimum of 2 hr.

Sec. 4.6 Joint Requirements

Bell-end pipe and fabricated fittings designed for making PVC joints using elastomeric gaskets to effect the pressure seal shall be tested as assembled joints and shall meet the laboratory performance requirements specified in ASTM D3139. (These are qualifying test requirements to determine proper design and performance of specimen joints.)

Sec. 4.7 Pressure Rating Designations

4.7.1 *Pressure class.* This standard classifies pipe in accordance with its PC. The following expression, commonly known as the ISO equation, is used to calculate the PC:

$$PC = \frac{2}{DR - 1} \times HDB \times DF \qquad \text{(Eq 1)}$$

Where:

PC = Pressure class
DR = Dimension ratio = D_o/t
D_o = Average OD
t = Minimum pipe wall thickness
HDB = Hydrostatic design basis, 4,000 psi
DF = 0.5; design factor; includes consideration of degree of safety and the variables, including limited surge effects in the end application

4.7.1.1 Temperature. For pipe that meets the requirements of this standard, the PC denotes the maximum WP rating for water at 73°F. When higher sustained operating temperatures are anticipated, the pipe's PC shall be reduced by the appropriate temperature-compensating multiplier (F_T) found in Table 3.

4.7.1.2 Maximum pressure. In all cases the maximum anticipated WP cannot exceed the pipe's PC times the temperature coefficient.

$$WP < PC \times F_T \qquad \text{(Eq 2)}$$

4.7.1.3 Pressure class ratings. Pressure class ratings for pipe described in this standard are given in Table 1. The PC values listed are the maximum WP ratings of pipe made and classified in accordance with this standard. They assume that the pipe is not subject to surge pressures or hydraulic transient above the WP

Table 4 Allowable maximum occasional surge pressure capacity and allowable sudden changes in water velocity for pipe operating at 73°F at working pressures expressed as percent of nominal pressure class (PC)*

DR	Pressure Class (PC) *(psi)*	Occasional Surge Pressure Capacity *(psi)*	Corresponding Sudden Delta V With WP = % of PC 100% *(fps)*	80% *(fps)*	60% *(fps)*	40% *(fps)*
25	165	264	6.7	9.0	11.2	13.5
18	235	376	8.1	10.8	13.5	16.2
14	305	488	9.2	12.3	15.4	18.5

*The surge pressure tolerances stated in this table apply only to pipe and not to system components, which may have lesser tolerances. The design should consider possible system reactions and their potential effect on system components.

See Section 3 for definitions of recurring and occasional surge pressures.

A pipe may sometimes be subject to net negative internal pressure because of the individual or combined effect of internal negative transients and external forces (such as water table). When this situation exists, refer to the supplier for information on the hydraulic collapse resistance of the pipeline.

in excess of those defined in Sec. 4.7.1.4 and the pipe's sustained operating temperature is at or below 73.4°F (23°C).

4.7.1.4 Surge pressure allowance. Two types of pressure surge, occasional and recurring, shall be considered.

4.7.1.4.1 Occasional surge pressure (P_{OS}) is a typical design parameter for most municipal water systems. Mathematically, P_{OS} is a simple concept that is easily accommodated by use of short-term pressure ratings or P_{OS} capacity found in Table 4.

4.7.1.4.2 Occasional surge pressure capacity (WP + P_{OS}). Occasional surge pressure capacity or short-term pressure rating is the sum of the maximum anticipated WP and maximum anticipated P_{OS}. Occasional surge pressure capacity cannot exceed the short-term pressure rating, which is 1.60 times the pipe's PC times F_T. The defined P_{OS} capacities and corresponding allowable velocity changes are stated in Table 4.

$$WP + P_{OS} < 1.60\ PC \times F_T \qquad \text{(Eq 3)}$$

4.7.1.4.3 Recurring surge pressure (P_{RS}) develops high-frequency, high-amplitude surge conditions that are not typically a design issue for municipal water systems, but may need to be considered. Pipe selection or design to accommodate recurring surge pressure is a function of three variables and thus does not lend itself

to tabular treatment. The body of the standard contains a limited discussion that is supplemented by a design example in appendix B.

4.7.1.4.4 Recurring surge pressure capacity ($WP + P_{RS}$). Recurring surge pressure capacity is the sum of the maximum anticipated WP and the maximum anticipated surge pressure. Recurring surge pressure capacity cannot exceed the pipe's PC times the temperature coefficient.

$$WP + P_{RS} < PC \times F_T \qquad \text{(Eq 4)}$$

4.7.2 *Fabricated fittings.* Fabricated PVC fittings meeting the requirements of this standard shall have the PC designations listed in Table 1-B that are equal to or less than the pressure for the dimension ratio of the pipe used in their fabrication. The determination of pressure classes and safety factors for fabricated fittings shall follow the method given in Sec. 4.7.1 for pipe meeting the requirements of this standard, ignoring the effect of any overwrap reinforcement.

SECTION 5: VERIFICATION

Sec. 5.1 Quality-Control and Qualification Test Requirements

The manufacturer shall take adequate measures in the production of extruded PVC pipe, couplings, and fabricated fittings to ensure product compliance with the requirements of this standard. The pipe, couplings, and fabricated fittings shall be tested at 73.4 ± 3.6°F (23 ± 2°C), unless otherwise specified, in accordance with the requirements of Sec. 4.3, 4.4, 4.5, and 4.6 at intervals as required in this standard.

5.1.1 *Pipe dimensions.* The dimensions of pipe produced from each extrusion outlet, and the bell or sleeve reinforced bell of pipe with such ends, shall be measured in accordance with Sec. 4.3.2 at the beginning of production of each specific material and each size. Thereafter, one specimen from each extrusion outlet shall be measured each hour.

5.1.2 *Coupling dimensions.* The dimensions of machined couplings shall be measured in accordance with Sec. 4.4.2 at the beginning of production of each specific material and each size. Thereafter, one specimen shall be measured each hour.

5.1.3 *Sustained pressure.* At the beginning of production of the first articles of products made to this standard at each production facility, qualification tests shall be conducted for the extrusion process in accordance with Sec. 4.3.3.1. The product test samples will represent the combination of size and class that results in the thickest minimum wall thickness to be produced at the production facility

as referenced in Table 1. These tests are only for qualification of the compound and the extrusion process. Changes in color pigment that meet the requirements of the PPI Generic Range Formulation for PVC pipe do not constitute a separate compound.

5.1.4 *Pipe burst strength.* The quick-burst strength of pipe produced from each production facility shall be tested in accordance with Sec. 4.3.3.2 at the beginning of production of first articles of each size, each class, and each PVC compound (i.e., material). These tests are only for qualification of the compound and extrusion process. As an alternative to the burst strength test, the ring tensile test may be conducted according to ASTM D2290. Changes in color pigment that meet the requirements of the PPI Generic Range Formulation for PVC pipe do not constitute a separate compound.

5.1.5 *Coupling burst strength.* The quick burst strength of machined couplings shall be tested in accordance with Sec. 4.4.3 at the beginning of a production run of each specific material and each size. Thereafter, one specimen shall be tested every 8 hr.

5.1.6 *Flattening capability.* The flattening capability of pipe shall be tested in accordance with Sec. 4.3.3.4 at the beginning of production of each specific material and each size. The test shall also be run immediately following any change from established running conditions that could affect extrusion quality.

5.1.7 *Extrusion quality.* The pipe produced from each extrusion outlet shall be tested in accordance with Sec. 4.3.3.5 at the beginning of production of each specific material and each size. The test shall also be run immediately following any change from established running conditions that could affect extrusion quality.

5.1.8 *Fitting segment fusion.* Each fitting manufactured using the butt fusion or thermal welding method of segment joining shall be tested in accordance with Sec. 4.3.3.1.

5.1.9 *Fitting segment solvent-cemented bond quality.* Where solvent cement is used to join fitting segments, the quality of the bond shall be tested in accordance with Sec. 4.5.3.2 at startup and once every 200 fittings produced using this procedure. Testing shall also be required upon changing PVC cement product brand, or surface preparation used in the process prior to any fittings being made using the alternative product(s). Failure to meet the requirements of Sec. 4.5.3.2 or Sec. 4.5.4 shall result in the rejection or testing of all fittings manufactured since the last successful test.

5.1.10 *Fabricated fitting pressure test.*

5.1.10.1 Qualification pressure test. For a specific production run process and whenever the production run process is changed, a representative fabricated fitting specimen shall be subject to a sustained pressure test in accordance with Sec. 4.3.3.1. A representative specimen shall be the most critically stressed fitting configuration. (NOTE: Critical stresses generally occur where fitting segments are joined together.)

5.1.10.2 Quality control pressure test. Test each fitting size and configuration once for every 50 fittings of the same configuration produced or when the fabrication process changes. Configurations shall be defined as the fitting types listed and described in Section 3, Subsection 4, with the coupling of tees and crosses. For the purposes of QC testing, fitting "size" in reference to tees and crosses shall refer to mainline pipe diameter, and for tapers shall refer to large-end pipe diameter, within three sets of diameters ranging from 14 in. through 24 in., from 30 in. through 36 in., and from 42 in. through 48 in. Separate configurations for tees and crosses shall be defined in terms of a mainline: branch diameter ratio, with ratios below and above 1:0.5 considered two separate configurations (e.g., 48 × 24 tee would be a separate configuration from a 48 × 20 tee). "Size-on-size" tees and crosses, with a mainline: branch ratio of 1:1, along with "one-step reduction fittings" (i.e., 48 × 42 tee or 24 × 20 tee) will also constitute a separate configuration.

5.1.11 *Provision for test failure.* When any PVC product fails to meet a requirement specified in this standard or in a referenced standard, additional tests shall be performed to determine which products are acceptable of those produced since the last favorable test. Products that fail to meet any requirement shall be rejected.

5.1.12 *Hydrostatic proof test for pipe.* Each length of pipe shall be pressure tested in accordance with Sec. 4.3.3.3.

5.1.13 *Hydrostatic proof test for machined couplings.* Each separate machined coupling shall be pressure tested in accordance with Sec. 4.4.4.

5.1.14 *Optional test frequency.* The purchaser or supplier may allow the manufacturer to conduct hydrostatic proof tests for pipes or couplings at test frequencies other than those required in Sec. 5.1.12 and 5.1.13. Each purchaser in the distribution chain shall be notified if this option is used.

Sec. 5.2 Quality Control Records

The manufacturer shall maintain, for a period of not less than two years, a record of quality control tests and shall, if requested, submit the pertinent record to the purchaser.

Sec. 5.3 Plant Inspection

5.3.1 *Plant access.* The purchaser's inspector shall have access at reasonable times to those parts of a manufacturer's plant that are necessary to ensure products comply with requirements.

5.3.2 *Responsibility for compliance.* Plant inspection by the purchaser or the omission of such inspections shall not relieve the manufacturer of the responsibility to furnish materials complying with the applicable requirements of this standard.

SECTION 6: DELIVERY

Sec. 6.1 Marking

6.1.1 *General.* Pipe, couplings, and fittings shall bear identification markings that will remain legible after normal handling, storage, and installation. The markings shall be applied in a manner that will not reduce the strength of any product covered by this standard.

6.1.2 *Pipe.* Marking shall include the following and shall be applied at intervals of not more than 5 ft (1.5 m):

a. Nominal size in inches and OD base (for example, 24 CI or 24 IPS).

b. PVC.

c. Dimension ratio per Tables 1-A and 1-B (for example, DR 25).

d. Pressure class in pounds per square inch (psi) per Tables 1-A and 1-B (for example, PC 165).

e. Test pressure (Sec. 5.1.12) for hydrotested pipe (for example, T330) or if not tested, "NOT HYDROSTATIC PRESSURE TESTED."

f. AWWA C905.

g. Manufacturer's name or trademark and production run record or lot code.

h. The mark of the certifying agency per Sec. 4.2.4 for pipe intended for potable-water service (Sec. 4.2.3).

6.1.3 *Couplings and fabricated fittings.* Marking on couplings and fabricated fittings shall include the following:

a. Nominal size OD base and deflection angle if applicable (for example, 18-in. IPS 45°).

b. PVC.

c. Pressure class in pounds per square inch (psi) per Tables 1-A and 1-B (for example, PC 165).

d. AWWA C905.

e. Manufacturer's name or trademark.

f. The mark of the certifying agency per Sec. 4.2.4 for the coupling or fitting for potable-water service (Sec. 4.2.3).

Sec. 6.2 Shipping and Delivery

6.2.1 *Shipping.* Pipe, couplings, and fabricated fittings shall, unless otherwise required by the purchaser, be prepared for standard commercial shipment.

6.2.2 *Delivery.* Pipe, couplings, and fabricated fittings that do not comply with the applicable requirements of this standard or that are damaged when received shall be replaced by the manufacturer or supplier at the agreed point of delivery.

Sec. 6.3 Notice of Nonconformance

Any pipe or fitting not conforming to the requirements of this standard shall be made satisfactory or replaced. The purchaser must provide a notice of nonconformance to the supplier that explains the reason for nonconformance.

Sec. 6.4 Affidavit of Compliance

The purchaser may require an affidavit from the manufacturer or supplier that the materials provided comply with the applicable requirements of this standard.

APPENDIX A

Bibliography

This appendix is for information only and is not a part of ANSI/AWWA C905.

ANSI/AWWA C605—Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.

ANSI/AWWA C900—Polyvinyl Chloride (PVC) Pressure Pipe—4 In. Through 12 In. (100 mm Through 300 mm), for Water Transmission and Distribution.

ANSI/AWWA C907—Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 In. Through 12 in. (100 mm Through 300 mm), for Water Distribution.

AWWA Manual M23, *PVC Pipe—Design and Installation*. Denver, Colo.: AWWA (2002).

Uni-Bell Handbook of PVC Pipe: Design and Construction, fourth edition. Dallas, Texas: Uni-Bell PVC Pipe Association (2001).

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APPENDIX B

Recurring (Cyclic) Surge—Figures and Design Example

This appendix is for information only and is not a part of ANSI/AWWA/C905.

SECTION B.1: DISCUSSION

Cyclic surge design is presented in terms of allowable cycles to failure as the quantity to which a safety factor is applied. The safety factor on cycles to failure is 2.0 (corresponding to a DF of 0.5).

Cyclic surge design is a function of three variables: mean (average) stress, stress amplitude, and number of cycles to failure:

1. From Figure B.1, "mean (average) stress" is the hoop stress caused by the static WP in the pipe. The surge pressure will cycle above and below this value.
2. Also from Figure B.1, "stress amplitude" is the increase in hoop stress caused by the cyclic surge pressure.
3. "Number of cycles to failure" is the value determined in Figure B.2. This value must be at least equal to the safety factor times the anticipated number of surge cycles.

SECTION B.2: DESIGN EXAMPLE

Given:

Pipe: 18-in. DR 18, PC = 235 psi

Working pressure, (WP) = 160 psi (determined by designer)

Anticipated cycles per day 55, Factor of Safety = 2

Design life: 50 years

Anticipated recurring surge pressure, (P_{RS}) = ±30 psi (determined by designer)

Anticipated occasional instantaneous change in flow velocity 7 ft/s (determined by designer)

Occasional surge pressure per 1 ft/sec instantaneous flow change is 17.4 psi for DR 18 pipe. (Please see AWWA Manual M23, *PVC Pipe—Design and Installation*.)

Sustained operating temperature: 60°F

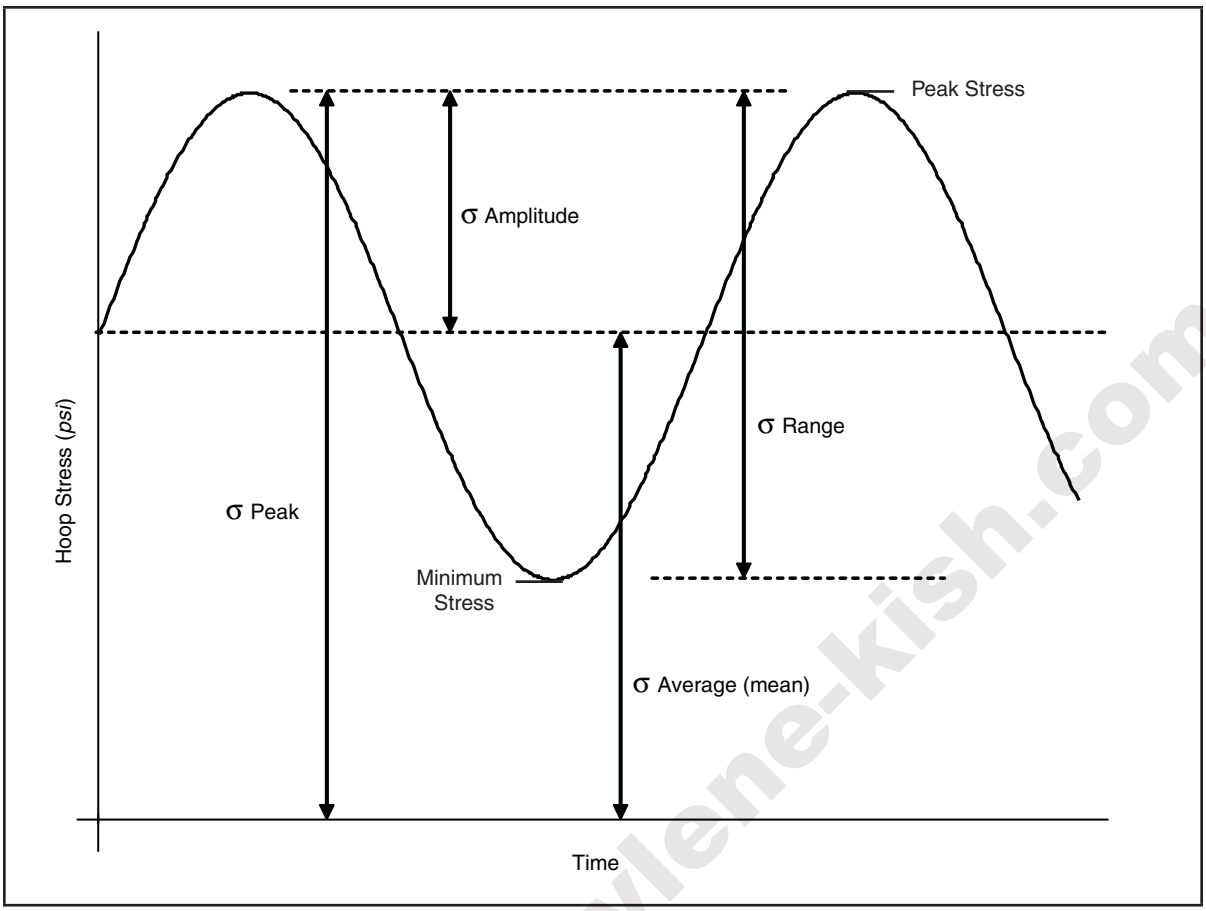

Figure B.1 Illustration of stress terms

Analysis:

Temperature considerations, operating temperature does not exceed 73°F,

F_T = 1 and pressure-rating reduction is not necessary, PC = 235 psi

Check working pressure versus pressure class

Working pressure: 160 psi

Per Eq 2, working pressure cannot exceed allowable pressure of

PC × F_T 235 psi × 1.00 = 235 psi > 160 psi

OK for working pressure

Check occasional surge pressure capacity, (WP + P_{OS})

Anticipated occasional surge pressure, (P_{OS})

17.5 psi / (1 ft/sec) × 7 ft/sec = 122 psi

Anticipated occasional surge pressure capacity, (WP + P_{OS})

160 psi + 122 psi = 282 psi

Allowable occasional surge pressure capacity, (1.60 × PC × F_T)

1.60 psi × 235 × 1 = 376 psi

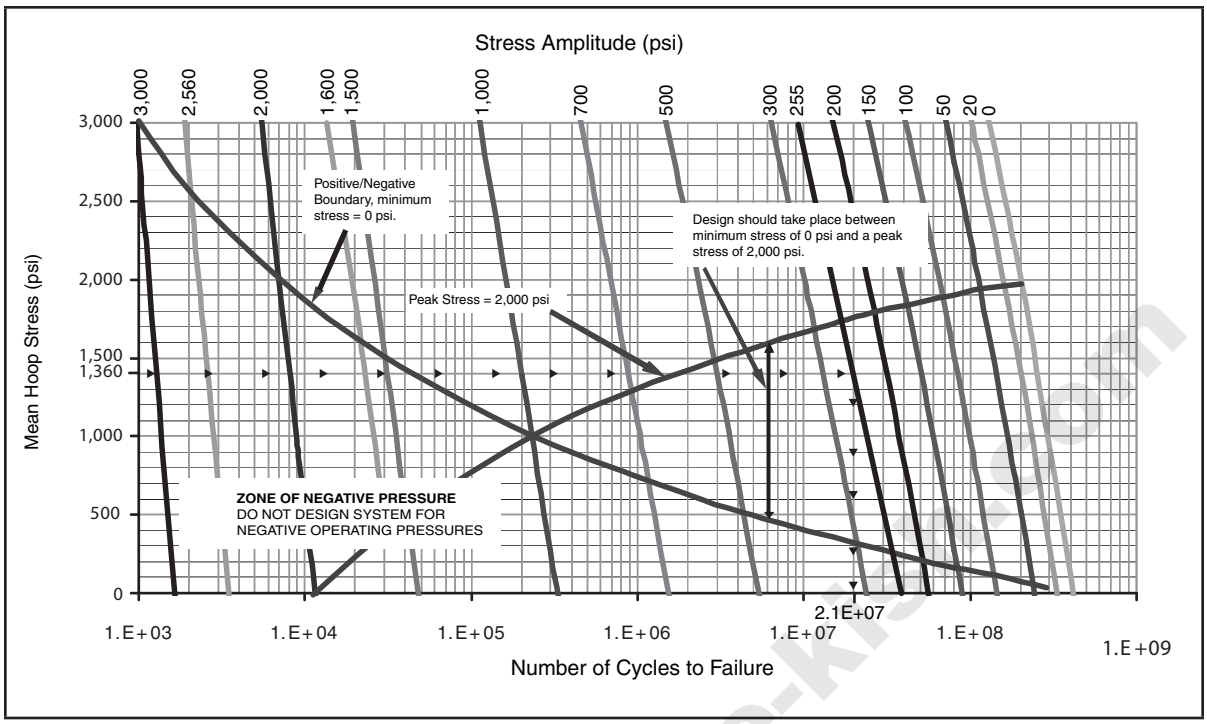

Figure B.2 Cyclic design curves

Checking allowable versus anticipated

376 psi > 282 psi

OK for occasional surge pressure capacity.

Check recurring surge pressure capacity, (WP + P_{RS})

(Please see *Uni-Bell Handbook of PVC Pipe: Design and Construction*)

Maximum design pressure, P_{max} = (WP + P_{RS}) = 160 psi + 30 psi = 190 psi

Minimum design pressure, P_{min} = (WP – P_{RS}) = 160 psi – 30 psi = 130 psi

Mean hoop stress (Figure B.1) = (P_{max} + P_{min}) (DR – 1) / 4

= (190 psi + 130 psi) (18 – 1) / 4 = 1,360 psi

Stress amplitude (Figure B.1) = (P_{max} – P_{min}) (DR – 1) / 4

= (190 psi – 130 psi) (18 – 1) / 4 = 255 psi

Total # of cycles = Factor of Safety × (# cycles/day) × (365 days/year)

× (Design Life in Years) = 2 × 54 × 365 × 50 = 2.0 E + 06 cycles

Actual number of cycles to failure (Figure B.2) = 2.1 E + 07 cycles

Check allowed versus anticipated cycles

2.1 E + 07 cycles > 2.1 E + 06 cycles

OK for recurring surge

DR 18 pipe is adequate for the design conditions

AWWA is the authoritative resource for knowledge, information, and advocacy to improve the quality and supply of water in North America and beyond. AWWA is the largest organization of water professionals in the world. AWWA advances public health, safety, and welfare by uniting the efforts of the full spectrum of the entire water community. Through our collective strength, we become better stewards of water for the greatest good of people and the environment.

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