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**American Water Works
Association**

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ANSI/AWWA C605-13
(Revision of ANSI/AWWA C605-05)

AWWA Standard

Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings

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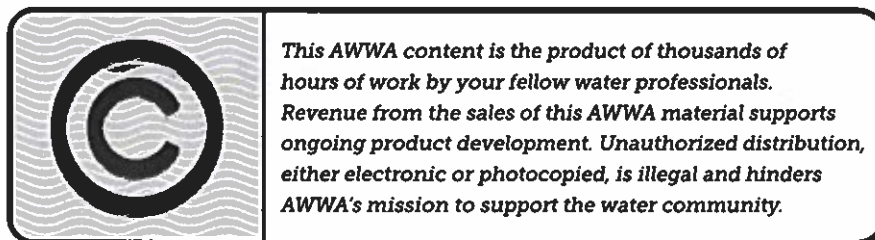
AWWA Standard

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA C605.

I. Introduction.

I.A. *Background.* ANSI/AWWA C605, Standard for Underground Installation of PVC and PVCO Pressure Pipe and Fittings is offered as a reference to be used when constructing new PVC or PVCO pressurized pipelines or when making repairs or extensions to existing PVC and PVCO pressure pipelines. This standard provides information on pipe handling, trench excavation, pipe installation, appurtenance placement, and preparation of pipelines for use. It is not intended that this AWWA standard be used as a contract document; however, it may be used as a reference in contract documents. This standard represents the consensus of the standards committee on the recommended practice for the proper installation of PVC and PVCO pressure pipe. The standard is not intended to preclude the manufacture, marketing, purchase, or use of any product, process, or procedure.

I.B. *History.* This is the third edition of ANSI/AWWA C605. In 1978, the AWWA Standards Council authorized the AWWA Standards Committee on Thermoplastic Pressure Pipe to prepare a design and installation manual that would be followed by an installation standard for PVC pressure pipe. AWWA Manual M23, *PVC Pipe—Design and Installation*, was published in 1980.

In 1988, the AWWA Standards Committee on Thermoplastic Pressure Pipe was dissolved to allow for the formation of the AWWA Standards Committee on Polyvinyl Chloride (PVC) Pressure Pipe and Fittings. A new subcommittee was convened to resume work on the installation standard in 1989. On completion of the manual, development of this standard began. The first edition was effective July 1, 1995. The second edition of ANSI/AWWA C605 was approved by the AWWA Board of Directors on June 12, 2005. This third edition of ANSI/AWWA C605 was approved on June 9, 2013.

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

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

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

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, provincial, and local agencies may use various references, including

1. An advisory program formerly administered by USEPA, Office of Drinking Water, discontinued on April 7, 1990.
2. Specific policies of the state, provincial, or local agency.
3. Two standards developed under the direction of NSF International, 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, provincial, or local agency.

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

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

ANSI/AWWA C605 does not address additives requirements. Users of this standard should consult the appropriate state, provincial, or local agency having jurisdiction in order to

1. Determine additives requirements, including applicable standards.

* Water Research Foundation, 6666 W. Quincy Ave., Denver, CO 80235.

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

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

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. Attention should be called to the need for users of this standard to provide proper design consideration for 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 comprising 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.

Guidance regarding the permeation resistance of pipe and pipe gasket materials is available in

Ong, S.K., J.A. Gaunt, F. Mao, C.-L. Cheng, L. Esteve-Agelet, and C.R. Hurburgh. 2007. *Impact of Hydrocarbons on PE/PVC Pipes and Pipe Gaskets*. Report No. 91204. Denver, CO: AWWA Research Foundation.

Holsen, T. M., J.K. Park, D. Jenkins, and R.E. Selleck. 1991. Contamination of Potable Water by Permeation of Plastic Pipe. *Journal AWWA*, 83(8): 53–56.

Glaza, E.C., and J.K. Park. 1992. Permeation of Organic Contaminants Through Gasketed Pipe Joints. *Journal AWWA*, 84 (7): 92–100.

Olson, A.J., D. Goodman, and J.P. Pfau. 1987. Evaluation of Permeation of Organic Solvents Through PVC, Asbestos/Cement, and Ductile Iron Pipes. *Journal of Vinyl Technology* 9(3): 114–118.

Vonk, M.W. 1985. Permeation of Organic Compounds Through Pipe Materials. Publication No. 85, Neuwegein, NL: Netherlands Waterworks' Testing and Research Institute (KIWA).

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 C605, Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings, of latest revision.

2. Reference to applicable plans, drawings, specifications, and other contract documents (all sections).
3. Whether compliance with NSF/ANSI 61, Drinking Water Treatment Chemicals—Health Effects, is required.
4. Details of other federal, state or provincial, and local requirements (Sec. 4.1).
5. Materials inspection and acceptance requirements (Sec. 5.1).
6. Affidavit of compliance for materials used (Sec. 5.1.1).
7. Special provisions for conflicting utilities and responsibility for facilities and responsibility for the location, relocation, and repair of the conflicting facility or relocation of the pipeline if necessary (Sec. 6.1.3 and Sec. 6.2).
8. Notification requirements (Sec. 6.3).
9. Open trench, trench water, and trench stability requirements (Sec. 7.1).
10. Requirements for the protection of workers and the safety of the general public (Sec. 7.1.1).
11. Special provisions for excavation and trenching requirements (Sec. 7.2).
12. Trench width, depth, bottom preparation, rock conditions, previous excavation, blasting, unstable subgrade, dewatering, and excavated material requirements (Sec. 7.2).
13. Special trench foundations (Sec. 7.2.7).
14. Special embedment materials (Sec. 8.3).
15. Thrust restraint requirements (Sec. 8.7).
16. Backfill requirements. (Sec. 8.8).
17. Type, number, and installation requirements for valves and fittings (Sec. 9.2).
18. Hydrant requirements (Sec. 9.3).
19. Special provisions for testing, including the assignment of responsibility for providing and conveying water for flushing, testing, disinfection, and provisions for disposal of disinfection water. Assignment of responsibility for providing equipment for testing witnessing and required recording of test results (Sec. 10.3.1).
20. Special requirements for the method of disinfection, sampling, and analysis (Sec. 10.4). See ANSI/AWWA C651, Standard for Disinfecting Water Mains, of latest revision.
21. System design pressure, required test pressure, and test duration (Sec. 10.3.5 and Sec. 10.3.4).
22. If delivery of an affidavit of compliance from the constructor is not required (Sec. 10.6).

III.B. *Modification to Standard.* Any modification of 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 revision include the following:

1. Permeation requirements were moved to the Special Issues section of the foreword.
2. Molecularly Oriented Polyvinyl Chloride (PVCO) pipe has been included (Sec. 1.1).
3. Soil classification requirements were added to Figure 1.
4. Trenchless construction requirements were added (Sec. 7.3).
5. Fused Joints are addressed (Sec. 8.5.6).
6. Tapping sleeves and valve requirements were added (Sec. 9.4.3).
7. Notice was added to bring the user's attention to the possibility that compliance with this standard may require use of an invention covered by patent rights (Sec 8.5.6).
8. Butt Fusion Inspection Requirements are addressed (Sec. 8.5.6.1).
9. Hydrostatic pressure testing requirements were changed to include the following: "not less than 1.5 times the stated sustained working pressure at the lowest elevation of the test section" shall be required (Sec. 10.3.5).
10. Notice of Nonconformance requirements was added (Sec. 10.5).
11. Delivery of an affidavit of compliance from the constructor is required (Sec. 10.6).

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, or write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098, or email standards@awwa.org.

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ANSI/AWWA C605-13
(Revision of ANSI/AWWA C605-05)

AWWA Standard

Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes underground installation and hydrostatic testing procedures for polyvinyl chloride (PVC) or molecularly oriented polyvinyl chloride (PVCO) pressure pipe and fittings that comply with either ANSI/AWWA C900, ANSI/AWWA C905, ANSI/AWWA C907, or ANSI/AWWA C909. These plastic components are installed in piping systems that may contain components made from other materials. It may be necessary to supplement this standard with provisions for special requirements not included in this standard (see foreword, Sec. III). Such special requirements should be specified by the purchaser with input from the purchaser's engineering consultant(s), product manufacturer(s), and/or supplier(s).

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for underground installation and hydrostatic testing procedures for PVC or PVCO

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

pressure pipe and fittings used to transport potable water, reclaimed water, irrigation water, or wastewater, or for the conveyance of any fluid compatible with PVC or PVCO.

Sec. 1.3 Application

This standard can be referenced in specifications for underground installation and hydrostatic testing procedures for PVC or PVCO pressure pipe and fittings used in the applications listed in Sec. 1.2.

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.

ANSI/AWWA C110/A21.10—Ductile-Iron and Gray-Iron Fittings.

ANSI/AWWA C111/A21.11—Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

ANSI/AWWA C153/A21.53—Ductile-Iron Compact Fittings for Water Service.

ANSI/AWWA C219—Bolted, Sleeve-Type Couplings for Plain-End Pipe.

ANSI/AWWA C651—Disinfecting Water Mains.

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

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

ANSI/AWWA C905—Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm).

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

ANSI/AWWA C909—Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 In. Through 24 In. (100 mm Through 600 mm), for Water, Wastewater, and Reclaimed Water Service.

ASME B36.10M—Welded and Seamless Wrought Steel Pipe.

ASTM* D698—Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft³ [600 kN-m/m³]).

ASTM D4832—Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.

ASTM F1674—Standard Test Method for Joint Restraint Products for Use with PVC Pipe.

ASTM F2331—Standard Test Method for Determining Chemical Compatibility of Thread Sealants with Thermoplastic Threaded Pipe and Fittings Materials.

AWWA Manual M3, *Safety Practices for Water Utilities*. AWWA, Denver, Colo.

AWWA Manual M12, *Simplified Procedures for Water Examination*. AWWA, Denver, Colo.

AWWA Manual M17, *Installation, Field Testing, and Maintenance of Fire Hydrants*. AWWA, Denver, Colo.

AWWA Manual M23, *PVC Pipe—Design and Installation*. AWWA, Denver, Colo.

UNI†-B-8—Recommended Practice for the Direct Tapping of Polyvinyl Chloride (PVC) Pressure Water Pipe (Nominal Diameters 6–12 Inch).

UNI-PUB-8—Tapping Guide for PVC Pressure Pipe. Uni-Bell PVC Pipe Association, 2711 LBJ Freeway, Suite 1000, Dallas, Texas 75234.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. **Constructor:** The party that furnishes the work and materials for placement or installation.
2. **Controlled Low-Strength Material (CLSM):** A mixture of soil or aggregates, cementitious material, fly ash, water, and sometimes chemical admixtures, that hardens into a material with a higher soil stiffness E' than the soil, but less than 1,200 psi. Used as a replacement for compacted backfill, CLSM can be placed as a slurry, a mortar, or a compacted material that typically has unconfined compressive strengths of 50 to 100 psi for most applications.

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

† Uni-Bell PVC Pipe Association, 2711 LBJ Freeway, Suite 1000, Dallas, Texas 75234.

3. *Day*: A day is defined as a 24-hr period.
4. *Fused joints*: Joining two pieces of plastic by heating and melting the mating surfaces of the pipe components to be joined and pressing them together so that they form a homogeneous bond. When the mating surfaces are pipe ends, the fusion process is referred to as *butt fusion* or *butt heat fusion*.
5. *Manufacturer*: The party that manufactures, fabricates, or produces materials or products.
6. *Purchaser*: The person, company, or organization that purchases any materials or work to be performed.
7. *PVC pressure pipe*: Polyvinyl chloride (PVC) pressure pipe manufactured in accordance with ANSI/AWWA C900, ANSI/AWWA C905, or ANSI/AWWA C909. NOTE: Pipe manufactured in accordance with ANSI/AWWA C909 is PVCO pipe. Unless otherwise noted, the requirements of this standard for PVC pipe shall also apply to PVCO pipe.
8. *PVCO pressure pipe*: Molecularly oriented polyvinyl chloride (PVCO) pressure pipe manufactured in accordance with ANSI/AWWA C909. Molecular orientation is achieved through the controlled expansion of conventionally extruded PVC pipe.
9. *Restrained joint*: A pipe to pipe (or fitting or appurtenance) connection that is joined mechanically or heat-fused so that it does not separate or leak in pressure applications under specified load conditions and does not require thrust blocking.
10. *Supplier*: The party that supplies materials or services. A supplier may or may not be the manufacturer.

SECTION 4: REQUIREMENTS

Sec. 4.1 Materials

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

SECTION 5: RECEIVING, HANDLING, AND STORAGE

Sec. 5.1 Receiving

5.1.1 *Inspection for damage and defects.* The purchaser may require that materials furnished by the constructor or supplier be subject to inspection and acceptance by the purchaser at the manufacturer's plant or at the point of delivery. The purchaser may request additional tests' results or affidavits of compliance as specified in ANSI/AWWA C900, ANSI/AWWA C905, ANSI/AWWA C907, or ANSI/AWWA C909 to ensure conformance. Inspection by the purchaser does not relieve the constructor of responsibility to inspect and accept materials.

5.1.2 *Responsibility.* The constructor or supplier shall be responsible for materials provided. The constructor shall replace at no additional expense to the purchaser provided materials found to be defective in manufacture or damaged in transport, jobsite handling, or placement. This shall include the providing of materials, equipment, and labor required for replacement of installed defective material.

5.1.2.1 *Purchaser-provided materials.* The constructor's responsibility for materials provided by the purchaser shall begin at the point of delivery to the constructor. Materials already on the site shall, on acceptance by the constructor, become the constructor's responsibility on the day work commences or the day designated by the purchaser. However, latent defects not identifiable by physical inspection shall remain the responsibility of the purchaser even after acceptance by the constructor. Defective material provided by the purchaser shall be replaced by the purchaser.

5.1.3 *Rejection.* On receipt, material found to be defective due to manufacture or damage in shipment shall be rejected and recorded on the Bill of Lading and removed from the jobsite. The constructor shall inspect materials provided by the purchaser and shall reject defective materials at the time of receipt. Any observed gouges or scratches that extend 10 percent or more into the pipe wall shall justify rejection of that pipe. The constructor may use the undamaged portion of a pipe by cutting off the damaged section. Defective materials shall be clearly marked, segregated, and removed from the site.

Sec. 5.2 Handling

5.2.1 *Unloading and loading.* The constructor shall be responsible for unloading and loading of materials at the jobsite. To avoid damage, pipe and appurtenances shall be loaded and unloaded with care and in accordance with the manufacturer's published recommendations. Adherence to the pipe manufacturer's published unloading recommendations is particularly important when temperatures are below 32°F (0°C). Under no circumstances shall such material be dropped.

5.2.1.1 *Padding.* Slings (other than nylon straps), hooks, or pipe tongs shall be padded and used properly to prevent damage to pipe and appurtenances.

5.2.2 *Hauling.* When hauling materials at the jobsite, care shall be exercised to prevent damage. If possible, pipe shall be hauled in unit packages with proper supports.

Sec. 5.3 Storage

5.3.1 *Stacking.* Stored materials shall be kept safe from damage. The interior as well as sealing surfaces of pipe and appurtenances shall be kept free from dirt and foreign matter per ANSI/AWWA C651. Pipe stored outdoors and expected to be exposed to direct sunlight for periods of one year or more after delivery shall be covered with canvas or other opaque material with provision for adequate air circulation. PVC pipe shall not be stored close to heat sources, such as heaters, boilers, steamlines, or engine exhaust.

5.3.1.1 *Packaging.* When possible, pipe shall be stored in unit packages on flat surfaces to avoid bending. When unit packages are stacked, care shall be exercised to ensure the weight of the upper units does not cause deformation to pipe in lower units. Unit packages shall be supported by racks or dunnage to prevent damage or bending of the pipe. When unit packages are stacked, care shall be exercised to ensure the height of the stack does not result in instability that could cause stack collapse, pipe damage, or personal injury. Generally, stack height should not exceed 8 ft (2.4 m). Safe stack height will vary by unit package configuration.

5.3.1.2 *Protecting gaskets.* Gaskets shall be protected from excessive exposure to heat, direct sunlight, ozone (from electric motors and equipment), oil, grease, or other contaminants.

5.3.2 *Stringing.* In preparation for installation, distribution (stringing) of pipe and appurtenances shall be as close to the trench as practical and, if possible,

on the opposite side from the excavated earth stockpile. Pipe shall be protected from traffic and secured to prevent rolling. Bell ends on pipe should be pointed in the direction of work progress. Caution shall be exercised to minimize the contamination of pipe interiors and joint components. For trenchless installations, the pipe shall be staged for appropriate joining and insertion at a location as close as reasonably possible to the installation following manufacturer's/supplier's instructions.

SECTION 6: PRELIMINARY SITE INFORMATION

Sec. 6.1 Alignment and Grade

6.1.1 *Pipe placement.* Pipe shall be installed and maintained at required lines and grades, within tolerances specified by the purchaser.

6.1.2 *Appurtenance placement.* Fittings, valves, air vents, and hydrants shall be installed at required locations with valve and hydrant stems properly set. The axis of fittings shall align with the longitudinal axis of the pipe.

6.1.3 *Obstructions.* It shall be the responsibility of the constructor to provide adequate protection and maintenance of underground and surface utility structures, drains, sewers, and other obstructions encountered in the progress of work. When the required grade or alignment of the pipe is obstructed by existing utility structures (such as conduits, ducts, pipes, branch connections to main sewers, or main drains), the obstruction shall be permanently supported, relocated, removed, reconstructed, or bypassed by the constructor in cooperation with the owners of such utility structures.

Sec. 6.2 Investigation

The constructor shall determine the location of existing underground utility structures in the vicinity of the pipe installation. In addition to the examination of available records, explorations and excavations shall be performed if required by the purchaser.

Sec. 6.3 Notifications

Unless otherwise specified by the purchaser, the constructor shall notify owners of private property, public traffic authorities, and other utilities prior to commencement of construction.

SECTION 7: EXCAVATION

Sec. 7.1 Preparation

7.1.1 *General.* The constructor shall comply with federal regulations for the protection of workers and the safety of the general public. (Refer to AWWA Manual M3, *Safety Practices for Water Utilities.*)

7.1.1.1 *Open trench.* Trench excavation shall proceed in advance of pipe installation only so far as can be backfilled the same day, or as permitted by the purchaser.

7.1.1.2 *Water removal.* The discharge from any trench dewatering pumps or directional drilling operations shall be conveyed to natural drainage channels, storm sewers, or proper reservoirs as approved by regulatory authorities having jurisdiction. Such discharge shall be in a manner that prevents property damage, erosion, or siltation.

7.1.1.3 *Trench stability.* Where necessary to prevent caving, trench excavations in unstable soils shall be adequately supported with steel sheeting or trench boxes. Before sheeting is withdrawn, or trench boxes moved forward, they shall be raised, in place, just above the pipe crown to safely allow the constructor to completely fill any voids left in the pipe zone.

Sec. 7.2 Trench Construction

7.2.1 *Trench width.* The trench width at the ground surface may vary with the trench depth, the nature of soils encountered, existence of any pavement, and the proximity of adjacent structures. The minimum clear width of an unsupported or supported trench measured at the centerline of the pipe shall be at least 18 in. (450 mm) or the pipe outside diameter plus 12 in. (300 mm), whichever is greater. Where embedment compaction is required, the trench shall be wide enough to accommodate the compaction equipment.

7.2.2 *Trench depth.* The trench shall be excavated to the depth that permits pipe to be laid at the elevations shown on the engineering drawings or with the required depth of cover specified by the purchaser. The depth of cover shall be measured from the finished grade or the surface of the permanent improvement to the top of the pipe barrel.

7.2.3 *Preparation of trench bottom.* The trench bottom shall be constructed to provide a firm, stable, and uniform support for the full length of the pipe. Blocking shall not be used to change pipe grade or to intermittently support pipe across excavated sections. When embedment Type 4 or 5 (See Figure 1) is

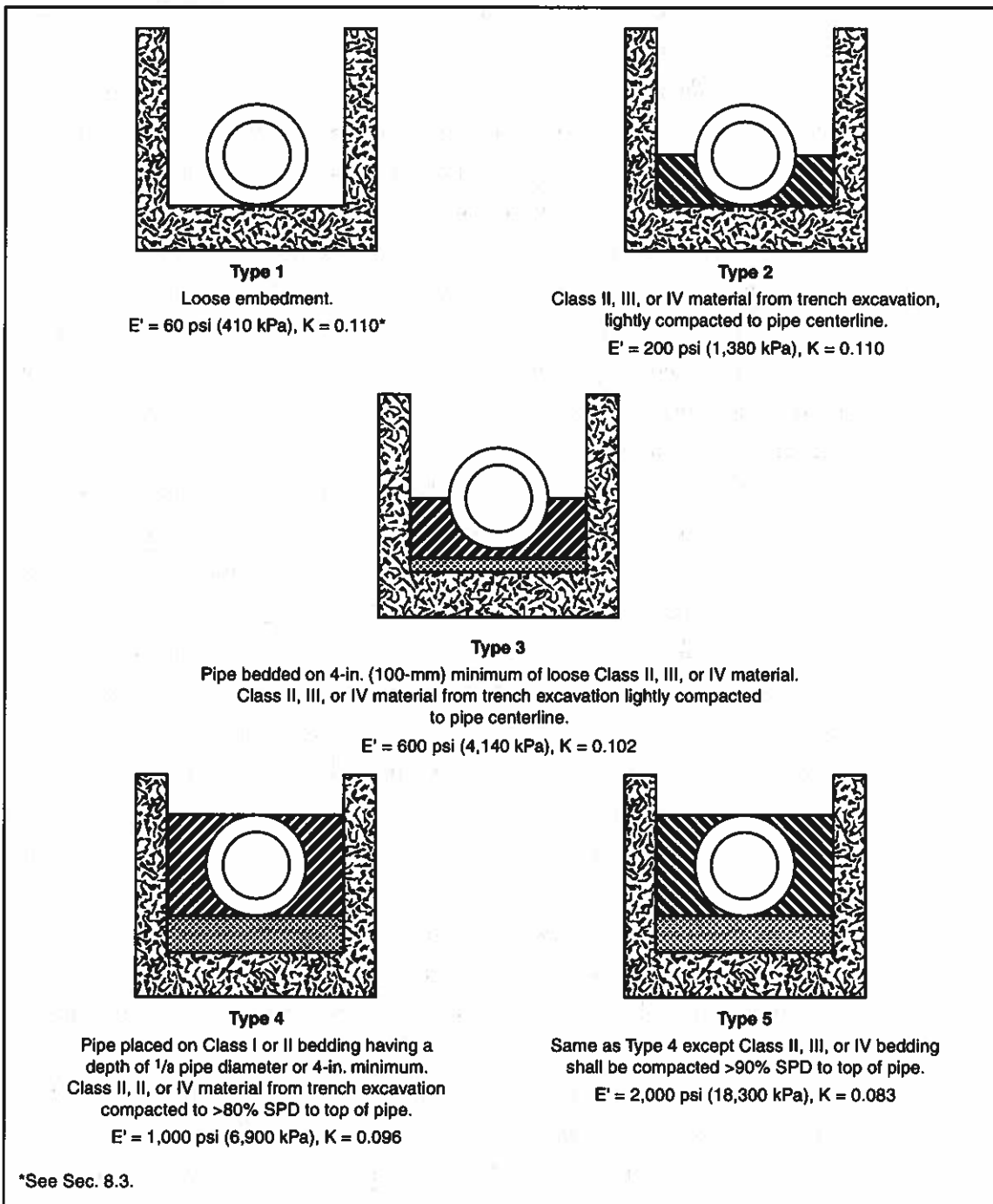


Figure 1 Typical embedment types

NOTES:

1. See Table 1 for descriptions of Class I, II, III, IV, and V soils.
2. Do not use Class V soils for bedding, embedment, or backfill.
3. SPD is Standard Proctor Density, AASHTO T-99 or ASTM D 698.
4. Required embedment type will depend on the pipe's dimension.

specified, bell holes at each bell and spigot joint shall be provided that conform to the shape of the pipe bell.

7.2.4 Rock conditions. Ledge rock, boulders, cobbles, and large stones shall be removed from the trench to provide at least 4 in. (100 mm) of embedment cushion on each side of and below pipe and appurtenances (see Figure 1). The excavation shall be sufficiently wide to enable proper placement of the embedment specified by the purchaser. When excavation is completed, embedment material shall be placed, leveled, and compacted to provide a proper cushion for the pipe. Such embedment shall be granular material graded in particle size so that the embedment material supporting the pipe shall be retained in place under all conditions, including the rapid movement of water through the pipe embedment and the surrounding material.

7.2.5 Previous excavations. If the trench passes over another pipeline or other previous excavation, the trench bottom shall (1) be compacted to provide support equal to that of the undisturbed native soil or (2) conform to specific regulatory requirements that preclude damage to the existing installed facility.

7.2.6 Blasting. Blasting for excavation shall be permitted only when specified by the purchaser and when proper precautions have been taken for the protection of persons and property. Hours permitted for blasting shall be specified by the purchaser. Damage caused by blasting shall be repaired by the constructor at no additional expense to the purchaser. Blasting procedures shall conform with applicable laws, ordinances, and regulations imposed by federal, state or provincial, and local authorities.

7.2.7 Unstable subgrade. Where an unstable trench subgrade condition exists that, in the opinion of the purchaser, cannot support the pipe, an alternative foundation shall be provided. At the discretion of the purchaser, an additional depth shall be excavated and refilled to pipe foundation grade with embedment material or special pipe foundation material in accordance with the purchase documents. Any part of the trench excavated below grade shall be backfilled to grade and compacted to the required density. Such embedment material shall have a gradation that inhibits migration of soil particles.

7.2.8 Dewatering. Where running or standing water occurs in the trench bottom or where the soil in the trench bottom displays a “quick” tendency, the water shall be removed by pumps. The trench shall be kept free from water during installation operations by suitable means, such as well points or pervious under-

Table 1 Soil Classes

Soil Class	Description	USCS* Symbol
I	Crushed rock: 100% passing 1½-in. sieve, ≤ 15% passing #4 sieve, ≤ 25% passing ¾-in. sieve, ≤ 12% passing #200 sieve	
II	Clean, coarse-grained soils: or any soil beginning with one of these symbols (can contain fines up to 12%) uniform fine sands (SP) with more than 50% passing a #100 sieve should be treated as Class III material	GW, GP, SW, SP
III	Coarse-grained soils with fines: or any soil beginning with one of these symbols	GM, GC, SM, SC
	Sandy or gravelly fine-grained soils: or any soil beginning with one of these symbols with > 30% retained on #200 sieve	ML, CL
IV	Fine-grained soils: or any soil beginning with one of these symbols with ≤ 30% retained on #200 sieve	ML, CL
V	Fine-grained soils, organic soils: high-compressibility silts and clays, organic soil	MH, CH, OL, OH, Pt

*USCS—Unified Soil Classification System

NOTES:

1. Soil Classification descriptions and symbols are in accordance with ASTM D2487 and ASTM D2488.
2. For Class I, all particle faces shall be fractured.
3. Materials such as broken coral, shells, slag, and recycled concrete (with less than 12% passing a No 200 sieve) should be treated as Class II soils.

drain bedding, until the pipe has been installed and backfill placed and compacted to a sufficient height to prevent pipe flotation. A cover depth of 1.5 pipe diameters will normally prevent flotation. For pipes having a dimension ratio (DR) greater than 32.5, a cover minimum of 2.0 pipe diameters is recommended. Soil migration in the pipe zone shall be prevented through the use of geotextile fabric or embedment material gradation.

7.2.9 Excavated material. Excavated material shall be placed in a manner that will not obstruct work or endanger personnel or the public. Excavated material shall not obstruct sidewalks or driveways for extended periods unless provided for in the contract documents. Hydrants under pressure, valve-pit covers, valve boxes, curb-stop boxes, fire and police call boxes, or other utility controls shall remain unobstructed and accessible. Gutters shall remain clear unless other satisfactory

provisions have been made for street drainage. Natural water courses shall not be obstructed. Surplus excavated material shall be disposed of in a suitable manner.

7.2.10 *Steep slopes.* Where steep slopes approximately 20 percent or greater are encountered, special considerations must be taken to control subsequent sliding or settlement of trench material in the pipe environment that would result in additional spigot penetration into the socket of the completed joint (overbellling).

7.2.11 *Encasements.* When specified, skids or casing spacers must provide sufficient height to permit clearance between bell joints or couplers and casing walls. Skids shall be fastened securely to pipe with strapping, cables, or clamps as specified. If the pipe will be pushed into the casing, the end of the skids or casing spacers shall be secured at the assembly reference mark on the spigot end of the pipe to avoid over-insertion during installation.

Sec. 7.3 Trenchless Construction

7.3.1 *Insertion and exit excavations.* Insertion and exit trenches, pits, and/or approaches shall be in accordance with manufacturer/supplier recommendations and excavated in accordance with Sec. 7.1 and Sec. 7.2. Backfilling shall be done in accordance with Sec. 8.8.

7.3.2 *Excavated and evacuated material.* Excavated and evacuated material shall be placed and disposed of in accordance with Sec. 7.2.9.

SECTION 8: PIPE INSTALLATION

Sec. 8.1 Material Inspection

Pipe and appurtenances shall be inspected for defects prior to installation. Defective, damaged, or unsound material shall be marked and held for inspection by the purchaser, who may prescribe corrective repairs or reject the material.

Sec. 8.2 Precautions

Proper equipment, tools, and facilities shall be provided and used by the constructor for the safe execution of work. Pipe and appurtenances shall be lowered carefully into the trench using suitable equipment and methods to prevent material damage or personnel injury. Under no circumstances shall pipe or appurtenances be rolled, dropped, or dumped into the trench. For trenchless installations, the manufacturer's or supplier's instructions for safe handling and installation shall be followed.

Sec. 8.3 Pipe Trench Embedment

Selection of the required laying condition and the method of embedment shall be made in accordance with the requirements specified by the purchaser. Common embedment types are shown in Figure 1, with the bedding constant (K) and typical soil modulus (E') values associated with each. These values, along with other embedment design parameters specified by the purchaser, should be used to calculate pipe deflection per the design information provided in AWWA Manual M23. The purchaser may also specify embedment types other than those shown in Figure 1. The type of pipe embedment should be selected so as to prevent a vertical cross-section long-term ring deflection of more than 7.5 percent.* Maximum embedment particle size shall not exceed $\frac{3}{4}$ in. (20 mm) for angular rock or $1\frac{1}{2}$ in. (40 mm) for rounded rock and shall be no larger than 10 percent of the pipe diameter. Embedment shall be selected and placed to prevent gouges, crimping, or puncture of pipe, joints, or appurtenances. If flowable fill or controlled low-strength material (CLSM) is used for embedment, the maximum particle size should not exceed one-eighth of the distance between the pipe and the trench wall. When using CLSM, care shall be taken to maintain the specified line and grade and to avoid floating the pipe.

Sec. 8.4 Pipe Installation

8.4.1 *Potable pipe cleaning.* Prior to installation, all dirt and foreign material shall be removed from pipe and fittings that will be used for the transport of drinking water. Dirt and foreign matter that cannot be removed by normal flushing shall be cleaned by mechanical means. The purchaser shall determine when such mechanical cleaning is required. During installation operations, no debris, hand tools, clothing, or other materials shall be placed in the pipe. Pipe shall be kept clean during and after installation.

8.4.2 *Pipe placement in trench.* Pipe shall be installed to required line and grade within tolerances specified by the purchaser. The pipe and joint shall be uniformly supported and secured in place with the specified embedment material. Bell and spigot pipe joints shall be assembled after placement in the trench and shall be installed with the bell end pointing in the direction of work progress.

8.4.3 *Interrupted operations.* When installation is interrupted or terminated at the end of a day, all potable water pipe ends shall be sealed temporarily to

* Pipe embedment type shall be selected solely on the basis of the pipe stiffness and the anticipated external load. Internal pipe pressure shall not be included in the embedment selection evaluation.

prevent the entry of water, debris, small animals, and similar types of contamination. Precautions shall be taken to prevent flotation of the sealed pipe during work stoppages. (See Sec. 4.2.8.)

8.4.4 *Trenchless operations.* Trenchless installation by pulling and/or pushing the pipe into position shall be permitted when specified. All joints must be capable of safely withstanding the projected installation pulling and pushing forces. The maximum safe pulling/pushing forces and minimum bending radius shall be provided by the manufacturer or supplier and followed during installation.

Sec. 8.5 Pipe Joining

8.5.1 *Gasket-seal joint preparation.* The sealing surface of the pipe spigot end, the pipe bell, the coupler or fitting, and the elastomeric gaskets shall be cleaned immediately before assembly. Factory-installed gaskets should not be removed.* An approved lubricant shall be applied in accordance with the pipe manufacturer's published recommendations. Application of a nonapproved lubricant or too much lubricant can result in a pipeline that is difficult to disinfect and cause temporary taste and odor problems.

8.5.2 *Field cuts.* Circular saws, handsaws, or similar equipment may be used for cutting PVC pipe. Abrasive disc saws should be used for cutting and beveling PVC pipe. Cuts shall provide a smooth end at right angles to the longitudinal axis of the pipe. Pipe spigot ends shall be marked to match the manufacturer's insertion line and beveled to match factory supplied bevel prior to joining with another PVC pipe bell end.

8.5.3 *Gasket-seal joint assembly.* Joints shall be assembled under conditions that allow for the clean mating and sealing of joining surfaces using equipment, materials, and procedures in accordance with recommendations published by the pipe and fitting manufacturers. The elastomeric gasket will have been factory installed in most bell joints. If the gasket is not preinstalled, position the gasket in the annular groove of the bell or coupling. To assure compatibility, only gaskets supplied by the particular pipe and fitting manufacturer(s) shall be used.

8.5.4 *Spigot insertion.* Pipe spigot ends are premarked with a circumferential insertion line. This line references how far the spigot should be inserted into the adjoining PVC pipe bell. Field-cut pipe spigot ends shall be marked to match

* In very cold installation conditions, the manufacturer or producer may permit the constructor to remove factory-installed gaskets and take them to a heated truck cab or shelter to restore their flexibility prior to joint assembly. Always check with the pipe and fittings manufacturers before attempting to remove the gasket, because not all factory-installed gaskets are removable.

the manufacturer's insertion line and beveled to match factory-supplied bevel (see Sec. 8.5.2). Pipe-to-pipe joints shall be assembled only to the insertion line. After assembly, the insertion line shall remain visible and be nearly flush with the lip of the adjoining PVC pipe bell. Joints assembled beyond the insertion line shall be considered overassembled and may result in damaging stresses or leakage. The bell or coupler shall be in straight alignment with the pipe spigot end before and during joint assembly.

8.5.5 *Types of gasket seal joints.* Unless otherwise specified by the purchaser, gasketed joints shall be the push-on type. PVC pressure pipe shall be assembled using the following types of joints:

8.5.5.1 Pipe to pipe. Gasket seal bell joints integral with the pipe (ANSI/AWWA C900, ANSI/AWWA C905, and ANSI/AWWA C909 may be used).

8.5.5.2 Pipe-to-couplings PVC fittings. Double-gasketed couplings and PVC fittings (ANSI/AWWA C900, ANSI/AWWA C905, ANSI/AWWA C907, and ANSI/AWWA C219) may be used. The procedures of Sec. 8.5.1 and Sec. 8.5.2 shall be followed except the factory-applied insertion line may not provide for proper depth of assembly. The constructor shall determine the proper insertion depth by measuring the inside depth of the fitting bell or coupler and subtracting no less than 0.5 in. while also ensuring full engagement of the gasket with the joined pipe spigot will occur. The constructor shall mark new insertion line(s) on the pipe spigot(s) to be joined. After assembly, the new insertion line shall be nearly flush with the lip of the adjoining coupler or PVC fitting bell.

8.5.5.3 Pipe-to-iron fittings. Any of several joint designs that have gaskets and are manufactured in accordance with ANSI/AWWA C110/A21.10, ANSI/AWWA C111/A21.11, and ANSI/AWWA C153/A21.53 may be used. For pipe assembly commonly found with fittings, valves, hydrants, or other appurtenances, the insertion depths of these joints are significantly less than those of PVC pipe and fittings. The procedures of Sec. 8.5.1 and Sec. 8.5.2 shall be followed, except the insertion depths for these joints are generally less than those with PVC pipe or PVC fittings. Before assembly or insertion, the constructor shall make sure the pipe spigot end is squarely cut, deburred, and given only a slight outer bevel. If the pipe spigot end has the factory bevel, the factory bevel shall be removed or shortened to ensure that, when assembled, the gasket will be in full contact with the nonbeveled portion of the pipe outside diameter. Additionally, the published assembly recommendations of the fitting or appurtenance manufacturer shall be followed. Joints

may be either mechanical or push-on as described in ANSI/AWWA C110/A21.10, ANSI/AWWA C111/A21.11, or ANSI/AWWA C153/A21.53.

8.5.5.4 *Pipe-to-steel fittings.* Any of several push-on joint designs that have gaskets and are manufactured in accordance with ANSI/AWWA C200 may be used. The procedures of Sec. 8.5.1 and Sec. 8.5.2 shall be followed except the insertion depths for these joints are generally less than those with PVC pipe or PVC fittings. Before assembly or insertion the constructor shall make sure the pipe spigot end is squarely cut, deburred, and given only a slight outer bevel. If the pipe spigot end has the factory bevel, the factory bevel shall be removed or shortened to ensure that, when assembled, the gasket will be in full contact with the nonbeveled portion of the pipe outside diameter. Additionally, the published assembly recommendations of the fitting manufacturer shall be followed.

8.5.5.5 *Mechanical joint.* The mechanical joint shall be assembled in accordance with the fittings manufacturer's published recommendations. Pipe spigot bevels may require shortening for use with mechanical joints or fitting joints. Special consideration must be given to the recommended tightening of bolts and technique of appurtenance installation in accordance with manufacturer's recommendations.

8.5.6 *Fused joints.* Fused joints shall be used when specified. PVC pipe fusion requires heat, pressure, and proper alignment. The heat plate temperature, gauge pressure, and time duration required are dependent on the equipment used, pipe diameter, pipe wall thickness, and ambient conditions. Fused joints shall be assembled in accordance with the manufacturer's or process licensor's recommendations. NOTE: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, details may be obtained from the standards developer.

8.5.6.1 *Butt fusion inspection requirements.* The pipe provider shall provide the following information to the owner so that the owner's inspector can witness the procedures and visually inspect the joint and the joining procedures for quality.

1. Equipment requirements.
2. Operator qualification.

3. Cleanliness conditions on site (wind and rain protection).
4. Pipe end preparation requirements.
5. Fusion temperature requirements.
6. Interfacial pressure or contact pressure between the pipe end surfaces during heat soak time and after joining.
7. Cooling time required before pipe can be removed from the machine and before the pipe can be pulled on the ground and installed.
8. Acceptable bead configurations.
9. Examples of visual appearance of the bead, and/or examples of acceptable data loggers plot.

Sec. 8.6 Pipe Bending and Gradual Alignment Change

8.6.1 *Longitudinal bending of gasket-joined pipe.* If permitted by the purchaser, gasket-joined pipe may accommodate longitudinal bending (Figure 2) with the following limitations.

8.6.1.1 *Blocking.* The constructor shall block or brace pipe joints to ensure bending of pipe does not result in joint offset (Figure 3) that exceeds the

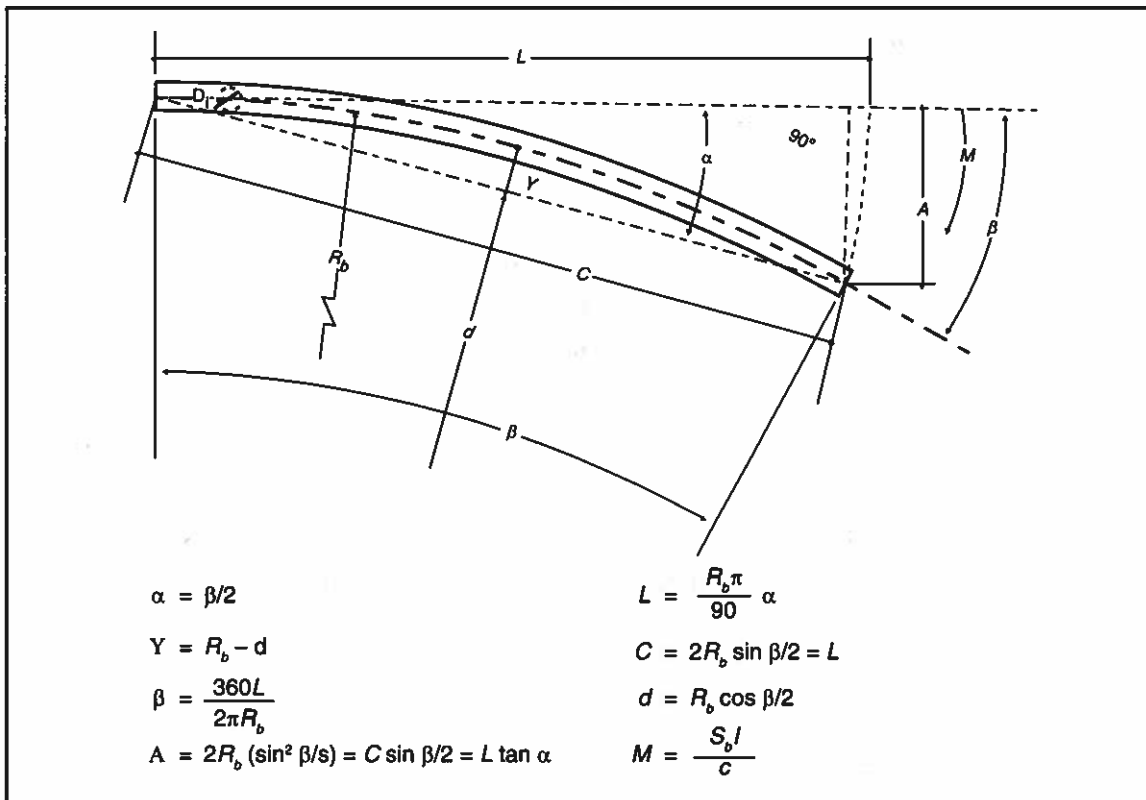


Figure 2 Measurements in relation to the allowable longitudinal bending radius (R_b)*

*M23, *PVC Pipe—Design and Installation*, Fig. 4-4.

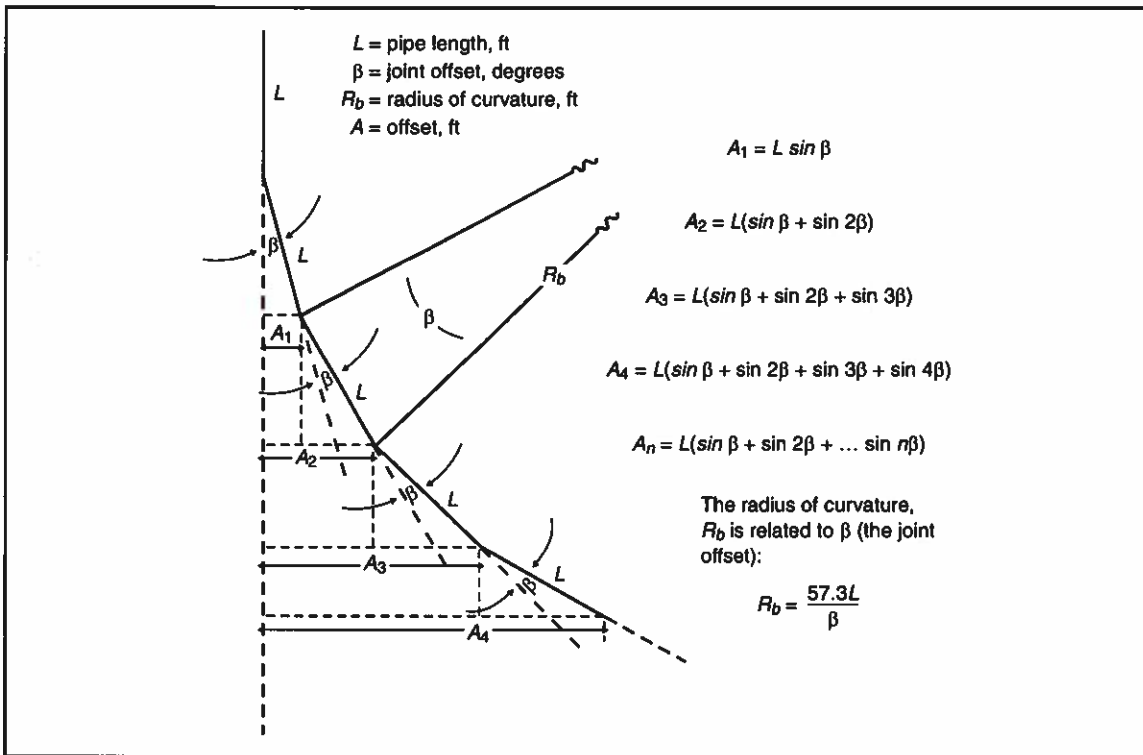


Figure 3 Measurements in relation to the allowable PVC pipe joint offset (β)*

* Adapted from M23, *PVC Pipe—Design and Installation*, Fig. 4-5.

manufacturer's published limits. Excessive joint offset may result in damaging stresses or leakage.

8.6.1.2 Embedment restrictions. Embedment Types 1 and 2 found in Figure 1 shall not be permitted for longitudinally bent pipe segments.

8.6.1.3 Longitudinal bending in the PVC pipe barrel for gasket-joined pipe shall not result in a bending radius (R_b) less than the minimum listed in Table 2.

8.6.1.4 Gasket-joined pipe, 10 in. and larger. Longitudinal bending of 10-in. (250-mm) diameter and larger gasket-joined pipe is not recommended because of the required forces.

8.6.1.4.1 The curved alignment of pipelines larger than 10 in. (250 mm) in diameter shall be determined by the pipe manufacturer's published joint offset limits (Figure 3).

8.6.2 *Longitudinal bending of fused-joined pipe.* The minimum longitudinal bending radii for fused-joined PVC pressure pipe are listed in Table 3 and shall not be exceeded during handling, installation, or final alignment.

Table 2 Allowable Longitudinal Bending for Gasket-Joined PVC and PVCO Pressure Pipe

Nominal Size		Minimum Bending Radius (R_b)	
<i>in.</i>	<i>(mm)</i>	<i>ft</i>	<i>(m)</i>
4	(100)	100	(30.5)
6	(150)	144	(43.9)
8	(200)	189	(57.6)
10	(250)	231	(70.4)

Table 3 Allowable Longitudinal Bending for Fused-Joined PVC Pipe

Nominal Size		Minimum Bending Radius (R_b) CIOD*		Minimum Bending Radius (R_b) IPS†	
<i>in.</i>	<i>(mm)</i>	<i>ft</i>	<i>(m)</i>	<i>ft</i>	<i>(m)</i>
4	(100)	100	(30.5)		
6	(150)	144	(43.9)		
8	(200)	189	(57.6)		
10	(250)	231	(70.4)		
12	(300)	275	(83.8)		
14	(350)	319	(97.2)	292	(89.0)
16	(400)	363	(110.6)	333	(101.5)
18	(450)	406	(123.7)	375	(114.3)
20	(500)	450	(137.2)	417	(127.1)
24	(600)	538	(164.0)	500	(152.4)
30	(750)	667	(203.3)	620	(189.0)
36	(900)	798	(243.2)	742	(226.2)
42	(1,050)	927	(282.6)		
48	(1,200)	1,058	(322.5)		

*CIOD (Cast Iron Outside Diameter): Outside diameters that are equivalent to iron pipes and fittings, in accordance with the ductile-iron or cast-iron (CIOD) sizing system (ANSI/AWWA C110/A21.10).

†IPS (Iron Pipe Size): Outside diameters that are equivalent to steel pipes and fittings, in accordance with the steel (IPS) sizing system (ASME B36.10M).

8.6.3 *Deflection fittings and couplers.* Fittings, bends, or couplings that allow additional joint offset shall be used to achieve gradual alignment changes that exceed the pipe manufacturer’s published limits or, in the case of fused-joined pipe, the allowable bend radius minimums in Table 3.

8.6.3.1 *Default limits.* In absence of the manufacturer’s published joint offset limits, one degree per joint shall be considered the maximum.

Sec. 8.7 Thrust Restraint

Reaction or thrust restraint shall be provided for each dead end, valve, bend, T-connector, and unrestrained hydrant; at reducers or fittings otherwise unrestrained; and where changes in pipe diameters or directions occur. The size and shape of concrete thrust blocks shall be as specified by the purchaser. The length of restrained-joint piping and details of joint-restraint glands, clamps, friction slabs, or other anchors shall be as specified by the purchaser. Restraining mechanisms for PVC pipe and fittings shall be tested and meet the requirements of ASTM F1674.

Sec. 8.8 Backfill

Trench backfill above the pipe shall be specified by the purchaser. If the purchaser plans to use metal-detection equipment to assist in locating the water line after installation, a tracer wire or coated metal strip should be placed immediately above the initial backfill material and directly over the pipe. The tracer wire shall be insulated for protection from corrosion and be at least 12 gauge. Alternatively, plastic-coated metal strips that have been specifically designed for this purpose may be used.

8.8.1 Material. The initial backfill material immediately above the top of the pipe shall be free of refuse, cobbles, boulders, large rocks or stones, frozen soil, or other similarly unsuitable material. The balance of the backfill shall be free of debris and contain no stones or rocks larger than 8 in. (200 mm). Additional backfill material shall be supplied by the constructor if needed to reestablish the surface grade or to completely fill in ground surface depressions at the top of the trench.

8.8.2 Placement. After the embedment material has been placed in accordance with Figure 1, initial backfill material shall be placed to a depth of 6 to 12 in. (150 to 300 mm) over the top of the pipe in a manner that will fill the remaining voids and avoid damage to the pipe. Backfilling shall follow pipe laying as closely as possible. In general, backfilling should be no further than 100 ft (30 m) behind pipe installation. Backfill shall be mounded in unpaved areas to allow for future settlement.

8.8.2.1 Remaining backfill. The balance of the backfill shall contain no stones or rocks larger than 8 in. (200 mm), frozen material, or debris. Backfilling shall follow pipe installation as closely as possible. In general, backfilling should be no further than 100 ft (30 m) behind pipe laying. Backfill shall be mounded in unpaved areas to allow for future settlement.

8.8.3 Compaction. Trench backfill that will be under paved surfaces, such as sidewalks or roads, shall be compacted in layers to the density required

by the governmental agency having jurisdiction over the road or sidewalk. Trench backfill in locations other than to-be-surfaced areas shall be compacted to a density equivalent to that of the surrounding soil.

8.8.3.1 *Nonsurfaced areas.* Trenches in locations other than surfaced areas shall be compacted as required by the contract specifications or, if not specified, in accordance with local requirements.

8.8.3.2 *Additional material.* Additional backfill material shall be supplied by the constructor if needed to backfill trenches completely or to fill depressions caused by subsequent settlement.

8.8.4 *Partial backfilling during testing.* Newly installed pipelines are normally tested after backfilling. When the purchaser requires that pressure and leakage testing be accomplished before completion of backfilling or with pipe joints exposed for examination, sufficient backfill material shall be placed over the pipe barrel between the joints to prevent movement, and consideration shall be given to restraining thrust forces. In particular, pipes connected to restrained joints, which derive their stability from the interaction of the pipe and soil, should be backfilled prior to testing.

SECTION 9: APPURTENANCE PLACEMENT

Sec. 9.1 Examination of Material

Prior to installation, valves, fittings, and hydrants shall be inspected by the constructor to ensure proper function, cleanliness, proper sealing surfaces, and compliance with purchaser requirements. Appurtenances displaying damage from handling, cracks, or other defects shall be repaired or replaced to the satisfaction of the purchaser.

Sec. 9.2 Fittings and Valves

9.2.1 *General.* Fittings and valves shall be provided and installed as specified by the purchaser. Valves shall be placed with operating stems vertical, except gear-operated butterfly valves shall be placed with the operating stems horizontal.

9.2.2 *Placement.* The pipe shall not carry the full weight of valves and fittings. Such appurtenances shall be provided with proper support, such as crushed stone, concrete pads, or a well-compacted trench bottom.

Sec. 9.3 Hydrants

9.3.1 *General.* Hydrants shall be installed as specified by the purchaser.

9.3.2 *Placement.* The full weight of hydrants shall not be carried by the pipe. Hydrants, hydrant lead valves, fittings, and branch T-connectors shall be provided with proper support, such as crushed stone, concrete pads, or a well-compacted trench bottom. Hydrants shall stand plumb, be properly located and oriented, and be set to proper elevation. The constructor shall provide a coarse-aggregate drain pocket or drain pit for dry-barrel hydrants. The installation recommendations of AWWA Manual M17 shall be followed.

Sec. 9.4 Service Connections

9.4.1 *Direct tapping.* Direct tapping involves the tapping of threads into the pipe wall and the insertion of a corporation stop.

9.4.1.1 Tapping conditions. Direct tapping shall require that the following conditions are met:

1. Approval by the purchaser.
2. Taps shall be 1 in. (25 mm) or smaller, that is, $\frac{5}{8}$, $\frac{3}{4}$, and 1 in. (16, 20, and 25 mm).
3. Pipes shall meet the requirements of ANSI/AWWA C900 with a DR of 18 or 14.
4. Tapping appurtenances typically require 2–3 threads for sealing the appurtenance to the pipe wall. Some jurisdictions successfully tap sizes through 16 in., however, direct tapping is generally not allowed for the external bending radii (see Sec. 8.6.1), for 4-in. C900 pipe, for DR25 C900 pipe, for all C905 and C909 pipe, and for fused joined pipe. Direct tapping is common for DR 14 and DR 18 nominal pipe sizes 6, 8, 10, and 12 in. (150, 200, 250, and 300 mm).
5. Corporation stops shall be threaded and conform to ANSI/AWWA C800.
6. A combination core drill and tap manufactured specifically for PVC pipe, which cuts ANSI/AWWA C800 tapered threads, shall be used. The core drill must retain the plug of material removed from the pipe wall and must have a throat depth sufficient to accommodate walls as thick as DR 14. Single-tooth, core-drill cutters shall not be used.
7. The tapping machine shall be of a design in which the feed rate of the boring bar is controlled and accomplished with a feed nut or feed screw and yoke.
8. The maximum allowable pressure in the pipe when tapping shall be the pressure class of the pipe.*

* When easily practicable, a reduction of line pressure during tapping is suggested.

9.4.1.2 Tap spacing. No direct tap shall be made closer than 2 ft (600 mm) from the ends of the pipe. Multiple taps in a single pipe shall be staggered around the circumference and at least 18 in. (450 mm) apart when measured along the longitudinal axis of the pipe. Refer to safety precautions 9.4.4.

9.4.1.3 Tapping procedure. The following procedures shall be followed when making a direct tap:*

1. The tapping machine shall be placed firmly on the pipe in accordance with recommendations of the machine manufacturer, but not in a way that distorts the pipe.

2. Before tapping, the cutter shall be lubricated with a cutting grease recommended by the cutter manufacturer.

3. Cutting the hole shall require only finger-pull effort, allowing the cutter to work without forcing it through the pipe wall. Excessive effort indicates that the cutter is either being advanced too rapidly or that the cutter has become dull. The number of taps made with a core drill cutter should be limited to the recommendations published by the cutter manufacturer. The ratchet handle shall be rotated at least one complete turn for every $\frac{1}{8}$ turn of the feed yoke.

4. The feed yoke shall be engaged to cut the first few threads in the pipe wall. After this, the tapping bit should be self-feeding and the feed yoke can be disengaged from the boring bar.

5. Tapping to the correct depth is important and should be determined by performing one or more bench taps in advance. During the bench tap, the operator should carefully note the position of the top of the threaded feed sleeve relative to the thrust collar or other datum point, when the corporation stop is correctly inserted. The "cast-iron" mark on the boring bar is not a reliable indicator of how deep to tap.

6. As the tapping tool is reversed out of the hole, the feed yoke shall be reengaged or the boring bar held until the tap clears the threads. The bar shall be released slowly so as not to damage the threads or injure the machine operator.

7. Two spiral wraps of 3-mil PTFE[†] tape shall be applied clockwise to the inlet threads on the closed corporation stop. Below freezing temperatures where an acceptable liquid thread sealant is desired, sealants recommended for use with PVC and that are prequalified in accordance with ASTM F2331 may be used.

* For more information concerning direct tapping, refer to AWWA Manual M23, UNI-B-8, and UNI-PUB-8.

† Polytetrafluorethylene, nonstick coated.

8. The boring-bar assembly shall be replaced in the machine and used to insert the stop into the main. Care shall be taken when starting the first few threads in the hole so that they are not forced or punched into the pipe.

9. The feed yoke shall be disengaged and the ratchet handle removed as soon as the corporation stop has firmly engaged the threads in the pipe wall. The insertion shall be completed using a torque wrench and tightening to 27 ft-lb (36.6 N m).

10. Following the removal of the tapping machine, the corporation stop shall be inspected for leakage. If there is leakage past the threads, the corporation stop should be tightened to no more than 35 ft-lb (47.5 N m) using a torque wrench. At correct insertion, one to three threads should be visible.

11. If leaking past the threads persists, the line shall be depressurized and the corporation stop unscrewed. Pipe-wall threads shall be cleared of any cuttings, and new PTFE tape shall be applied to the corporation-stop threads. The corporation stop shall then be reinstalled to 27 ft-lb (36.6 N m) using a torque wrench. The previous step shall be repeated if necessary.

9.4.2 *Saddle tapping.* Saddle tapping involves making a service connection through the use of a service clamp or saddle. All sizes and classes of PVC pipe may be tapped using a service clamp or saddle. The maximum outlet size with a service clamp or saddle shall be 2 in. (50 mm). If a tap larger than 2 in. (50 mm) is required, a tapping sleeve and valve shall be used.

9.4.2.1 *Clamps and saddles.* Service clamps or saddles shall provide full support around the circumference of the pipe. Because the outside-diameter manufacturing tolerances for PVC pipes are tighter than those for compatible ductile-iron pipes, only tapping saddles manufactured specifically for PVC pipe shall be used.

Service clamps or saddles shall provide a sufficient bearing area. A minimum of 2 in. (50 mm) total width along the pipe's axis shall be required for taps up to 1 in. (25 mm) in size to prevent pipe distortion when the saddle is tightened to manufacturer's torque specifications. Taps 1¼ in. (32 mm) through 2 in. (50 mm) should have a minimum of 3 in. (75 mm) total band width with full circumferential support. Narrow U-bolt-type straps and saddles having lugs that dig into the pipe wall shall be prohibited.

9.4.2.2 *Cutting tool.* The drilling machine shall operate with a cutting tool classified as a core-cutting tool of the shell (hole) design that retains the coupon cut while penetrating the pipe wall. The drilling machine shall be provided with a ratchet handle on the boring bar. The drilling machine shall also be of a design where the

cutting tool's feed rate is controlled and accomplished with a feed nut or feed screw and yoke. The cutting tool should have a minimum of two cutting edges and slots to minimize stress and facilitate easier flow of shavings during the cutting process.

9.4.2.3 Throat depth. The shell-type (hole) cutting tool shall have a throat depth that exceeds the PVC pipe wall thickness. Twist-drill bits and auger bits shall be prohibited.

9.4.2.4 Saddle tapping procedure. The following procedures shall be followed when making a saddle tap:

1. The service clamp or saddle shall be evenly tightened on the pipe. Visible distortion of the pipe indicates overtightening and shall be prohibited. The inlet side of the main stop or corporation stop shall be screwed into the saddle threads. The main-stop valve shall then be opened.

2. The drilling machine shall be attached to the main-stop outlet threads.

3. The boring bar shall be lowered to the main and rotated using finger-pull pressure on the feed handle. Cutting the hole shall require only finger-pull effort, allowing the cutter to work without being forced through the pipe wall. The ratchet handle shall be rotated at least one complete turn for every $\frac{1}{8}$ turn of the feed yoke.

4. After the hole has been cut, the cutter should be advanced through the hole with two or more full turns. The cutter shall then be withdrawn, the main stop closed, and the drilling machine removed from the pipe. If leakage is observed past the threads, the main stop should be tightened.

9.4.3 *Tapping sleeve and valve.* Tapping sleeves are used when making a service connection larger than 2 in. (50 mm). Tapping sleeves may be used for making large taps under pressure. The use of tapping sleeves and valves is recommended for all sizes and classes of PVC pressure pipe. When making this type of connection, equipment is used that attaches to the valve and permits a cutting tool to be fed through the valve to cut a hole in the PVC pressure pipe.

9.4.3.1 Tapping sleeve. Tapping sleeves should provide full support around the circumference of the pipe. The tapping sleeve should be well supported independently from the pipe during the tapping operation. Support used should be left in place after tapping. Thrust restraint shall be provided with tapping sleeves as it would with any other fitting or appurtenance.

9.4.3.2 Cutting tool. The tapping machine shall use a cutting tool that is a toothed core cutter that retains the coupon cut from the pipe. The cutting tool shall have a throat depth that exceeds the PVC pipe wall thickness.

9.4.3.3 Tapping sleeve procedure. The following procedures shall be followed when making a sleeve tap:

1. The tapping sleeve shall be installed on the pipe to be tapped in accordance with the sleeve manufacturer's instructions. The mounting bolts shall be tightened to manufacturer's requirements. Over-tightened bolts can induce stress into the pipe being tapped. Failure to use lubrication on mat-type gaskets can induce stress into the pipe being tapped.

2. The tapping valve shall be attached to the tapping sleeve. The tapping valve is typically a specialty valve with a gasket-flanged connection to the outlet side and an MJ-type connection to the tapping machine side.

3. Provide a low-pressure (5-psi) pressure test to the tapping sleeve and tapping valve to verify a pressure-tight seal between the tapping sleeve and the pipe-line to be tapped. The application of a soapy water solution to the outside of the pipe at the pipe-gasket interface can facilitate the detection of an air leak.

4. The tapping sleeve and valve shall be supported independently from the pipe. Supports shall be left in place after tapping.

5. The required PVC cutter and support hardware shall be installed.

6. The drilling machine shall be attached to the tapping valve.

7. Temporary supports shall be installed under the tapping machine to support it independently from the pipe, sleeve, and valve.

8. The tapping valve shall be opened.

9. The cutter shall be advanced to the pipe being tapped.

10. The cutter shall be engaged and the tapping hole cut. On power-operated tapping machines, the advance rate, the cutting rate, and the travel distance shall be set per manufacturer's recommendations. If using a hand-operated model, the proper advance rate, cutting rate, and travel distance shall be ensured.

11. After the hole has been cut, the cutter shall be retracted, the tapping valve closed, and the tapping machine removed.

12. The new line shall be attached.

9.4.3.4 Tap spacing. Placement restrictions vary by the diameter of the pipe that is being cut into, as follows:

9.4.3.4.1 Tap not closer than 24 in. (600 mm) from both the back of the bell and the spigot insertion line for pipes with diameters of 12 in. or less.

9.4.3.4.2 Tap not closer than 36 in. (900 mm) from both the back of the bell and the spigot insertion line for pipes with diameters of 14 in. or more.

9.4.4 *Safety precautions.* The following safety precautions are always recommended when tapping a pressurized pipe:

1. Personnel on the surface should have a clear understanding of the valve location(s) and operation necessary to isolate the tapping site in the event of a problem.
2. At least one worker should remain on the surface (out of the trench) during the tapping operation.
3. The tapping-machine operator should wear protective goggles and be provided with a ladder or other appropriate means to exit the trench quickly and safely.
4. The pipe adjacent to the tap should be covered with a protective blanket.

SECTION 10: PREPARATION FOR USE

Sec. 10.1 Potable Water Pipe Cleaning

Before filling, testing, and disinfecting the installed line, the constructor shall ensure the line is clean in conformance with ANSI/AWWA C651. To facilitate effective disinfection and minimize the chlorine dosage needed, when practicable, pre-disinfection flushing should continue until the discharge turbidity drops below 5 ntu, using measurement procedures described in AWWA Manual M12.

Sec. 10.2 Filling and Flushing

Lines shall be filled slowly with potable water at a maximum velocity of 1 ft/sec (0.3 m/sec) while venting air. Precautions shall be taken to prevent entrapping air in the lines. After filling, lines shall be flushed at blowoffs and dead ends at a minimum velocity of 3 ft/sec (0.9 m/sec). A minimum of three changes of treated water shall be used in flushing operations. Valves shall be closed slowly to prevent excessive surges while maintaining positive pressure at all times throughout the new line. Flushing water shall be discharged without causing erosion damage, nuisance, or interruption of traffic. Disposal of flushing water shall be in accordance with Sec. 7.1.1.2. A special pipeline pig may be required when the required flushing velocity cannot be achieved or when needed to conserve water. The constructor shall make provisions for launching and retrieving the pig.

Sec. 10.3 Hydrostatic Testing

WARNING: Hydrostatic testing described in this section shall be conducted with water or other environmentally safe, incompressible fluids, because of the

inherent safety hazard potential associated with testing components and systems with compressed air or other compressed gases.

10.3.1 *General.* The constructor shall provide measurement gauges and recording devices for the test, including pump, pipe, connections, and other necessary apparatus, unless otherwise specified by the purchaser, and shall provide the necessary assistance to conduct the test. Before testing, the constructor shall place sufficient backfill to prevent pipe movement. When local conditions require that the trenches be backfilled immediately after the pipe has been laid, the testing may be carried out after backfilling has been completed but before placement of permanent surfacing. The constructor shall ensure thrust-blocking or other types of restraining systems will provide adequate restraint before pressurizing the pipeline. Refer to Sec. 8.8.4 for backfilling requirements.

10.3.2 *Cross-connection control.* When existing water mains are used to supply test water, they should be protected from backflow contamination by temporarily installing a double-check-valve assembly between the test and supply main or by other means approved by the purchaser. Before pressure and leakage testing, the temporary backflow protection should be removed and the main under test isolated from the supply main.

10.3.3 *Procedure.* Tests shall be performed only after the pipeline has been properly filled, flushed, and purged of air. The specified test pressure shall be applied by means of an approved pumping assembly connected to the pipe in a manner satisfactory to the purchaser. The test pressure shall not exceed the design pressure of the pipe, fittings, valves, or thrust restraints. If necessary, the test pressure shall be maintained by additional pumping for the specified time. During tests, the system and exposed pipe, fittings, valves, and hydrants shall be carefully examined for leakage. Visible leaks shall be stopped. Defective elements shall be repaired or removed and replaced and the test repeated until the test requirements have been met.

10.3.4 *Test duration.* The duration of the hydrostatic test shall be 2 hr.

10.3.5 *Test pressure.* The hydrostatic test pressure shall not be less than 1.25 times the stated anticipated maximum sustained working pressure of the pipeline measured at the highest elevation along the test section and not less than 1.5 times the stated sustained working pressure at the lowest elevation of the test section. However, in no case shall the test pressure exceed the rated working pressure for any joint, thrust restraint, valve, fitting, or other connected appurtenance of the test section.

10.3.6 *Test allowance.* The testing allowance shall be defined as the quantity of water that must be supplied to the pipe section being tested to maintain a pressure within 5 psi (34 kPa) of the specified hydrostatic test pressure. No installation will be accepted if the quantity of makeup water is greater than that determined by the formula:

$$Q = \frac{LD \sqrt{P}}{148,000} \quad (\text{Eq 1})$$

Where:

Q = quantity of makeup water, in gallons per hour

L = length of pipe section being tested, in ft

D = nominal diameter of the pipe, in in.

P = average test pressure during the hydrostatic test, in pounds per square in. (gauge)

In metric units,

$$Q_m = \frac{LD \sqrt{P}}{795,000} \quad (\text{Eq 2})$$

Where:

Q_m = quantity of makeup water, in liters per hour

L = length of pipe section being tested, in meters

D = nominal diameter of the pipe, in millimeters

P = average test pressure during the leakage test, in kilopascals

These formulas are based on a testing allowance of 10.5 gpd/mi/in. (0.978 L/day/km/mm) of nominal diameter at a pressure of 150 psi (1,030 kPa).

10.3.6.1 Allowance tables. Makeup water allowances for various pipe diameters and test pressures are provided in Tables 4a and 4b.

10.3.6.2 Metal-seated valves. When testing against closed metal-seated valves, an additional allowance per closed valve of 0.0078 gph/in. (0.0012 L/hr/mm) of nominal valve size shall be allowed.

10.3.6.3 Hydrant. When hydrants are in the test section, the test shall be made against closed hydrant valves.

10.3.6.4 Visible leaks. Visible leaks shall be repaired, regardless of the amount of leakage.

Sec. 10.4 Disinfecting Potable Water Lines

Prior to placing any installed potable water line in service, the new pipe and exposed sections and appurtenances of existing pipelines shall be cleaned and

Table 4a Hydrostatic test makeup water allowances per 1,000 ft (50 joints) of PVC pipe, (US gal/hr)

Avg. Test Pressure	Nominal Pipe Diameter, in. (mm)															
	4	6	8	10	12	14	16	18	20	24	30	36	42	48		
300 (2,070)	0.47	0.70	0.94	1.17	1.40	1.64	1.87	2.11	2.34	2.81	3.51	4.21	4.92	5.62		
275 (1,900)	0.45	0.67	0.90	1.12	1.34	1.57	1.79	2.02	2.24	2.69	3.36	4.03	4.71	5.38		
250 (1,720)	0.43	0.64	0.85	1.07	1.28	1.50	1.71	1.92	2.14	2.56	3.21	3.85	4.49	5.13		
225 (1,550)	.041	.061	.081	1.01	1.22	1.42	1.62	1.82	2.03	2.43	3.04	3.65	4.26	4.86		
200 (1,380)	0.38	0.57	0.76	0.96	1.15	1.34	1.53	1.72	1.91	2.29	2.87	3.44	4.01	4.59		
175 (1,210)	0.36	0.54	0.72	0.89	1.07	1.25	1.43	1.61	1.79	2.15	2.68	3.22	3.75	4.29		
150 (1,030)	0.33	0.50	0.66	0.83	0.99	1.16	1.32	1.49	1.66	1.99	2.48	2.98	3.48	3.97		
125 (860)	0.30	0.45	0.60	0.76	0.91	1.06	1.21	1.36	1.51	1.81	2.27	2.72	3.17	3.63		
100 (690)	0.27	0.41	0.54	0.68	0.81	0.95	1.08	1.22	1.35	1.62	2.03	2.43	2.84	3.24		
75 (520)	0.23	0.35	0.47	0.59	0.70	0.82	0.94	1.05	1.17	1.40	1.76	2.11	2.46	2.81		
50 (340)	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.96	1.15	1.43	1.72	2.01	2.29		

Table 4b Hydrostatic test makeup water allowance per 305 m (50 joints) of PVC pipe (L/hr)

Average Test Pressure (<i>kPa</i>)	Nominal Pipe Diameter (<i>mm</i>)													
	100	150	200	250	300	350	400	450	500	600	750	900	1,050	1,200
2,200	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.1	9.0	10.8	13.5	16.2	18.9	21.6
2,000	1.7	2.6	3.4	4.3	5.1	6.0	6.9	7.7	8.6	10.3	12.9	15.4	18.0	20.6
1,800	1.6	2.4	3.3	4.1	4.9	5.7	6.5	7.3	8.1	9.8	12.2	14.6	17.1	19.5
1,600	1.5	2.3	3.1	3.8	4.6	5.4	6.1	6.9	7.7	9.2	11.5	13.8	16.1	18.4
1,400	1.4	2.2	2.9	3.6	4.3	5.0	5.7	6.5	7.2	8.6	10.8	12.9	15.1	17.2
1,200	1.3	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.6	8.0	10.0	12.0	14.0	15.9
1,000	1.2	1.8	2.4	3.0	3.6	4.2	4.9	5.5	6.1	7.3	9.1	10.9	12.7	14.6
800	1.1	1.6	2.2	2.7	3.3	3.8	4.3	4.9	5.4	6.5	8.1	9.8	11.4	13.0
600	0.9	1.4	1.9	2.3	2.8	3.3	3.8	4.2	4.7	5.6	7.0	8.5	9.9	11.3
400	0.8	1.2	1.5	1.9	2.3	2.7	3.1	3.5	3.8	4.6	5.8	6.9	8.1	9.2
200	0.5	0.8	1.1	1.4	1.6	1.9	2.2	2.4	2.7	3.3	4.1	4.9	5.7	6.5

disinfected in accordance with ANSI/AWWA C651, unless otherwise specified. Pipelines shall be flushed following completion of disinfection procedures. Disposal or neutralization of disinfection water shall comply with applicable regulations (refer to appendix B of ANSI/AWWA C651).

Sec. 10.5 Notice of Nonconformance

If the installation does not meet the requirements of this standard, the constructor shall be notified by the purchaser promptly and the installation shall be made satisfactory by the constructor.

Sec. 10.6 Affidavit of Compliance

The constructor shall provide a sworn statement that the installation complies with the requirements of this standard.

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